The Effects of Seductive Details and Segmentation on Interest, Recall and Transfer in a Multimedia Learning Environment

Danielle L. Lusk

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Peter E. Doolittle, Chair
Michael A. Evans
Brett D. Jones
Thomas M. Sherman

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ABSTRACT

Multimedia learning theory, and the research that has supported it, is largely focused on the cognitive elements of learning. Although motivation has been mentioned as a factor in learning in a multimedia environment, motivation has not been measured as a distinctive variable in most studies. Specific attributes of multimedia, including seductive details and segmentation, have been hypothesized to increase interest; however, only studies examining these attributes' effects on learning (measured by recall and transfer) have been conducted. The present study aimed to extend the examination of the use of seductive details and segmentation in multimedia learning by measuring interest in addition to recall and transfer.

The participants were 167 undergraduate students who were randomly assigned to four treatment groups involving a tutorial on the formation of lightning, which differed according to the multimedia attributes featured in the tutorial. Treatment groups included seductive details and segmentation (SD+S), seductive details and no segmentation (SD+NS), no seductive details and segmentation (NSD+S), and no seductive details and no segmentation (NSD+NS). Participants took an interest questionnaire before engaging with the tutorial and immediately following the tutorial. Tests of recall and transfer were used to measure learning after the tutorial. Two trained raters evaluated responses.

Data from the study were analyzed using Analysis of Variance (ANOVA) and correlation procedures. The results of the study revealed no significant differences among treatment groups in regards to interest, recall, or transfer. There was no significant relationship between interest and recall or interest and transfer. Although the results did not provide support for existing literature on seductive details and segmentation effects or reveal that these attributes increase interest, the implications of the findings present several valuable areas for future research.

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CHAPTER ONE

INTRODUCTION

As the use of educational technology advances, a stronger understanding of how learning occurs within these environments is necessary. Multimedia learning is being employed in a variety of educational settings – public schools, universities and colleges, industry, and the military – as a means of instruction. However, a full comprehension of how people learn from multimedia messages is still lacking.

In relation to other theories of learning, multimedia learning theory is relatively new, with most research beginning in the mid-1980s (Samaras, Giouvanakis, Bousiou, & Tarabanis, 2006). Educational psychologists, instructional designers, and instructional developers have studied the components of multimedia and how learning occurs in this type of instructional environment (e.g., Mayer, 2005a; Moreno & Mayer, 2000; Paas, Renkl, & Sweller, 2003; Sweller, 2005). While many researchers have examined learning and multimedia instruction, Richard Mayer and his colleagues have been the most prolific and developed the most comprehensive multimedia learning theory.

One problem with Mayer’s (2005c) cognitive theory of multimedia learning, however, is its general lack of motivational components. Even though a few multimedia researchers have included motivation within their learning models (Astleitner & Wiesner, 2004; Hede, 2002; Malone & Lepper, 1987), the majority of these models are incomplete in terms of how motivation influences learning. Mayer’s cognitive theory of multimedia surpasses many of these models based on its theoretical foundations and generation of research; however, it is still lacks the motivational components necessary to make it complete.

Motivational components are needed in a comprehensive theory of multimedia learning for several reasons. First, motivation influences learning (Asleitner & Wiesner, 2004; Hidi & Renninger, 2006; Silvia, 2006). Second, motivational processes employ mental resources which may affect working memory capacity (Asleitner & Wiesner, 2004; Brooks & Shell, 2006). Third, motivation must be at an optimal level for learning to occur (Clark, 1999).

While research in multimedia learning is progressing into new frontiers (Samaras, Giouvanakis, Bousiou, & Tarabanis, 2006), more research is needed to examine how certain features of multimedia instructional messages influence motivation in learners and, in turn, how that motivation influences learning. In regards to motivational interest theory in multimedia learning environments, studies examining the utilization of seductive details and learner control have been conducted (e.g., Harp & Mayer, 1997; Kettanurak, Ramamurthy, & Haseman, 2001; Lawless, Brown, Mills, & Mayall, 2003; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000). However, many of these studies have either failed to measure interest as a dependent variable or have ignored how interest levels influence learning. Therefore, more research needs to be conducted in this area which does measure interest as a dependent variable in order to understand how interest affects learning in the multimedia learning environment.

The goal of the current research study is to examine how the motivational variable of interest is influenced by attributes commonly sued in multimedia learning environments. Based on Mayer's (2005c) cognitive theory of multimedia learning, the multimedia attributes that are typically used for interest purposes are most likely variables that will increase cognitive load and, therefore, decrease learning. However, motivational theorists argue that interest plays an important role in learning (e.g., Hidi & Renninger, 2006). The contradiction between cognitive theory and motivational theory is one that needs to be addressed in the multimedia learning environment.

For most people who work in instructional design and educational materials development, Keller's (1983, 1997, 1999) ARCS model has been the primary model of motivation. The ARCS model, however, can be criticized for its lack of intrinsic motivational focus. The ARCS model focuses more on extrinsic factors and how the instruction is designed instead of looking at what is occurring within the learner.

However, the gaps in multimedia learning theory and the flaws of the ARCS model can be addressed with more research examining how motivational factors interact with learning in a multimedia environment. In addition to filling the gaps of existing theory, this research is needed in order to discover how individual differences such as motivation affect learning. A strong theoretical basis is needed before moving on to design issues. Once researchers have a stronger understanding of how certain multimedia attributes influence learning, then more prescriptive guidelines can be developed for instructional designers who make multimedia learning materials. It is expected, however, that much more research will need to be conducted in the realm of motivation and multimedia learning before researchers can fully grasp how the various attributes influence learning. This study will serve as a baseline for future research examining multimedia attributes and their effects on user interest, recall, and transfer in multimedia learning environments. Mayer’s (2005c) cognitive theory of multimedia learning will be utilized along with interest theory (e.g, Hidi, 1990; Hidi & Baird, 1986; Hidi & Renninger, 2006) to provide a framework for this research.

CHAPTER TWO

REVIEW OF THE LITERATURE

To provide a thorough framework for this study, this literature review is divided into five sections. The first section describes the theoretical framework of multimedia learning from cognitive psychology. The second section details the cognitive theory of multimedia learning and its limitations. The third section looks at motivational impacts on learning and the inclusion of motivation in models of multimedia learning. Fourth, an overview of motivational interest theory is provided, while, fifth, a discussion of specific multimedia features used in relation to interest concludes the literature review.

A Framework from Cognitive Psychology

Researchers studying human learning in the past century have drawn upon behaviorist, cognitivist, and constructivist perspectives. While there is a shift towards different theories of learning in the realm of educational technology, many researchers are still focusing more on what cognitive factors influence learning in new types of learning environments. The multimedia learning environment, in particular, has embraced cognitive psychology in relation to instruction (Doolittle, McNeill, Terry, & Scheer, 2005). Rouet, Levonen, and Biardeau (2001) describe it as a shift from what technology can do to a focus on how technology should be designed for meaningful instruction. This shift, Doolittle et al. (2005) note, has generated a focus on the limited resources of working memory and the effects of cognitive load. Mayer (2005c, p. 38) remarks that the "central work of multimedia learning takes place in working memory," which is the "cognitive structure in which we consciously process information" (Sweller, 2005, p. 29). Together, these theories focusing on working memory and cognitive load, among others, provide the theoretical foundation behind the cognitive theory of multimedia learning.

Working Memory

Memory must be considered when discussing learning because memory initiates the ability to learn (Friedenberg & Silverman, 2006). Until the late 1950s memory was viewed as a singular unit (Baddeley, 2006); however, research began to support a multidimensional view of memory in which short-term and long-term memory were conceived as separate units. While different models of memory exist, one consistency is the existence of distinct memory systems with different functions (Friendenberg & Silverman, 2006).

Atkinson and Shiffrin (1968) provided one of the first modern multi-unit theories of human memory, the modal model. In the modal model, there are three distinct units: a sensory register, a short-term store, and a long-term store (Shiffrin & Atkinson, 1969). The sensory register holds, for a very short period of time – a few seconds at most, incoming sensory information. The sensory information is initially processed before being transferred to the short-term memory store. The short-term store can hold material for about 30 seconds or less if the information is not rehearsed. The rehearsal buffer, though, helps keep information in short-term memory for longer periods of time. During its time in short-term memory, information begins to be transferred to long-term storage. The long-term store permanently holds information (Shiffrin & Atkinson, 1969) in the modal model, and the information, once stored, is never forgotten. Retrieving information from long-term storage can, however, vary with time and interfering information.

In the modal model, the short-term store serves several purposes (Shiffron & Atkinson, 1969). The first function of short-term memory is to provide a separation from the external environment. The sensory register handles the constant incoming information from the environment, so that short-term memory does not have to handle that information. The short-term store also provides a working memory where people can manipulate information if needed. Also, for some tasks, the short-term store is the main memory system utilized. These tasks involve retaining information in the short-term store until discharged, such as remembering a phone number for dialing purposes. However, the primary purpose of the short-term store is to manipulate information for storage and retrieval from the long-term store.

Problems with Atkinson and Shriffron's (1968) model arose, however, upon further study in the field of neuropsychology during the 1970s (Baddeley, 1986, 1992b). Specifically, problems were noted with Atkinson and Shiffron's (1968) view of a dual-store model. Atkinson and Shiffron (1968) argued that the short-term store also served as working memory and aided in the retrieval of prior knowledge from the long-term store. Studies, however, showed that even patients with short-term storage defects could perform well cognitively and appeared to have a normal long-term memory capacity (Baddeley, 1986, 1992b). Baddeley (1992a, 1998) conducted several studies to help dispel the idea of a singular short-term store that was also a working memory; short-term storage or memory faded as the new concept of a working memory appeared. The results from these studies helped Baddeley derive his working memory model.

Baddeley's (1986, 1992a, 1992b, 1998, 1999) original model of working memory was a tripartite system controlled by a central executive and supplemented by two slave systems: the phonological loop and the visuospatial sketchpad. The central executive is a crucial part of working memory (Baddeley, 1986). In this model, the central executive manages working memory's resources by coordinating the information from the slave systems (Baddeley, 1986; 1992a). Baddeley (1996) identified four functions of the central executive: (a) dual-task performance, (b) retrieval plans switching, (c) selective attention, and (d) long-term memory activation. Despite its importance, little is still known about the central executive and more research is needed (Baddeley, 1986, 2006).

The first slave system, the phonological loop (sometimes called the articulatory loop), handles verbal information (Baddeley, 1986, 1992, 2006, 2007) and is perhaps the simplest part of working memory (Baddeley, 1992). The phonological loop consists of two components: (a) a phonological store which holds speech-based information for about 1-2 seconds, and (b) an articulatory control process which is similar to inner speech (Baddeley, 1986, 1992a). Additionally, the phonological loop functions in two ways. First, by employing subvocal repetition, it sustains information in the phonological store. Secondly, by subvocalization, the phonological loop can register visually presented material in the phonological store.

The second slave system, the visuospatial sketchpad, works with visual and spatial information and verbal material that is encoded as imagery (Gathercole & Baddeley, 1993). The visuospatial sketchpad stores and manipulates visual and spatial information and is divided into separate visual, spatial, and possibly kinesthetic components (Baddeley, 2000). Little information is known about the visuospatial sketchpad; however, new studies in the visual arena are redefining the purpose and functions of the visuospatial sketchpad (Baddeley, 2007). New information has led Baddeley (2007) to believe that this slave system integrates visual and spatial information from a variety of sources including visual, tactile, and kinesthetic sources in addition to episodic and semantic information from long-term memory.

While Baddeley's (1986) original model of working memory only included two slave systems, another slave system was recently added to address issues linking working memory with long-term memory (Baddeley, 2000). The episodic buffer is, like both the phonological loop and visuospatial sketchpad, a limited capacity storage system and is controlled by the central executive. In some ways it is similar to episodic memory because it can hold information across space and potentially time. Conscious awareness provides the means by which the central executive accesses the episodic buffer and helps link working memory to long-term memory (Baddeley, 2000, 2006, 2007). The episodic buffer is essentially an interface between visual, verbal, perceptual, semantic, and episodic information in working and long-term memory.

Baddeley's (1986, 1992a, 1992b, 2000, 2006, 2007) working memory model suggests that different systems handle and process visual and verbal information, the visuospatial sketchpad and phonological loop respectively. Paivio (1990) expanded this idea of separate visual and verbal information channels in working memory and how they connect to long-term memory in what is termed dual-coding theory.

Dual-Coding Theory

Paivio (1971, 1990) created dual-coding theory based on the assumption that humans handle the representation and processing of verbal information and non-verbal information in two separate subsystems. The nonverbal system handles information such as pictures, smells, and sounds, while the verbal system handles information such as words, text, and stories. Each subsystem contains modality-specific representations related to their respective sensorimotor events. Once these imagery and verbal codes are formed they are typically processed serially (Clark & Paivio, 1991).

These two subsystems, the verbal and nonverbal, while functionally and structurally distinct units, are interconnected. In terms of structure, the two subsystems are organized differently and manage different representational units. The representational units are derived from information in long-term memory which corresponds to "perceptually identifiable objects and activities, both verbal and nonverbal" (Paivio, 1990, p. 54). Functionally, the systems are independent as each system can be active without the influence of the other system, or, as Paivio (1991) notes, they can work in parallel with each other influencing activation of the other system, thus promoting interaction.

Paivio (1990) incorporates three levels of processing into dual-coding theory. Representational processing entails the direct activation of logogens (verbal code) by language-based stimuli and the activation of imagens (nonverbal code) by nonverbal stimuli. Referential processing describes a process of cross-system activation where images are processed as words and words processed as objects. Associative processing refers to activated representations within either system activating more representations in the same system (Sadoski & Paivio, 2001). Essentially, associative processing is like spreading activation within the same system, while referential processing is like spreading activation across the systems.

Studies examining dual-coding theory have presented two important findings (Doolittle et al., 2005). The first finding is that when learners process material both verbally and visually, greater learning, retention, and transfer occurs (Clark & Paivio, 1991). The second finding concerns the limited capacity of each system. If a system is overloaded, learning, retention, and transfer may suffer (Doolittle et al., 2005). The limited capacity nature of the two systems and the experience of cognitive over load within each one corresponds to the next theoretical tenet of multimedia learning theory: cognitive load theory.

Cognitive Load Theory

Cognitive load is “the load imposed on working memory by information being presented” (Sweller, 2005, p. 28).Cognitive load theory is based on the idea of a limited working memory system that has separate units for processing visual and verbal information (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Several assumptions regarding human cognitive architecture underlie cognitive load theory (Mousavi, Low, & Sweller, 1995):

- Humans have a limited working memory,
- Humans have an essentially unlimited long-term memory,
- Schema acquisition is a primary means of learning, and
- Automation of cognitive processes can reduce working memory load.

However, the main tenet of cognitive load theory is that working memory is where cognitive processing transpires (Paas, Renkl, & Sweller, 2003) and if it becomes overloaded, then learning will suffer. According to Kirschner (2002), working memory is the only memory system that is able to be monitored. Researchers view it as a limited capacity system that processes and temporarily maintains information (Kirschner, 2002; Mayer, 2005c; Paas, Renkl, & Sweller, 2003). Due to its limited nature, working memory compensates by relying on long-term memory to store schemas (Paas, Renkl, & Sweller, 2003), which are singular constructs that organize existing information and determine how future information will be processed (Kirschner, 2002;

Sweller, 1994). Because schemas organize multiple ideas into a singular structure, they reduce the load on working memory. Reducing this load is vital to learning. When learners' cognitive systems are overtaxed, it affects what, how much, and how well information is learned (Sweller, 1994, 2005).

In cognitive load theory, there are three types of cognitive load that instructional materials place on the learner: intrinsic, extraneous, and germane. Working memory demands resulting from the instructional activity itself are *intrinsic cognitive loads* (Paas, Renkl, & Sweller, 2003) and cannot be reduced as the load is inherent in the task itself (Sweller, 1994). It is the working memory load required to perform a task. According to Sweller (1994, 2005), the amount of element interactivity – "the extent to which elements of information that must be processed interact" (Sweller, 2005, p. 28) – influences intrinsic cognitive load. If the elements involved in learning a task can be learned in isolation, then there is low element interactivity; however, if the elements must be learned together then there is a higher amount of element interactivity (Sweller, 1994). Thus, the instructional designer has little to no control over intrinsic cognitive load.

Extraneous load, on the other hand, is reducible. Caused by poor instructional design, *extraneous cognitive load* is the cognitive demand resulting from the way information is presented, which can interfere with learning (Paas, Renkl, & Sweller, 2003). According to Sweller (2005), there are many instructional design principles based on cognitive load theory. For example, the split attention effect occurs when a learner must split his/her attention amongst multiple sources of information that are key to learning. The use of multiple sources places a high extraneous cognitive load on the learner who must mentally integrate all of these sources to understand.

The third type of cognitive load is termed germane load. *Germane load* is also influenced by the presentation's design, but it does not interfere with learning (Paas, Renkl, & Sweller, 2003). Germane load focuses cognitive resources on forming schemas and automation which can aid comprehension. While providing several examples to demonstrate a key point may raise cognitive load, the increase is germane and will support the construction of schemas (Sweller, 2005). However, germane cognitive load can only occur when the sum of both intrinsic and extraneous cognitive loads does not exceed the limits of working memory (Doolittle et al., 2005).

Cumulatively, the three types of cognitive load cannot exceed working memory's resources. If working memory is overloaded, then active processing may not occur (Mayer & Moreno, 1998). Furthermore, instructional designers must especially consider cognitive load effects when creating design for complex material (Sweller, 2005). If the material itself results in a high intrinsic load, then the designer must be careful to ensure that his/her design does not add extraneous load and overload working memory capacities.

The effects of instructional design and working memory capacity are equally important in multimedia learning. Richard Mayer's (2001, 2005c) cognitive theory of multimedia learning relies heavily on the theoretical foundation built by the interaction of Baddeley's (1986, 1992, 1998, 2006) model of working memory, Paivio's (1971, 1990, 1991) dual-coding theory, and Sweller's (1994, 2005) cognitive load theory. However, Mayer's (2001, 2005c) theory supplements these three theories by contextualizing learning in multimedia environments and describing the unique features that coincide with multimedia learning.

Mayer's Cognitive Theory of Multimedia Learning

With computers and pictorial forms of instruction being heavily incorporated into today's society, it is important to understand how these multimedia instructional messages impact learning. Mayer (2005b) defines multimedia instruction as "Presenting words (such as spoken text or printed text) and pictures (such as illustrations, photos, animation, or video) that are intended to promote learning" (p. 15). Multimedia learning, then, "occurs when people build mental representations from words […] and pictures" (p. 15). Tests of retention and transfer are often the means by which learning is measured in multimedia instruction (Mayer, 2005c).

Mayer's *cognitive theory of multimedia learning* is largely influenced by cognitive psychology, including the theories previously discussed, and is based on three assumptions – (a) dual-channel processing, (b) limited channel capacity, and (c) learners' active processing – and five necessary cognitive processes.

Dual-Channel Processing Assumption

The dual-channel assumption in Mayer's (2005c) multimedia learning theory suggests that humans posses separate, distinct channels which process visually represented material and auditorily represented material. The dual-channel assumption is based heavily on Paivio's dual-coding theory and Baddeley's model of working memory. Paivio's (1990) dual-coding theory incorporates verbal and nonverbal channels by which humans process information, whereas in Baddeley's (2006) model of working memory, a phonological loop holds and processes auditory information while the visuo-spatial sketchpad holds and processes visual information. Specifically, Mayer believes humans posses an auditory/verbal channel and a visual/pictorial channel. In this belief, Mayer mixes presentation-mode and sensory-modality approaches to explain how humans process different types of information.

A sensory modality approach to how the dual channels work is most similar to Baddeley's (1986, 2006, 2007) model. This approach focuses on how learners initially process presented materials, either via their eyes or ears. In this approach, one channel handles visually represented material, much like Baddeley's visuospatial sketchpad, while the other manages auditorily represented material, like Baddeley's phonological loop.

The other approach to the channels, the presentation mode approach, resembles Paivio's (1990) dual-coding theory. This approach focuses on how the information is presented - verbal (i.e., spoken words or text) or non-verbal (i.e., pictures, animation, sounds) – and aligns with Paivio's own verbal and non-verbal channels.

Mayer (2002, 2005c) compromises and uses both approaches to explain how multimedia processing occurs. The two channels are able to interact and convert representation to process in the other channel, which reflects a feature of Paivio's dual-coding theory. By using both modes of presentation – visual and auditory – Mayer (2005c) believes multimedia instruction will be more effective as the two modes accommodate for each other's limited capacity, which is the second assumption of multimedia learning theory.

Limited Capacity Assumption

According to Mayer (2005c), each channel is limited in the amount it can process at one time, an idea that reiterates both Baddeley's (1986, 2006, 2007) working memory model and Sweller's (1994, 2005) cognitive load theory. Mayer stresses that a learner's working memory can hold and process a few pieces of information during multimedia instruction and manages the load by utilizing the two channels.

While individual differences exist concerning working memory capacity (Baddeley, 2006), the average memory span is small and can handle from five to nine chunks of information

(Miller, 1956). Due to the limited capacity of working memory, learners must be selective with their attention. When learners engage with a multimedia instructional message, they are only able to hold a few images and words in working memory at one time. The images and words are not exact replicas of the material; instead, learners form mental representations of the material they believe to be relevant (Mayer, 2005c).

In his working memory model, Baddeley (1999, 2006, 2007) notes that the central executive serves as an attentional control system. Through its control of working memory's attentional resources, the central executive operates metacognitive strategies which allow a learner to adjust his/her cognitive resources and may also influence learners' choices regarding what is and is not relevant towards understanding. Sweller (1994, 2005), in his cognitive load theory, reiterates the importance of leaving room for germane load to occur which increases schema acquisition and automation. Both metacognition and germane load (leading to schema acquisition and automation) are useful, powerful tools in learning. However, because of the limited capacity of working memory, instructional designers must be careful to ensure that working memory is not overloaded so learners can employ metacognitive strategies and think about how they are learning the material. Learners, with their awareness of cognition and adjustment of cognitive resources, are always actively processing information, which Mayer argues, leads to improved learning.

Active Processing Assumption

According to Mayer (2005c, p. 36), "Humans actively engage in cognitive processing in order to construct a coherent mental representation of their experiences." The active processing assumption maintains that people participate in active learning via three steps: (a) selecting relevant information, (b) organizing the selected information into coherent mental representations, and (c) integrating these mental representations with existing knowledge (Mayer, 2005c).

Whenever a learner interacts with multimedia instruction, he/she applies cognitive processing to comprehend the instruction. The learner's active processing leads to the construction of a mental model, which is formed by the learner selecting relevant information and then organizing it into a logical structure (Mayer, Mathias, & Wetzell, 2002). When designing a multimedia instructional message then, Mayer (2005c) and van Merriënboer and

Kester (2005) suggest structuring it in an organized manner which will guide the learner in forming his/her mental model.

Five Processes in Multimedia Learning

In addition to three theoretical assumptions, Mayer (2005c) postulates five cognitive processes that are key for meaningful learning to occur. These five processes are (a) selecting relevant words from the multimedia instructional message, (b) selecting relevant images from the multimedia instructional message, (c) organizing the selected words into a logical representation, (d) organizing the selected images into a logical representation, and (e) integrating both the word and image representations into a new coherent mental representation. Each of these processes may frequently occur during a multimedia instructional message as the learner processes the presented information.

Selecting relevant words, the first step in multimedia learning, involves paying attention to words presented in the multimedia instructional message while they pass through auditory sensory memory (Mayer, 2005c). Spoken words begin processing in the auditory channel, while text begins processing in the visual channel. Eventually, however, text representations may move to the auditory channel if the learner mentally articulates the words. Because of the limited capacity of the auditory channel, learners must focus their attention on what they deem is most relevant. The result of this step is a mental representation of some of the words in verbal working memory.

After a learner selects relevant words, then he/she begins selecting relevant images (Mayer, 2005c). This process includes paying attention to relevant parts of a multimedia instructional message’s animation, images, or illustrations. While this process starts in the visual channel, part of it may be converted to the auditory channel. Again, because capacity is limited, the learner must only select the most relevant images. The result is a mental representation of selected images in visual working memory.

The third and fourth cognitive processes in multimedia learning are organizing selected words and images (Mayer, 2005c). After the learner has mental representations of words and images in his/her working memory, then the process of forming more coherent representations begins. These processes involve building connections between pieces of verbal and visual information in working memory and are constrained by limits on working memory capacity.

After more coherent representations of the verbal and visual information have been formed, then the final process of integration occurs (Mayer, 2005c). This process is the most crucial step in multimedia learning according to Mayer (2005c). During integration the learner forms connections between the verbal and visual models and with prior knowledge obtained from his/her long-term memory. Integration occurs in both visual and verbal working memory and involves coordination between the two. Because integration is a highly demanding process, cognitive capacity becomes a concern due to limited capacity.

The three cognitive assumptions and five cognitive processes comprising the cognitive theory of multimedia learning are founded on previous cognitive theories of working memory, dual-coding theory, and cognitive load. The theory has generated a great deal of research on multimedia learning (see Mayer, 2005a) which has led to the development of "well-proven principles of multimedia learning" (Astleitner & Weisner, 2004, p. 11). These principles have been tested to form a more comprehensive theory of multimedia learning that provides designers a stronger knowledge set on how to create their multimedia programs. Table 1 presents some of the basic principles.

Reflections on Multimedia Learning Theory

Looking at the assumptions and theoretical basis of multimedia learning theory, it is clear that the theory is based primarily on cognitive learning aspects (i.e., dual coding, cognitive load, active processing). What is missing from multimedia learning theory, however, is a focus on other factors that may influence learning, mainly motivation. This is true for most theories of multimedia learning which tend to focus, as Clark (1999) states, "on types of knowledge and strategies for knowledge acquisition and more or less ignore motivational issues" (p. 3). As Astleitner and Weisner (2004) point out, multimedia environments may also contain elements of a "non-cognitive quality" (p. 11). While Mayer and colleagues have performed numerous studies involving multimedia and learning, few of these studies have explicitly examined motivation as a variable in the learning equation. Several studies have looked at the inclusion of seductive details in multimedia (e.g., Harp & Mayer, 1997; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000; Park & Lim, 2007) as well as learner control (e.g., Lawless, Brown, Mills, & Mayall, 2003; Kettanurak, Ramamurthy, & Haseman, 2001) as means of arousing interest, yet interest itself – as a dependent variable – was not measured in all of the studies. Rather, it was assumed that interest was created as a result of certain multimedia elements.

Table 1

Basic Principles of Multimedia Learning Theory

Principle	Definition (from Mayer, 2005a)
Multimedia principle	People learn more deeply from words and pictures than from words alone. (p. 47)
Split-attention principle	Instructions in which multiple sources of information are not physically or temporally integrated so that working memory resources need to be used for mental integration. (p.146)
Redundancy principle	Instructions that present the same information in different forms or with unnecessary explanatory material increase extraneous cognitive load that interferes with learning. (p. 167)
Segmenting principle	People learn more deeply when a multimedia message is presented in user-paced segments rather than as a continuous unit. (p. 180)
Coherence principle	People learn more deeply from a multimedia message when extraneous material is excluded rather than included. (p. 198)
Redundancy principle	People learn more deeply from graphics and narration than from graphics, narration, and on-screen text. (p. 198)
Signaling principle	People learn more deeply from a multimedia message when cues are added that highlight the organization of the essential material. (p. 198)
Spatial contiguity principle	People learn more deeply from a multimedia message when corresponding words and pictures are presented near rather than far from each other on the page or screen. (p.198)
Temporal contiguity principle	People learn more deeply from a multimedia message when corresponding animation and narration are presented simultaneously rather than successively. (p. 198)

Motivation and Multimedia Learning Theory

Why does multimedia learning theory need to incorporate motivational theory? Astleitner and Wiesner (2004) outline three key reasons: (a) motivation influences learning, (b) motivational processes use mental resources which may influence cognitive load, and (c) cognitive and motivational variables are connected. Clark (1999) reiterates the need for motivation in multimedia learning theory by writing that appropriate levels of motivation are needed to acquire knowledge, while Deimann and Keller (2006) remark that although the cognitive processing aspects of multimedia learning are making strides, little is still known about motivation.

Currently, multimedia learning theory lacks a strong utilization of motivation in multimedia learning. While this does not mean that multimedia researchers have not considered motivation, the majority of the focus has been on the design side – creating prescriptive guides on how multimedia should be created to create or increase motivation. Few have attempted to fully integrate motivation and multimedia learning theory.

Brooks and Shell (2006) remark on the “silence” in the instructional design literature by citing the very limited number of references to motivation in instructional design books (e.g., Clark & Mayer, 2003; Dick, Carey, & Carey, 2001; Morrison, Ross, & Kemp, 2004). They note that in Dick, Carey, and Carey’s (2001) *The Systematic Design of Instruction* the references to motivation refer to Keller’s ARCS model, which components do not “point to learning systems intrinsic to the learner” (p. 17). On the other hand, the motivation literature does little to support studies of learning. As Brooks and Shell (2006) illustrate, one seminal book, *The Handbook of Competence and Motivation*, by Elliott and Dweck (2005), has over 5,000 citations but hardly cites any cognitive theorists (e.g., Baddeley, Schraw, Mayer, and Sweller). Thus, there is very little literature relating motivation to the concept of working memory.

Chan and Ahern (1999) note that the neglect of motivation in instructional design may be “due in part because of the complexity of human motivation, and also because motivation is traditionally viewed as a product of personality” (p. 159). In traditional instructional design, Chan and Ahern assert, motivation is viewed as a step that must occur before instruction and is not viewed as a part of the instruction itself. Instructional elements that influence motivation have not been thoroughly researched and the assumption that “good quality instruction is by itself motivating” (p. 152) permeates the field.

Additionally, Samaras et al. (2006) mention that little research in multimedia learning has looked at factors that separate individual learners. However, a new generation of multimedia research (what Samares et al. term a third generation) is rising and looking at the gaps of the first two generations' research. This new generation, Samaras et al. state, is including research on motivation in the multimedia learning setting as well as topics like prior knowledge, active processing, and learning styles. Thus, while little research exists on motivation in the realm of multimedia learning, the future looks promising.

Motivation and Cognition

Motivation in the multimedia learning environment, as with any learning environment, plays a key role (Astleitner & Wiesner, 2004). While numerous theories currently exist in the field of motivation (e.g., attribution theory, value theory, interest theory, self-determination theory), they all have a common theme: learners' motivation determines what, how well, and to what extent they learn information. However, a complete understanding of how motivation impacts cognition is missing.

It is known that a learner must utilize working memory resources in order to complete a learning task. Reeve (2005) defines motivation as "those processes that give behavior its energy and direction" (p. 39). In this definition, Reeve (2005) notes that the exact processes involved are debatable: motivation researchers cannot agree if the processes are driven by needs, cognitions, or emotions.

Most motivational theories claim that higher levels of motivation increase learning and performance. In particular, intrinsic motivation theory - and theories such as self-determination theory which include intrinsic motivation - suggests stronger learning outcomes as a result of increased intrinsic motivation. Gottfried (1985) defines intrinsic motivation as "the performance of activities for their own sake in which pleasure is inherent in the activity itself" (p. 631), while Fairchild, Horst, Finney, and Barron (2005) claim intrinsic motivation is illustrated by interest in the activity. Studies examining intrinsic motivation have reported the use of deeper-level processing strategies and higher academic performance by intrinsically motivated learners (Grolnick & Ryan, 1989; Miserandino, 1996; Ryan & Deci, 2000; Sheldon & Kasser, 1998).

Because motivation research is still developing, there is still an incomplete understanding of how motivation affects cognitive processes, in particular working memory. Brooks and Shell (2006) examine motivation in terms of working memory to explore how the two interact. While an authoritative definition of motivation is lacking, Brooks and Shell (2006) believe motivation is the "process by which we consciously or unconsciously allocate working memory to a learning task" (p. 18). Motivation, therefore, is how we choose which of our limited memory resources will be activated.

In Brooks and Shell's (2006) model, the cerebral cortex is responsible for storage and working memory accesses that storage information, known as prior learning. Prior learning, or knowledge, is important as it is the largest contributor to new learning. Working memory limits the information that can be taken from storage while working on a problem, Brooks and Shell argue, even though the storage capacity is quite large. Motivation, then, becomes a part of the system as it influences learners to continue to put forth mental effort. In addition to the information used in working memory to solve a problem, learners also use up working memory resources for motivation purposes. These "tools" aid learning and can lead to self-regulation. While expert learners may not need to utilize many of their working memory "slots" due to automated processes, novice learners often have little automation and may be doubtful of their skills while learning new material.

While Brooks and Shell (2006) focus on working memory and motivation, Clark (1999) makes suggestions for instructional designers based on what he calls a cognitive "Yin and Yang" process model. Clark (1999) writes, "Excellent design systems for complex learning are incomplete without key motivational components" (p. 28). He reiterates Pintrich and Schunk's (1996) suggestion to observe mental effort and persistence, two important indexes of motivation.

Pintrich and Schunk's (1996) first index of motivation, *mental effort*, is the "amount of energy invested in the conscious, deliberate and cognitive elaborative processing required to learn novel declarative knowledge" (Clark, 1999, p. 28). Clark believes there is a connection between students' expectations of cognitive load, their actual experience of it, and the mental effort they must put forth to learn. In other words, learners' perception of task difficulty manipulates their amount of mental effort. Instructional designers, Clark suggests, should include ways of measuring mental effort so that students are challenged enough by the material yet not overwhelmed. Furthermore, "it seems better to attempt to measure mental effort since each student's effort will be directly related to their individual perceptions of their own cognitive load" (p. 7).

Mental effort can also affect learners' task-specific self-efficacy (Bandura, 1997). According to Clark (1999), "The experience of mental effort influences our personal efficacy expectations about a learning task" (p. 7). Mental effort has an inverted U relationship with cognitive load and task-specific self-efficacy. In other words, self-efficacy decreases when task novelty increases, while task novelty decreases as self-efficacy increases. However, if self-efficacy is too high or too low, mental effort can come to a halt creating learning problems. Therefore, it is necessary to ensure that the appropriate amount of mental effort is being required by the task and the learning environment it is presented within to promote learning.

Persistence, the second important index of motivation, is the degree to which learners will continue with a task over time. Even if mental effort is sufficient, a lack of persistence in the face of obstacles can inhibit learning (Clark, 1999). The effects of persistence on learning are also highlighted in achievement goal theory (Anderman, Austin, & Johnson, 2002; Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Wolters, 2004). Achievement goal theory specifies two types of goals: mastery and performance. Learners with a mastery orientation persist at a task longer than performance oriented students in the face of difficulty, which leads to improved learning. Additionally, mastery goal oriented learners often employ deep cognitive strategies and connect new knowledge with prior knowledge leading to long-term learning (Anderman, Austin, & Johnson, 2002).

While little has been written on how motivation directly affects cognitive processes, new studies are emerging from the neurosciences that examine motivational and cognitive effects on the brain (e.g., Gray, Braver, & Raichle, 2002; Perlstein, Elbert, & Stenger, 2002; Taylor, Welsh, Wager, Phan, Fitzgerald, & Gehring, 2004). These researchers believe that the prefrontal regions of the brain may also influence motivational information in addition to executive functioning. Taylor et al. (2004) asked participants to complete a task in which a financial incentive was used as a motivational aspect. During this task, they found that "an interaction between working memory and motivation occurred in the dorsolateral [prefrontal cortex]" (p. 1051). Taylor et al. (2004) concluded that the same neural networks that process the task in working memory also interact with the motivational aspects of reward/punishment.

Although instructional design lacks a good framework for incorporating motivational elements (Chan & Ahern, 1999), designers still include certain features into multimedia design intended to bolster learners' motivation, specifically interest. Seductive details, information irrelevant to learning the material, are often added to gain learners' attention and keep them interested. Learner control, a feature which allows learners to make decisions during the instructional process, is believed to generate interest among learners. However, including these extra details and learner control may overload working memory resources (Brooks & Shell, 2006; Sweller, 2005), but both features may also trigger a deeper interest in the material that goes beyond the situational interest of the multimedia instruction.

Models of Multimedia Learning Incorporating Motivation

Because other models of multimedia learning theory exist besides Mayer's (2005c), there are a few that do incorporate some motivational theory. However, these theories lack a more comprehensive view of motivation in light of multimedia learning. Brief descriptions of these theories follow.

Malone and Lepper's theory. Malone and Lepper (1987) developed a theory based on four factors: challenge, curiosity, control, and fantasy. They believe that by creating multimedia learning environments that embrace these four components, instructional designers will motivate learners.

Challenge results when the activities are at a level of difficulty that is neither too easy (boring) nor too difficult (frustrating) (Malone & Lepper, 1987). By presenting information to make learners believe they have an incomplete knowledge base, multimedia presentations can generate curiosity. Additionally, by allowing learners some control and engaging them in fantasy contexts, the multimedia environment promotes intrinsic motivation.

While Malone and Lepper's (1987) theory incorporates an awareness of motivational issues in multimedia design, the theory is largely prescriptive for instructional designers (Astleitner & Wiesner, 2004). Astleitner and Wiesner (2004) criticize the theory for not representing how multimedia elements are related to motivational processes and how they affect learning. They also critique the theory for being too descriptive and not relating how motivational factors relate to multimedia learning based on psychological theory. What appears to be missing from Malone and Lepper's theory is a strong theoretical basis for how motivation affects learning in multimedia environments. Although prescriptive guidelines are useful in many ways, they must be supported with research that emphasizes why these guidelines work.

Combined model of motivation and ARCS. Astleitner and Wiesner (2004) note that the flaws of Malone and Lepper's (1987) theory can be decreased by combining Rheinberg, Vollmeyer, and Rollet's (2000) model of motivation in self-regulated learning and Keller's (1983, 1997, 1999) ARCS model. Keller's ARCS model is often cited by instructional designers as a way to influence learners' motivation. The ARCS model highlights four distinct areas: Attention, Relevance, Confidence, and Satisfaction. Keller essentially argues that these four steps will create an effective learning environment: (a) include material that gains learners' attention, (b) ensure that the material is perceived by learners as being relevant, (c) inspire confidence in the learners, and (d) satisfy learners' instructional desires and needs.

In the combined model of the two theories, the process is iterative (Astleitner & Wiesner, 2004). A self-regulated learner who is "attracted to different goals" (p. 5) compares different goals and selects one after receiving information from the multimedia learning environment. As the learner progresses through actions to accomplish goals, the iterative process of motivation continues until all goals have been accomplished or no new goals are set. Essentially learners work through a series of goal statuses - outcome expectancies and incentives - while controlling their attention, encoding, cognition, emotion, motivation, and environment. Various instructional strategies, such as those which influence attention, confidence, relevance, and satisfaction - influence the learner's actions.

As with Malone and Lepper's (1987) model, this combined model is not without its drawbacks. First, the two models are from different theoretical backgrounds, and, secondly, they lack an incorporation of multimedia elements (Astleitner & Wiesner, 2004). Rheinberg et al.'s (2000) model is based on a cognitive theory, while ARCS is more behaviorist. In combining the two theories, it is also difficult to show which cognitive processes are affected by which instructional strategies, which may be because the ARCS model is generalized. Additionally, the absence of multimedia elements is problematic as elements such as audio-visuals can influence learning. Finally, the problem of combining two theories is that the combined theory is only as strong as its components. In this case, the ARCS model presents several problems which need to be considered when working with a multimedia learning theory that incorporates motivational aspects.

From a design perspective, Keller (1999) makes strong points. It is important to have material that captures attention in order for any learning to occur the learners must be paying attention. Secondly, only relevant material should be covered in instruction; otherwise it's a waste of instructional time. Finally, the learners should feel confident that they can perform the tasks or know the material and leave feeling satisfied. If the learners do not feel confident or satisfied with the instruction, then most likely learning has suffered.

What is missing from Keller's ARCS model, however, is an intrinsic motivational focus (Brooks & Shell, 2006). The ARCS model is highly extrinsic with the focus being on the instruction's ability to inspire these things versus the learner being able to generate them. As Brooks and Shell comment, the first step is to gain the learner's attention; after that, the other steps "are involved in both the first capture of attention as well as sustaining that attention" (p. 11). As a result, the ARCS model does not suffice motivational theorists who are more concerned about what is occurring with the learner versus how the material is designed.

Hede's integrated model. A third model that attempts to incorporate both multimedia learning and motivation is Hede's (2002) integrated model. Hede groups the elements of his theory into four elements: multimedia input, cognitive processing, learner dynamics, and knowledge and learning. Each of these elements has its own features which work into the theory (see Figure 1).

The first element is multimedia input and focuses on the two primary input modalities: vision and hearing. Visual inputs could include text, diagrams, pictures, and video, while auditory inputs may include narration, music, and cues. This theoretical aspect reiterates Mayer's (2005b) multimedia learning theory which suggests learners have two modes in which they work: visual and verbal. However, a unique aspect of Hede's (2002) theory is the inclusion of learner control over the inputs. Aspects of learner control in Hede's theory include time on task, interactivity, and navigation. Hede does point out that learner control is not always positive in regards to learning and needs to be viable with the learner's capacities (Stemler, 1997).

After the multimedia input factors, cognitive processing factors must be considered. In Hede's (2002) model, attention and working memory are the main cognitive factors that shape learning. Attention focuses the learner's concentration, while working memory handles the main processing. Hede relies on Baddeley's (1992) model of working memory in espousing his theory. The factors which affect working memory, Hede notes, include modality effects, dual-coding, cognitive overload, interference, retention, and cognitive linking. Again, this aspect of Hede's theory aligns with Mayer's (2005c) theory in regards to multiple modalities, dual-coding, and cognitive load, yet goes beyond Mayer's theory to include interference during processing, rehearsal and retention, and referential associations that learners make.

Learner dynamics, the third element of Hede's (2002) theory, focuses on motivation, learner style, and cognitive engagement. Motivation in this theory includes both extrinsic and intrinsic forms. Extrinsic motivational factors generate interest for learners to use the multimedia and include the multimedia’s design features. However, without intrinsic motivation inspired by “interesting and challenging content” the learners will not persist with the multimedia instruction. The motivational factors influence learner control as they affect how much time and effort learners spend with multimedia. Intrinsic motivation also leads to cognitive engagement, “which is the process whereby learners become motivated to take full control of their own learning” (Hede, 2002, p. 183).

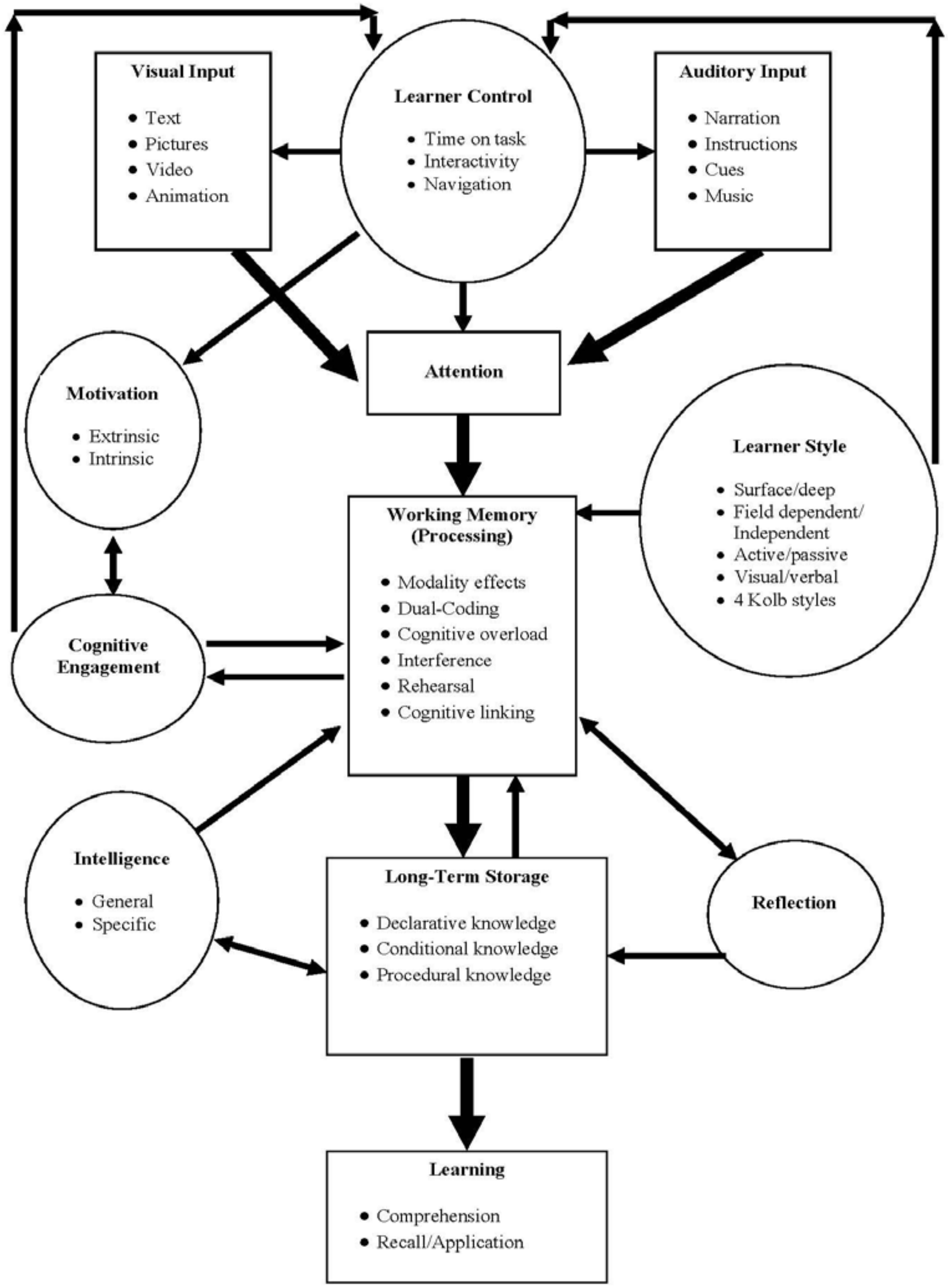
Learner style, while it can refer to numerous characteristics of learners, in Hede’s theory refers to these specific types: field dependence/independence, surface/deep processing, active/passive learning, visual/verbal processing, and the four Kolb Learning Style Inventory types (divergers, assimilators, convergers, and accommodators). Hede notes, “These different approaches to learning style need to be accommodated by an integrated model” (p. 184).

Finally, knowledge and learning supplement Hede’s (2002) integrated theory. Under this category, four elements are vital: intelligence, reflection, long-term storage, and learning. Intelligence refers to both general and specific intelligence. Hede incorporates Fetherston’s (1998) argument concerning a multi-faceted view of intelligence that includes seven different kinds. Reflection, in this theory, refers to self-directed learning and metacognition. Next, long-term storage factors in by holding declarative, procedural, and conditional knowledge and allowing working memory to access this storage to create new cognitive links. Lastly, learning completes the model and “comprises the immediate level of comprehension of material accessed through multimedia plus the ability to recall and apply one’s acquired knowledge” (Hede, 2002, p. 184).

Hede (2002) admits that his integrated model is “more classificatory and descriptive than explanatory and predictive” (p. 185). Hede also comments that he designed the theory to “accommodate a wide range of contradictory research results.” The inclusion of such a wide range makes the theory eclectic and ornate (Astleitner & Wiesner, 2004). The incorporation of a variety of theoretical backgrounds and a lack of explanation regarding how they specifically relate to multimedia research makes Hede’s (2002) theory incomplete.

Figure 1

Hede's Integrated Model of Multimedia Learning



Note. Adapted from Hede, A. (2002). An integrated model of multimedia effects on learning. *Journal of Educational Multimedia and Hypermedia, 11*(2), 177-191.

Astleitner and Wiesner's expanded model. Astleitner and Wiesner (2004) expand Mayer's (2005c) multimedia learning theory to develop a model where cost and benefit analysis, action control, and noncognitive elements are part of working memory's processing. In the development of their model, Astleitner and Wiesner (2004) also borrowed elements from other researchers, specifically Brunken, Plass, and Leutner (2002), Keller (1983, 1997), Hoogeveen (1997), and Hede (2002). Figure 2 illustrates the resulting model of multimedia, learning, and motivation.

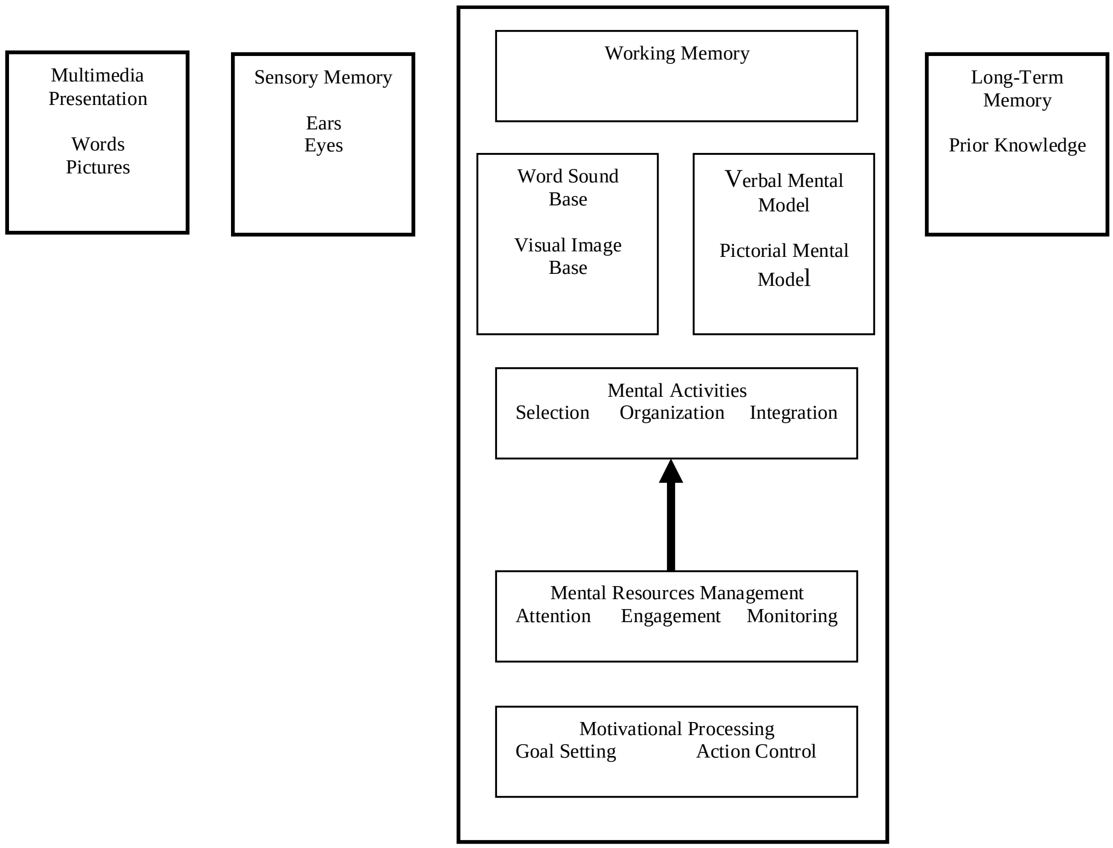
In this model, mental resources management and motivational processing affect the mental activities and the mental models involved in multimedia learning. Astleitner and Wiesner (2004) consider goal setting and action control under the motivational processing component. Goal setting involves the "expectancies and values related to a certain task and selecting that task as intention for carrying out" (p.14). Action control refers to Kuhl's (1985) model which illustrates a view of working memory that includes volitional aspects in addition to cognitive aspects. Volition helps goal acquisition by preventing competing goals from interfering. Six components compose the volitional processes: (a) active attentional selectivity, (b) encoding control, (c) emotion control, (d) motivation control, (e) environmental control, and (f) parsimony of information-processing (as cited in Astleitner & Wiesner, 2004).

Together, mental activities, mental resources management, and motivational processing affect the availability of working memory capacity, the number of activities that can occur, and the quality of those activities. Attention, engagement, and monitoring all influence if a mental activity will be completed and if it will be completed well. Goal setting and action control work to make sure the task responds to the goal and the mental resources needed to complete the task are active.

Astleitner and Wiesner (2004) provide recommendations for future research based on the model, including more research on the motivational quality of multimedia elements. They also note that, in relation to seductive details, more clarification on what motivational strategies are seductive is needed along with how these strategies can be implemented without overloading the learner.

Figure 2

Astleitner and Wiesner's Expanded Model



Note. Adapted from Astleitner, H., & Wiesner, C. (2004). An integrated model of multimedia learning and motivation. *Journal of Educational Multimedia and Hypermedia, 13*(1), 3-21.

While Astleitner and Wiesner's (2004) model is probably the best out of the four theories, it is not without its drawbacks. Perhaps the most prevalent flaw is the assumption that motivational processes include only goal setting and action control as the authors rely only on two theories. However, there are numerous motivational theories that explain how certain elements of motivation influence learning. In particular, interest and self-efficacy are two "mini" motivational theories that are important in the multimedia learning environment. Learning factors resulting from learners' interest and self-efficacy are not readily apparent in this model. Admittedly, it would be difficult to develop a multimedia learning model that includes all motivational theory as such a model would be very broad and may not integrate all theoretical aspects effectively. Perhaps new theories of multimedia learning need to be developed which assimilate motivational theories (e.g., an integrated model of multimedia learning and interest, an integrated model of multimedia learning and self-efficacy, and an integrated model of multimedia learning and attribution theory). However, more research is needed before these theories can be developed. The following looks at interest theory specifically and what studies have been conducted on multimedia elements which may manipulate learners' interest.

Multimedia Learning and Interest Theory

Hidi and Renninger (2006) describe interest as "a motivational variable [that] refers to the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time" (p. 112). Research on interest has found an influence of interest on attention, goals, and levels of learning (see Hidi & Renninger, 2006). Hidi and Renninger differentiate interest from other motivational variables in three ways. The first difference is that interest includes separate affective and cognitive components. Affective components describe the positive emotions which come with interest, while cognitive components describe perceptual and representational activities associated with interest.

The second manner in which interest differs from other motivational variables is in the way that both the affective and cognitive components of interest have biological roots (Hidi & Renninger, 2006). Neuroscientific research on approach circuits in the brain has suggested that interested activity has a biological basis for all mammals. When a person is interested with an object, he/she is engaged physically, cognitively, or symbolically.

The third way in which interest is unique is that it is the result of an interaction between a learner and particular content (Hidi & Renninger, 2006). Although the potential for interest resides within the learner, the content of the material and the environment can affect the development of interest. In this regard, other individuals, the environments' organization, and the learner's efforts all factor into the development of interest. Because of this, interest does not apply across all content and activities, but rather it is always content specific.

Hidi and Renninger (2006) and Renninger and Hidi (2002) focus on two types of interest: situational and individual. *Situational interest* is a result of environmental stimuli and may not last, while *individual interest* "refers to a person's relatively enduring predisposition to reengage particular content over time as well as to the immediate psychological state when this predisposition has been activated" (Hidi & Renninger, 2006, p. 113). Both types of interest are always motivating, but individual interest focuses more on a person's perceptions and cognitive representations which makes it more intrinsically driven than situational interest which is encouraged by extrinsic situations.

Both types of interest have been shown to have positive effects. Studies examining situational interest and cognitive performance have shown increased reading comprehension (Hidi, 1990; Hidi & Baird, 1988) and work with computers (Azevedo, 2004; Cordova & Lepper, 1996). Hidi and Renninger (2006) also mention research on situational interest's influence on narrowing inferencing (McDaniel, Waddill, Finstand, & Bourg, 2000), enabling the intergration of new information with prior knowledge (Kintsch, 1980), and enhancing levels of learning (Mitchell, 1993; Schraw, Bruning, & Svoboda, 1995). Studies focusing on individual interest have revealed positive effects on attention, recognition, and recall (Renninger & Wozniak, 1985); persistence and effort (Krapp & Lewalter, 2001; Renninger & Hidi, 2002); academic motivation (Ainley, 1998); and levels of learning (Renninger & Hidi, 2002).

Hidi and Renninger (2006) note that both situational interest and individual interest consist of two phases. Situational interest is subdivided into triggered and maintained phases, while individual interest has emerging and well-developed phases.

The first phase of situational interest is triggered situational interest. *Triggered situational interest* is a state of interest resulting from temporary changes in affective and cognitive processing (Hidi & Renninger, 2006; Hidi & Baird, 1986). Triggered situational interest can be initiated by the environment or certain textual features, including inconsistent or surprising information, intensity, or personal relevance. It is typically externally supported, and may be an antecedent to developing a predisposition to reengage with content (Renninger & Hidi, 2002; Renninger et al., 2004).

The second phase of situational interest is maintained situational interest. *Maintained situational interest* is a state of interest following a triggered state and includes focused attention and persistence over an extended period of time (Hidi & Renninger, 2006). This type of situational interest can be preserved through meaningfulness or personal involvement (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000). Like triggered situational interest, maintained situational interest is typically externally supported (Renninger & Hidi, 2002) and may also be an antecedent to developing a stronger predisposition to reengage with content in more developed forms of interest (Harackiewicz et al., 2000).

The first phase of individual interest is the emerging individual interest phase. *Emerging individual interest* is a state of interest which highlights an “enduring predisposition to seek repeated reengagement with particular classes of content over time” (Hidi & Renninger, 2006, p. 114). This phase is characterized by positive feelings as well as stored knowledge and value (Renninger, 2000). An emerging individual interest requires some external support, but it is usually self-generated (Renninger & Shumar, 2004). Learning environments can affect the development of an emerging individual interest as can instruction (Renninger & Shumar, 2002, 2004). Reaching this phase of interest development does not, however, guarantee that an individual will cultivate a well-developed individual interest (Lipstein & Renninger, 2006).

The second phase of individual interest is the well-developed individual interest phase. A *well-developed individual interest* is a state of interest which refers to a continuing predisposition to reengage with particular content over extended periods of time (Hidi & Renninger, 2006). Like the emerging individual interest phase, this phase is characterized by positive feelings, stored knowledge, and stored value. However, in well-developed individual interest these concepts surpass the levels maintained at an emerging individual interest phase (Renninger, 2000). Additionally, well-developed interest is mostly self-generated, but external support can help foster the interest (Renninger, 2000). Finally, well-developed interest can be facilitated by instruction and learning environments which challenge the learner and provide more opportunities to interact with the content (Renninger & Hidi, 2002).

Interest is influential in the learning process as people gravitate towards activities that interest them (Lawless, Brown, Mills, & Mayall, 2003). For those focusing on improving educational practice, interest is an important consideration. Because interest influences attention, goal setting, and learning strategies (Hidi & Renninger, 2006), instructional designers need to consider instructional features which can generate and maintain interest in the content.

Multimedia Attributes That Influence Interest

Scholars of both cognition and motivation have pointed out the importance of attention in learning. Of course, gaining learners’ attention is largely based on gaining and sustaining learners’ interest in the material (Hidi & Renninger, 2006; Lawless et al., 2003); however, as Silvia (2006) warns, interest goes beyond attention. Manipulating interest does not guarantee more attention. In fact, some studies have shown learners pay less attention to interesting texts versus uninteresting texts (McDaniel et al., 2000), perhaps due to the increased amount of attention learners feel they have to pay in order to understand the material or stay on track.

In the realm of multimedia instruction, designers have followed prescriptive guidelines for designing features that gain user's attention and hopefully keep their interest. Keller's (1983, 1997, 1999) ARCS model is often cited by instructional designers as a framework. However, few studies have explicitly examined specific features of multimedia in terms of learners' interest and their effects on learning. Studies that have looked at interest in a multimedia learning environment have mainly focused on two features: seductive details and learner control.

Seductive details. The term *seductive details* refers to intriguing information added to make instructional content more interesting to the learner but is unnecessary for learning to occur (Harp & Mayer, 1997). Seductive details serve as "interest-getters" and can "undermine effective learning if they interfere with the coherence of a text" (Pugh & Bergin, 2006, p. 152). Harp and Mayer (1997) examined seductive details with scientific texts and illustrations based on Kintsch's (1980) distinction between emotional interest and cognitive interest. Emotional interest theory supports the use of seductive details to increase enjoyment, which subsequently helps the learner to pay more attention and encode the material. Therefore, the learner will retain and transfer more information.

Cognitive interest theory, on the other hand, is based on the idea that when a learner structurally understands the material he/she will pay more attention and enjoy it more. The learner essentially develops a causal chain when presented with explanative summaries. However, if seductive details are included in an explanative summary, learning will be decreased because the seductive details will distract the learner from key information to form the causal chain necessary for understanding (Harp & Mayer, 1997).

In order to test this hypothesis, Harp and Mayer (1997) conducted two experiments. The first experiment examined the cognitive effects of adding seductive details to a scientific passage about lightning. (The passages for this study were printed handbooks and not computer based tutorials. However, this meets Mayer's guidelines for multimedia – words and pictures.) Four treatment groups consisting of a base text (control group), base text plus seductive text, base text plus seductive illustrations, and base text plus seductive text and illustrations were used. The control group outperformed all other groups on tests of retention and transfer. Interest was measured with a four question inventory: (a) While reading the passage I felt interested, (b)

While reading the passage I felt bored, (c) I found the information in the passage to be useful, (d) I found the information in the passage to be worthless. Participants answered these questions on a scale of 0 to 3 with 0 being the least interested and 3 being most interested. However, the interest ratings did not show statistically significant differences between the groups; the researchers believed this lack of difference was due to the instrumentation used to measure interest and its failure to distinguish between cognitive and emotional interest. Thus, a second experiment was conducted to differentiate issues surrounding emotional and cognitive interest that may have confounded the results in experiment 1.

Experiment 2 utilized a new interest survey which rated emotional and cognitive interest instead of general interest. The new scale contained six questions followed by a 10-point scale (Harp & Mayer, 1997). Four portions of text – a base text, base text with explanative illustrations, base text with seductive text, and base test with seductive illustrations – were used. All students read each portion, in various orders, and rated those portions based on their interestingness using the new questionnaire (see Table 2). As predicted, the seductive text and seductive illustrations portions had much higher levels of emotional interest, while the base text and explanative illustrations portions had much higher levels of cognitive interest. Recall and transfer were not measured in this study. Harp and Mayer (1997) concluded that seductive details geared towards increasing emotional interest hinder learners' comprehension of scientific explanations, but skilled readers possess the metacognitive skills necessary to "weed out" unnecessary details.

Table 2

Interest Survey Questions from Harp and Mayer (1997) Study

Emotional Interest Questions	1. How interesting is this material? 2. How entertaining is this material?
Cognitive Interest Questions	3. How much does this material help you to understand the process of lightning? 4. How helpful is this material for organizing the steps involved in the process of lightning?
Questions Regarding the Importance of the Information	5. How important is this material for explaining how lighting works? 6. How necessary is this material for explaining the process of lightning?

There are a few limitations to this study. First, in context of multimedia learning, the printed workbooks, while technically multimedia with words and pictures, are not quite the same as computer aided multimedia learning. Second, even with correcting interest confounds from the first study, the second study is problematic. All participants read all portions of the text and rated them based on interest. At some point, participant fatigue begins to set in. A stronger study would have separated the participants into portion groups to rate interest and measured recall and transfer ability. Furthermore, both interest inventories used in the studies do not adequately measure interest. In addition to interest, Harp and Mayer (1997) ask about the importance and usefulness of the information presented. While one's interest could possibly affect his/her response to these questions, usefulness and importance are *not* the same as interest. For instance, one could be uninterested in the subject material, yet still find the material useful.

In another study, Moreno and Mayer (2000) looked at seductive details, specifically auditory adjuncts, in multimedia instruction. Part of the experiment focused on testing the coherence principle of multimedia learning theory: "people learn more deeply from a multimedia message when extraneous material is excluded rather than included" (Mayer, 2005d, p. 184). Two experiments were conducted with multimedia tutorials explaining the formation of lightning and how car brakes work. Four groups – a control group, a group with additional background music, a group with additional sounds, and a group with both music and sounds – were used. Framing the study in the context of the coherence principle and arousal theory, Moreno and Mayer found that learners in groups with the seductive details performed worse on tests of retention and transfer than the control group. The auditory adjuncts, Moreno and Mayer (2000) believed, overloaded the users' working memory. Interest, however, as implicitly referenced by arousal theory was not measured in this study. Moreno and Mayer made a large assumption that the auditory adjuncts increased interest in the multimedia tutorials, while in fact they may not have.

A similar study that builds upon Moreno and Mayer's (2000) findings was conducted by Mayer, Heiser, and Lonn (2001). The trio carried out four experiments to determine if presenting more information in a multimedia instructional message resulted in less understanding of the formation of lightning. These experiments included the addition of textual seductive details (Experiment 1), irrelevant video clips interspersed throughout the tutorial (Experiment 3), and irrelevant video clips presented before or after the multimedia instruction (Experiment 4). In all instances, the seductive details hurt students' recall and transfer scores, implying that, while possibly interesting, it does not help learning. As with Moreno and Mayer's (2000) study, the researchers did not measure interest before or after the tutorials.

While Mayer and his fellow researchers have examined auditory adjuncts (Moreno & Mayer, 2000), text and illustration (Harp & Mayer, 1997), and additional narration and video clips (Mayer, Heiser, & Lonn, 2001), some researchers have chosen to focus on only illustrative adjuncts and their influence on interest. The use of illustration in instructional materials is not a new concept. Illustrations are believed to help learners interpret and remember material while providing support for interest (Park & Lim, 2007). Anglin, Towers, and Levis (1996) reviewed studies involving illustrations and concluded that simultaneous use of illustrations with text aids learning.

Park and Lim (2007) have examined interest in multimedia settings in relation to graphical representations (or visual illustrations). Park and Lim (2007) looked at illustrations aimed at cognitive interest and emotional interest in the context of a multimedia tutorial on hurricanes. Three groups – cognitive interest illustration, emotional interest illustration, and text-only no illustration – were utilized as the researchers measured post-interest, achievement, and motivation. Interest was measured by a one question item regarding learners' level of interest toward the instructional material, while motivation as a whole construct was measured by Keller's Instructional Material Motivation Survey (IMMS). Achievement was measured by a recall and comprehension test.

Results indicated that learners who had illustrations were more interested than learners with no illustrations. No significant difference was found between the cognitive and emotional illustration groups however. The text-only group had a mean interest of 3.05, while the cognitive interest and emotional interest illustration groups both had means of 3.87. Park and Lim (2007) conclude that the illustrations did increase interest in the multimedia instructional message, regardless of whether of not the illustrations were intended for cognitive or emotional interest.

On the IMMS scale, the emotional illustration group had the highest score followed by the cognitive illustration group indicating that the inclusion of illustrations boosts learners' motivation while participating in a multimedia instructional tutorial. However, learners' motivation and interest prior to multimedia instruction were not measured and the possibility remains that learners were highly interested in the content before engaging with it.

In regards to achievement and recall, the effects were limited. The text-only group actually outperformed the two illustration groups. However, the recall test scores overall were low – with the cognitive interest illustration group scoring the highest mean with 5.64 out of a maximum of 11 - a fact Park and Lim (2007) neglect to mention. Overall achievement scores were 12.88 for the test-only group and 12.78 and 12.00 for the cognitive interest and emotional interest illustration groups respectively. The maximum score for the achievement test was 19.

Learner control. Learner control, sometimes called interactivity, is a term used to describe a feature in which learners make decisions about the instructional process (Kettanurak, Ramamurthy, & Haseman, 2001). However, learner control, while in the same realm as interactivity, is more focused than a truly interactive environment (Betrancourt, 2005). Betrancourt defines it as “the capacity of the learner to act upon the pace and direction of the succession of frames” (p. 288). The most common features include control over pace, sequence, and branching (Kettanurak, Ramamurthy, & Haseman, 2001), while levels of learner control include browsing, searching, connecting, collecting, and generating (Lawless & Brown, 1997).

Researchers who have studied learner control note that this attribute allows the instruction to accommodate the learner instead of the learner accommodating to the instruction (Friend & Cole, 1990). From a motivational standpoint, the benefits of incorporating user control include allowing a learner to match instruction to his/her needs or interests (Lawless & Brown, 1997) and increase intrinsic motivation (Kennedy, 2004). The risks, however, are that many learners lack an understanding of how they learn best (see Lawless & Brown, 1997, and Kennedy, 2004, for a review).

Studies that have examined the effects of learner control in regards to its influence on learning have found mixed results. In a study examining sequence control, Gray (1987) found that students who were in the learner control group performed better than the control group (computer controlled presentation) on an immediate test of recall. However, they performed worse on a recall test given a week later and also perceived the instruction more negatively than the control group.

Milheim (1990) used an interactive video program to study sequencing and pacing control on participants’ learning. Pacing control allowed participants to determine the length of time they spent on each screen, while the sequencing control allowed the participants to determine the lesson order. The pacing control group performed better on both posttests: one immediately following the video and one given a week later. The sequencing control group did not present any significant differences on the tests of recall. It is possible that the pacing control in this study made the participants feel more in control of their learning, while the sequencing control was perhaps too much for learners to accommodate in addition to retaining the information.

In two other studies, learner control was shown to have negative effects. Coldevin, Tover, and Brauer (1993) studied the effects of three levels of control: linear (least control), designer (moderate control), and learner (most control). The linear control group was given control over pacing only; the designer control group was given control over pacing and some instruction; the learner control group had a full range of pacing and sequencing options. They found that the students with the least amount of control, the linear control group, performed better than those given more control. Coldevin et al. (1993) suggested that a lack of prior knowledge about the topic could have contributed to participants making poorer choices and thus reducing their chances to learn more. Gay's (1986) results support Coldevin et al.'s conclusions. Gay examined how prior knowledge affected learning in addition to learner control Two groups were used: a program group which only had control over pacing and a learner control group which could control pacing, sequencing, presentation mode, and the amount of practice. Those students with high amounts of prior knowledge performed equally under both the learner and program control conditions. However, the participants in the learner control group who had low levels of prior knowledge performed the worst on the posttest. The results support the view that learners need some prior knowledge to effectively make choices regarding their own instruction. However, prior knowledge may not be all that is necessary in order to perform well with learner control; other studies have examined such factors as learner characteristics (e.g., Carrier & Williams, 1988), time on task (e.g., Kulik & Kulik, 1991), and learning strategies (e.g., Relan, 1995). In regards to learner control and motivation in multimedia environments, a few studies have been conducted, yet much improvement remains in understanding how learner control as a multimedia attribute can influence interest.

Lawless, Brown, Mills, and Mayall (2003) studied interest in the realm of hypermedia. The hypermedia environment lends itself to a higher level of learner control. Participants in this study were allowed to read a hypertext in any order they chose. The researchers looked at the participants' levels of interest and knowledge about Lyme Disease before engaging with the hypertext. Afterwards, unstructured and structured recall tests were given. Individual interest related to Lyme Disease was measured by a questionnaire as was situational interest in the learning environment (computer graphics). Lawless et al. (2003) found that neither individual nor situational interest had an effect on recall. However, it should be noted that the participants were instructed to read the material carefully because they would be asked questions about it afterwards. This likely primed even uninterested students to pay more attention and remember key details. Furthermore, this study does little to show if certain features of the learning environment influenced interest. Interest was not measured after the hypertext reading so comparisons even among how navigational patterns affected interest could not be obtained.

Another study by Kettanurak, Ramamurthy, and Haseman (2001) examined motivation and learning in relation to degrees of interactivity. In a quasi-experimental study, participants were divided into no, low, and high interactivity groups. The groups were exposed to different levels of interactive features with the system they used; afterwards, their posttest attitudes were measured. Participants in the high interactivity group reported having the highest motivation. It is unclear, however, how exactly motivation was measured and if the researchers were looking at any specific motivational theory.

Segmentation. Segmentation refers to a specific type of learner control in which the learner has control over the pacing of a multimedia tutorial through the use of a Start/Stop button or a Continue button (Mayer, 2005). The instruction is divided into meaningful segments by the designer (Hasler, Kersten, & Sweller, 2007). According to the segmentation effect of multimedia learning, a tutorial with this type of pacing control will generate more learning than a tutorial which plays from beginning to end with no control over the pace (Mayer & Chandler, 2001). The cognitive theory of multimedia learning (Mayer, 2005) includes the segmentation effect, which is believed to improve learning because it allows the learner the opportunity to stop the flow of information when necessary. Thus, the learner should be less likely to experience cognitive load and process the information more deeply.

Mayer and Chandler (2001) examined the segmentation effect by using a segmented (S) and non-segmented (NS) version of a 140 second tutorial about the formation of lightning. In the first experiment, participants viewed both versions successively, either S-NS or NS-S. Mayer and Chandler found that the S-NS group performed better on a transfer task; however, they performed poorer on the recall task than the NS-S group. Mayer and Chandler determined that the S-NS group's stronger transfer performance was due to the avoidance of cognitive overload. Also, the S-NS group was likely able to build stronger mental models of the lightning cause-and-effect relationship during the first engagement with the segmented version of the tutorial. The second engagement with the NS version allowed participants to connect the component parts of the lightning process.

Mayer, Dow, and Mayer (2003) found similar results using a tutorial on electric motor with segmented and non-segmented instructional groups. Participants engaged in a 20-minute tutorial on how an electric motor works. Participants in the segmented group outperformed those in the non-segmented group on tests of transfer; recall was not measured in this study.

As a form of learner control, segmentation may influence participants' interest in multimedia tutorials. Since segmentation allows the learner the opportunity to process the information more deeply, it is possible that it may also influence interest in a positive manner. However, interest was not measured as a variable in Mayer and Chandler's (2001) or Mayer, Dow, and Mayer's (2003) segmentation studies.

Reflections on Existing Studies

Although the literature on interest in multimedia learning generally supports the position that seductive details negatively affect learners, still more research is needed to examine (a) if seductive details generate interest, and (b) the extent to which seductive details can be used.

On the other hand, the learner control literature is not conclusive about the effects of learner control on interest or on learning. Future research needs to clarify these issues, specifically (a) what effect does adding learner control to multimedia have on interest and learning, and (b) to what extent can learners effectively handle control over multimedia instructional messages?

While these questions will not be answered in a singular study, it is important to begin exploring these issues now. As research on individual differences in multimedia learning increases, the inclusion of motivation as one of these differences needs to be a focus.

Research Questions

While multimedia learning theory is moving into a new "generation" of research (Samaras et al., 2006), more research on individual differences, specifically in the realm of motivation, is needed. As most of the existing literature in multimedia learning focuses on cognitive information processing, the effects of motivation on learning in multimedia environments is needed to promote a deeper understanding of how learning occurs.

Although a few integrated models of multimedia learning and motivation exist, these models do not specifically take into account users' interest and how it may influence learning. Additionally, research on how particular multimedia design attributes affect users' interest is minimal. Therefore, this study will investigate the following research questions:

(a) Does the inclusion of seductive details affect recall and transfer?
(b) Does the inclusion of segmentation affect recall and transfer?
(c) Does the inclusion of seductive details affect student interest?
(d) Does the inclusion of segmentation affect student interest?
(e) What is the relationship between interest and recall?
(f) What is the relationship between interest and transfer?

CHAPTER THREE

METHOD

The purpose of this study was to examine the influence of seductive details and segmentation on learners' interest, recall, and transfer. The study extended the work of Moreno and Mayer (2000) and Mayer and Chandler (2001) by measuring interest as a variable in the multimedia learning process. Moreno and Mayer (2000) postulated that seductive details may affect interest; however, interest was not measured as a variable in either of their studies. Mayer and Chandler (2001) proposed that segmentation would improve participants' recall and transfer, but they did not measure if segmentation – which is a form of user control – influenced interest.

Participants and Design

The participants in this study were 167 undergraduate students enrolled in a non-majors' health education course at a large research university in the Mid-Atlantic region. Participants received course credit for participating in the research study. The experimental design was a 2 X 2 factorial design with seductive details (yes, no) and segmentation (yes, no) as between-subject variables. Participants were randomly assigned to one of the following groups: no seductive details + no segmentation (NSD+NS), seductive details + no segmentation (SD+NS), no seductive details + segmentation (NSD+S), or seductive details + segmentation (SD+S).

Materials and Apparatus

The materials used in this study included a demographics questionnaire, situational interest inventory, multimedia tutorial describing the formation of lightning, recall test, and a transfer test.

Situational interest inventory. A situational interest inventory was used to measure participants' interest regarding how lightning forms, the subject of the multimedia tutorial, prior to and immediately following their engagement with the tutorial. Schraw's (1995, 1997; see also Flowerday, Schraw, & Stevens, 2004) Perceived Interest Questionnaire (PIQ) was adapted semantically to measure situational interest in the lightning formation multimedia tutorial. Semantic changes included substituting the words *story* and *read* for *multimedia tutorial* and *watch*. For example, the original PIQ read, "I thought the story was very interesting." The adapted PIQ for this study read, “I thought the multimedia tutorial on the formation on lightning was very interesting.”

The PIQ was determined to have a coefficient alpha of .83 (Schraw, Bruning, & Svoboda, 1995) and, in another study, reached a .92 Cronbach’s alpha (Schraw, 1997). In order to assess participants’ situational interest before engaging with the tutorial, participants were asked to respond to 10 statements on a scale of 1 (strongly disagree) to 5 (strongly agree) (see Appendix A). Participants’ self-reports were summed to determine their level of situational interest concerning lightning formation with scores on the PIQ ranging from 10 to 50.

After completing the tutorial, participants took a post-tutorial version of the PIQ. This version was the same as the previous version with changed verb tenses (present tense to past tense) to reflect the participants’ current situation of having just watched the tutorial (see Appendix B). For example, the pre-tutorial version read, “I think a multimedia tutorial on the formation of lightning would be very interesting,” while the post-tutorial version read, “I thought the multimedia tutorial on the formation of lightning was very interesting.”

Multimedia tutorial. The lightning formation multimedia tutorial was an Adobe Flash™ file based on Mayer and Chandler’s (2001) description of their animation depicting how lightning forms. The tutorial described the formation of lightning via the following process. First, drawings are shown of cool air moving from the ocean to land. The air then becomes heated, rises, and forms a cloud. This cloud rises above the freezing level and to form ice crystals, which then rise and fall inside the cloud to generate electrical charges. The negatively charged particles drop to the bottom of the cloud and then towards land, while positively charged particles rise up from land to meet the descending negative charge. Finally, positive charges move up the new charged pathway to form lighting (see Appendix C).

Four different versions of the tutorial were created to accommodate the four different treatment groups. All tutorial versions contained auditory narration and animation. The seductive detail versions (SD+NS, SD+S) contained the same lightning animation and auditory narration; however, additional sounds (i.e., electrical charges, rain, thunder, wind) and images (i.e., darkening skies, excessive clouds, flashes of lightning) were added as seductive details. These details were unnecessary for comprehension of the material and were, instead, intended to create interest. The non-seductive details versions (NSD+NS, NSD+S) did not contain these additional sounds or images.

The segmentation (NSD+S, SD+S) versions both contained an additional attribute which allows for learners to control the pace of the tutorial through use of a continue button at the end of each segment of the tutorial. Participants pressed the continue button when they were ready to move to the next section of the tutorial. There were 16 segments, as established by Mayer and Chandler (2001), each about 10 seconds in length. The non-segmented versions (NSD+NS, SD+NS) did not contain this continue button and ran continuously through the tutorial without stopping. Each version of the tutorial lasted 140 seconds with the exception of those including segmentation which may affect the length of the tutorial.

Recall test. After the tutorial, participants were given a recall test of how lightning forms. The recall test contained one open-ended question: "Please provide an explanation of what causes lightning." The question was provided on its own screen with a response box below for participants to answer. Two trained raters evaluated each participant's recall response (inter-rater reliability, r = .95) and calculated a recall score by counting the presence of 8 idea units. Disagreements in scoring were settled by negotiation. One point was given to participants for including each of the following idea units: "(a) air rises, (b) water condenses, (c) water and crystals fall, (d) wind is dragged downward, (e) negative charges fall to the bottom of the cloud, (f) the leaders meet, (g) negative charges rush down, and (h) positive charges rush up" (Mayer et al., 2001, p. 191).

Transfer test. In addition to the recall test, participants were given a test to measure transfer. The transfer test included the four questions used by Moreno and Mayer (2000, p. 119): (a) "What could you do to decrease the intensity of lightning?"; (b) "Suppose you see clouds in the sky, but no lightning. Why might this happen?; (c) "What does air temperature have to do with lightning?"; and (d) "What do electrical charges have to do with lightning?" The four transfer questions were provided on the same computer screen with each question followed by its own response box.

Two trained raters evaluated each participant's transfer response (inter-rater reliability, r = .94) and calculated a transfer score by adding the number of valid responses to the four transfer questions. Acceptable answers for the transfer questions were those established by Moreno and Mayer (2000) and Mayer et al. (2001). For the first transfer question, "What could you do to decrease the intensity of lightning?," acceptable answers included decreasing the quantity of positively charged particles on land and increasing the quantity of positively charged particles next to the cloud. For the next question, “Suppose you see clouds in the sky but no lightning, why not?,” acceptable answers included the cloud not rising above the freezing level and ice crystals not forming. Acceptable answers to the third transfer question, “What does air temperature have to do with lightning?,” included needing both warm land and cool air and the cloud’s position (bottom part below the freezing level and the top part above the freezing level). For the final question, “What causes lightning?,” answers included the differences in electrical charges present within the cloud itself and the temperature differences within the cloud.

Procedure

Before participating in the experiment, participants registered for the study via the Internet. During registration, participants completed a demographics questionnaire. On the day of their scheduled participation in the study, participants came to a computer lab where the data was collected. Upon arriving at the lab, participants were greeted and assigned to individual laptop computers equipped with wireless Internet. The study was conducted via a database-driven Internet site which collected and stored the data on a server as the participants progressed through the study. As participants continued through the study, they were taken to the proceeding webpage which contained the next step in the study.

Participants were first presented with an opening screen which instructed them to login using their university email address. After participants successfully logged in, they were given a brief set of instructions concerning the research by the lab assistant. Participants then proceeded to begin the study with the pre-tutorial situational interest inventory. Next, participants viewed their assigned version of the multimedia tutorial (i.e., NSD+NS, SD + NS, NSD+S, SD+S). Following the tutorial, participants took, in the following order, the post-tutorial interest inventory, recall test, and transfer test. Participants were allowed 5 minutes for the pre-tutorial interest inventory and 5 minutes for the post-tutorial interest inventory. Participants were then allowed 5 minutes for the recall test and 10 minutes for the transfer test. Each data collection session lasted approximately 40 minutes.

CHAPTER FOUR

ANALYSIS

The present study was designed to examine the effects of seductive details and segmentation on participants' interest, recall, and transfer. Previous studies have revealed seductive details and segmentation effects (Mayer & Chandler, 2001; Mayer et. al, 2001; Moreno & Mayer, 2000); however, interest was not measured in these studies to examine if seductive details or segmentation have an effect on interest.

Validation of Seductive Details and Segmentation

The first analysis of the data was designed to validate the previous findings regarding the effects of seductive details and segmentation on student recall and transfer. According to the coherence principle of the cognitive theory of multimedia learning (Mayer, 2005), students who watch multimedia tutorials not including seductive details should perform better on tests of recall and transfer than those students who watch tutorials which do include seductive details. These two questions were analyzed using two 2 (SD, NSD) X 2 (S, NS) factorial ANOVAs based on the recall and transfer data. The coherence principle was not confirmed for recall (see Table 3), resulting in no significant main effect for seductive details, $F(1, 157) = 0.58$, $p = 0.44$, and Cohen's $d = 0.11$. Likewise, there was no significant effect of seductive details on transfer, $F(1, 157) = 0.99$, $p = 0.32$, and Cohen's $d = 0.16$. These results are inconsistent with the predictions of the cognitive theory of multimedia learning.

According to the cognitive theory of multimedia learning (Mayer, 2005), students who watch segmented tutorials should perform better on tests of recall and transfer than students not receiving segmented instruction. The segmentation effect was not confirmed for recall (see Table 3), resulting in no significant main effect for segmentation on recall, $F(1, 157) = 0.84$, $p = 0.35$, and Cohen's $d = 0.14$. Likewise, there was no significant effect for segmentation on transfer, $F(1,157) = 1.09$, $p = 0.29$, and Cohen's $d = 0.15$.

There was also no significant interaction between seductive details and segmentation with recall, $F(1,157) = 0.13$, $p = .71$, and no significant interaction between seductive details and segmentation with transfer, $F(1,157) = 0.53$, $p = 0.46$.

Table 3

Means and Standard Deviations of Recall and Transfer Scores

	Recall				Transfer			
	No Segmentation		Segmentation		No Segmentation		Segmentation	
	M	SD	M	SD	M	SD	M	SD
No Seductive Details	3.72	2.14	3.31	2.07	1.81	1.32	1.46	1.04
Seductive Details	3.36	1.81	3.18	2.07	1.86	1.29	1.80	1.21

Note. Maximum recall score = 8. Maximum transfer score = 8.

Effect of Seductive Details and Segmentation on Interest

Previous researchers hypothesized that seductive details and segmentation may have a positive effect on interest (Mayer & Chandler, 2001; Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000). These two research questions were addressed through the use of interest gain scores. The pre-tutorial situational interest scores were subtracted from participants' post-tutorial situational interest scores to yield a measure of the effects of the multimedia tutorial on participants' interest levels. The gain scores were then analyzed using a 2 (NSD, SD) X 2 (NS, S) ANOVA to compare the interest gain scores of participants (see Table 4). There was no significant difference between gain scores for seductive details, $F(1,157) = 0.51$, $p = 0.47$, and Cohen's $d = 0.11$. There was also no significant difference between gain scores for segmentation, $F(1,157) = 0.65$, $p = 0.65$, and Cohen's $d = 0.13$. Finally, there was no significant interaction between seductive details and segmentation on interest, $F(1,157) = 0.04$, $p = .83$.

Table 4

Means and Standard Deviations of Interest Gain Scores

	Interest Gain			
	No Segmentation		Segmentation	
	M	SD	M	SD
No Seductive Details	0.83	6.61	1.49	7.97
Seductive Details	-0.19	6.72	0.93	6.35

Relationship Between Interest and Recall and Transfer

Many researchers have hypothesized that interest affects learning, including recall and transfer (Hidi & Renninger, 2006; Mitchell, 1993; Renninger & Hidi, 2002; Schraw, Bruning, & Svoboda, 1995). In the realm of multimedia learning, however, studies measuring participants' interest and interest levels' relationship with recall and transfer have not been conducted. This analysis was conducted using two Spearman's p (rho) correlations, one correlation for the recall data and one correlation for the transfer data. The correlation between post-tutorial interest and recall was 0.05, $p = 0.46$, while the correlation between post-tutorial interest and transfer was 0.11, $p = 0.16$. Thus, there was no significant relationship between interest and recall or interest and transfer.

CHAPTER FIVE

DISCUSSION

The goal of this research was to examine the influence of seductive details and segmentation on learners' interest, recall, and transfer in a multimedia learning environment. The study was based upon the coherence and segmentation effects of the cognitive theory of multimedia learning (Mayer, 2005) and interest theory (Hidi & Renninger, 2006).

The overall effects of seductive details and segmentation were assessed via two tests. Participants were assessed on their ability to recall information on lightning formation and their ability to apply what was learned to problem solve (transfer). Interest was measured through the use of an interest questionnaire both prior to the animation and after the animation.

Seductive Details and the Coherence Effect

Previous research has indicated that the presence of seductive details within multimedia learning environments decreases students' recall and transfer (Mayer et al., 2001; Moreno & Mayer, 2000). This previous research was designed to compare two hypotheses: (a) seductive details increase participants' interest in a multimedia tutorial leading to increased recall and transfer, and (b) seductive details increase participants' cognitive load leading to a decreased recall and transfer. Moreno and Mayer (2000) as well as Mayer et al. (2001) determined that seductive details led to decreased recall and transfer, concluding that seductive details did not affect participants' interest but instead increased cognitive load. However, neither interest nor cognitive load was measured in Mayer's studies.

The results of the present study do not support the conclusions of Moreno and Mayer (2000) and Mayer et al. (2001) that seductive details lead to decreased recall and transfer, resulting in a coherence effect. Research revealing that seductive details decrease learner recall and transfer includes illustrated, scientific text studies conducted by Harp and Mayer (1997) and Mayer and Jackson (2005). Harp and Mayer (1997) found that recall and transfer performance suffered when additional, yet irrelevant, text and pictures were added to an illustrated booklet on the formation of lightning. Mayer and Jackson (2005) reported similar results for a text about the cause of waves.

Although a coherence effect was expected in this study, other research studies have shown the inconsistency of the coherence effect (Mayer et al., 2001; Moreno & Mayer, 2000).

The type of seductive details used made a difference in Mayer et al. (2001) and Moreno and Mayer's (2000) research; both of which presented inconsistent results concerning the use of seductive details. Mayer et al. (2001) found in one experiment that recall and transfer performance among participants were reduced when interesting, yet irrelevant, text was added to an animation about lightning formation. However, when irrelevant video clips were added instead of text in the second experiment, only transfer was reduced, not recall.

In Moreno and Mayer's (2000) research study, results also varied depending on the type of seductive details added. When background music was added to animations on lightning formation and the functioning of car brakes, recall and transfer performance was decreased. In another experiment, Moreno and Mayer found that mechanical sounds added to the car brakes animation also resulted in lower recall and transfer performance. However, lower recall and transfer performance scores were not replicated when environmental sounds were added to the background of the lightning animation. Therefore, it is possible that the type of seductive details employed in a multimedia tutorial may affect users differently.

The present study's lack of support for the coherence effect may be due to the type of seductive details used: background environmental sounds, as in Moreno and Mayer (2000), and additional on-screen graphics. It is possible that the environmental sound effects intended as seductive details for this specific animation were, actually, helpful in generating understanding among those who engaged with the tutorial. Since the environmental sounds effects were based upon actual sounds that might occur during a thunder storm, they may have triggered schemas which allowed the participants to better understand the material. Thus, it is possible that the environmental sound effects were not seductive details but functional details which increased the understanding of participants, which may explain why there was no coherence effect.

This study, along with the existing literature on seductive details, appears to indicate the complexity of seductive details as a variable in multimedia learning. Instead of examining seductive details as a dichotomous attribute – included or not included – multimedia researchers need to look at the varying levels of types of seductive details incorporated in multimedia instructional messages. Presently, much of the seductive details research has focused on items such as background music, sound effects, additional text, and video clips. However, the scope of seductive details could include concepts such as novelty, emotion, and personalization.

On the other hand, the lack of a coherence effect could be due to the working memory capacity of the participants in this study. Sanchez and Wiley (2006) postulate that seductive details only affect those learners with the least attentional control: those with low working memory capacity. In their study, Sanchez and Wiley found that low working capacity participants presented with seductive detailed versions of a text on ice ages performed worse on tests of recall and transfer than participants with high working memory capacity and participants with low working memory capacity not receiving seductive details. In a follow-up experiment, Sanchez and Wiley found that low working memory capacity individuals pay more attention to seductive details than do their higher working memory capacity counterparts. Since working memory capacity was not measured in this study, it is possible that it could have influenced the results. If the participants had medium to high working memory capacities, then the use of seductive details may not have affected the participants like they would lower working memory capacity individuals.

The Segmentation Effect

In previous research on segmentation conducted by Mayer and Chandler (2001), they found that segmentation aided participants on tests of transfer; however, on tests of recall, participants who watched segmented versions of the tutorial had significantly lower recall scores than those who watched non-segmented versions. Although the participants in the segmented instruction groups performed significantly lower on recall, their stronger performance on the problem-solving transfer tests convinced Mayer and Chandler that segmentation may allow for deeper learning. Mayer and Chandler concluded that segmentation allowed the learner time to understand one segment before moving on to the next, thus reducing cognitive overload and resulting in deeper understanding. Mayer et al. (2003) found similar results using a tutorial on electric motor with segmented and non-segmented instructional groups. Participants in the segmented group outperformed those in the non-segmented group on tests of transfer. Recall was not measured in this study.

The results of the present study, however, do not support the segmentation effect of multimedia learning. There was no significant main effect for segmentation on either recall or transfer in this study. It is likely that the length of the tutorial and the nature of the tutorial were factors in this regard. The length of the tutorial was 140 seconds, which may not have been long enough for a segmentation effect to occur. Additionally, the nature of the tutorial was a cause-and-effect explanation of how lightning forms. As with most cause-and-effect explanations, the explanation was logical and sequential making it easy for most participants to follow the tutorial. Finally, the tutorial's topic was also familiar to participants, meaning their prior knowledge of the subject may have influenced the results.

Recent studies examining segmentation have shown a segmentation effect for longer tutorials and tutorials which are not of a cause-and-effect nature. Hasler et al. (2007) found that primary school participants viewing segmented and learner-paced versions of a tutorial about the causes of day and night outperformed those participants viewing a system-paced version of the tutorial. The tutorial lasted 3 minutes and 45 seconds when system-paced. Moreno (2007) concluded that segmented versions of videos and animations resulted in better learning after examining segmentation with videos and animations of classroom teaching skills. Videos and animations were about 20 minutes in length. Finally, Lusk et al. (in press) studied the interaction of segmentation and working memory capacity using segmented and non-segmented versions of an 11 minute multimedia tutorial explaining how to use a strategy for historical inquiry. Learners receiving segmented instruction performed better on both tests of recall and application; additionally, the researchers found a significant interaction between segmentation and working memory capacity. Segmentation improved low working memory capacity learners' performance to where it equaled that of high working memory capacity learners. The study also revealed that low working memory capacity learners receiving non-segmented instruction performed significantly worse than any other group, reiterating what Sanchez and Wiley (2006) concluded: low working memory capacity individuals lack the skills necessary to block out additional information.

However, another possibility for the lack of a segmentation effect in this study is that participants did not fully make use of the segmentation. In other words, they may not have paused to reflect on the material before pressing "continue" to move on to the next segment. Hasler et al. (2007) found that participants in their learner controlled condition, who were able to stop/play the tutorial at any time, did not use the stop button (with the exception of one participant). The participants continued through the tutorial without ever stopping it. However, they still outperformed other groups on tests of learning afterwards, differing from the present study.

Interest

In regards to interest, researchers examining the effect of seductive details on recall and transfer have hypothesized that the inclusion of seductive details in multimedia instruction may increase the interest of participants (Mayer et al., 2001; Moreno & Mayer, 2000); however, interest has not been directly measured in these studies focusing on computer animated tutorials. Harp and Mayer (1997) did measure cognitive and emotional interest among participants who read seductive detail and non-seductive detail versions of an illustrated text about the formation of lightning. Harp and Mayer found that the inclusion of seductive details increased participants' emotional interest in the material; however, cognitive interest was higher for versions of the text which promoted understanding via explanative summaries. The validity and reliability of their interest questionnaire is questionable however. Harp and Mayer ask about the importance and usefulness of the information presented; however, usefulness and importance are *not* the same as interest.

Although segmentation has not been directly studied in relation to interest, learner control in general has been considered a motivational factor in achievement. Because segmentation allows learners control over the pacing of a tutorial and an opportunity to become more cognitively engaged in the material (by allowing more time for thought and reflection), learners may also become more interested in the material. Increased interest may affect recall and transfer; however, interest was not measured as a variable with the segmentation studies (Mayer & Chandler, 2001; Mayer, Dow, & Mayer, 2003).

The present study examined the effects of seductive details and segmentation on interest. An increase in interest for participants in the seductive details and segmentation groups was not found. Because only environmental sounds and additional animations were used as seductive details in this study, it is possible that their effects on interest were not strong enough to produce significant results. Other types of seductive details may engage participants more than these did. In terms of segmentation, interest may not have been affected due to the short duration (140 seconds) of the tutorial or the type of tutorial (cause and effect).

Interest, Recall, and Transfer

The relationship between interest and recall and interest and transfer was also analyzed. Prior studies on interest and academic performance have revealed a positive relationship between high interest and attention, recognition, and recall (Renninger & Wozniak, 1985), levels of learning (Renninger & Hidi, 2002; Schraw, Bruning, & Svoboda, 1995), and academic motivation (Ainley, 1998). The present study, however, found no significant relationship between interest and recall or interest and transfer. In other words, interest had no effect on how well participants did on the tests of recall and transfer. These results are somewhat similar to Park and Lim's (2007), who found that illustrations intended to increase interest in the multimedia tutorial had no effect on recall and transfer scores. Park and Lim hypothesize that their participants ability to navigate freely through the instructional materials allowed participants to go back to any material they did not understand and review it. Also, Park and Lim did not find a seductive details effect in their study with their illustrations. For the present study, it is possible that the short length of the tutorial, again, played a factor. A longer tutorial which requires more attentional effort might produce different results in regards to interest, recall, and transfer because participants' interest may play more of a role in how likely they are to remain engaged with the tutorial (i.e., keep paying attention).

Implications for Future Theory and Practice

Based upon the previous research on the cognitive theory of multimedia learning and the results of the present study, there are still questions regarding the use of seductive details in multimedia instruction. While this study incorporated background environmental sounds and additional animation, seductive details of a different nature may have generated different results. It is still unclear which type(s) of seductive details, if any, may be beneficial to learners without increasing cognitive load.

While Mayer (2005) would argue that multimedia learning materials should exclude seductive details because of their effect on learners' cognitive load, Sanchez and Wiley (2006) believe that seductive details only affect learners with poor working memory capacity who lack the metacognitive skills necessary to ignore these elements. The present study did not find a seductive details effect; however, as previously mentioned, working memory capacity was not measured to determine if it was a factor in recall and transfer performance. Also, it is possible that the details were useful in helping to understand the material. For instructional designers, the focus may need to be more on the need for these extra details. While items such as sound effects and additional animation may make multimedia instruction more appealing, they may negatively affect some learners because of their poor attentional control. However, other researchers in the field of multimedia are looking at ways to enhance users' understanding via attributes such as signaling and pre-training.

Although the present study did not provide support for the segmentation effect of multimedia learning, more research into segmentation and other forms of learner control (such as the ability to review material or control the sequence of instruction) needs to be conducted. Providing multimedia users with some form of control over their learning may encourage the deeper understanding and learning educators hope will take place during instruction. In regards to segmentation, Mayer (2005) argues that segmentation is a useful method of promoting deeper understanding by allowing the learner to have control over the pacing of instruction. Although the present study did not find a segmentation effect for a short tutorial, using segmented instruction for longer tutorials may be useful as Hasler et al. (2007) and Lusk et al. (in press) have found. Still yet, a stronger understanding of the cognitive and motivational effects of providing users control over their learning is needed.

While motivation itself still needs to be studied as a possible individual difference that may influence multimedia learning, the present study does not provide support for interest as an individual difference variable. Other areas of educational research have pointed to the difference motivational variables play in academic achievement and learning (e.g., Brooks & Shell, 2006; Elliot & Dweck, 2005; Ryan & Deci, 2000), thus perhaps motivation in the multimedia learning environment needs to be further investigated as suggested by Clark (1999), Deimann and Keller (2006), and Samaras et al. (2006). Although the current study did not find that seductive details and segmentation influenced interest, it is possible that other multimedia attributes, or even the same attributes used with different tutorials or populations, may present different results in regards to interest, recall, and transfer.

Limitations

The present study does present four limitations. First, the multimedia tutorial on the formation of lightning is short in length and is causal in nature. A longer tutorial or a tutorial which presents information that is not cause-and-effect may present different results in terms of the coherence effect and segmentation effect. Second, tests of recall and transfer were given immediately after the tutorial and learning sustained over time was not examined. Third, the context of the study may have influenced the results. The study was nonauthentic in the sense that it was not part of an actual class where learners may have more stake in the material. Finally, the present study utilized only one tutorial, an explanation of the formation of lightning. Other tutorials may present different findings.

Future Directions

Although the present study did not produce statistically significant results, several areas of valuable research can be extended from this study. First, more research into the complexity of seductive details needs to be conducted. Seductive details are more than a two-dimensional (yes, no) attribute of multimedia learning. Novelty, emotion, and personalization can be considered seductive details in addition to items such as background music, video clips, text, and environmental sounds. This underexplored area is vastly open for research. Secondly, more research into learner control needs to be conducted. This particular study looked at segmentation as a form of learner control over pacing. However, more studies in which participants have more control over the pacing and sequencing (for example, the ability to go back and review a previously played segment) may produce interesting results. Both seductive details and segmentation are complex variables which need to be carefully studied. Furthermore, interest in multimedia learning needs more exploration. For example, how might interest affect learners' performance with a longer, more complex tutorial that requires more attention? The field of multimedia learning is ripe with possibilities for research and this study only adds a small piece to the body of literature.

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Appendix A

Situational Interest Inventory Questions Pre-Tutorial

1. I think a multimedia tutorial on the formation of lightning would be very interesting.
2. I'd like to discuss a tutorial on the formation of lightning with others at some point.
3. I would watch a multimedia tutorial on the formation of lightning multiple times if I had the chance.
4. I may get caught-up in a multimedia tutorial on the formation of lightning without trying to.
5. I'll probably think about the implications of a multimedia tutorial on the formation of lightning for some time to come.
6. I think most people I know would be interested in a multimedia tutorial on lightning formation.
7. I would like a multimedia tutorial on the formation of lightning a lot.
8. I would like to watch similar multimedia tutorials in the future.
9. A multimedia tutorial on the formation of lightning would be one of the most interesting things I've watched in a long time.
10. I would like to know more about why an author created a multimedia tutorial on lightning formation.

Appendix B

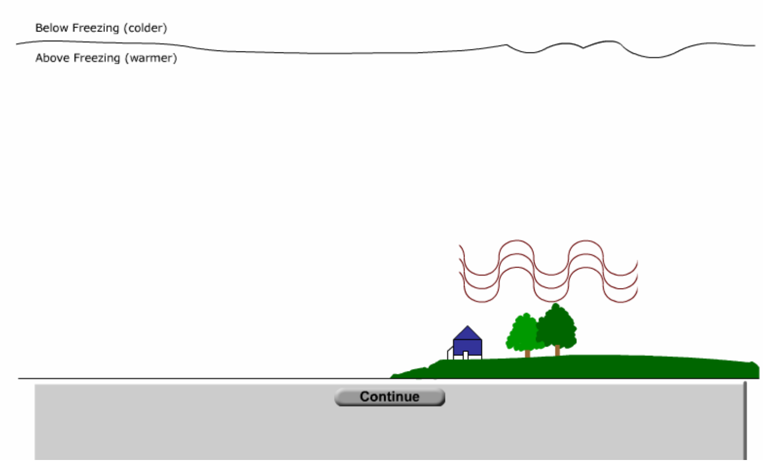
Situational Interest Inventory Questions Post-Tutorial

1. I thought the multimedia tutorial on the formation of lightning was very interesting.
2. I’d like to discuss this tutorial with others at some point.
3. I would watch this tutorial again if I had the chance.
4. I got caught-up in the tutorial without trying to.
5. I’ll probably think about the implications of this tutorial for some time to come.
6. I think most people I know would be interested in this tutorial.
7. I liked this tutorial a lot.
8. I would like to watch similar multimedia tutorials in the future.
9. The tutorial was one of the most interesting things I’ve watched in a long time.
10. I would like to know more about why the author created this tutorial.

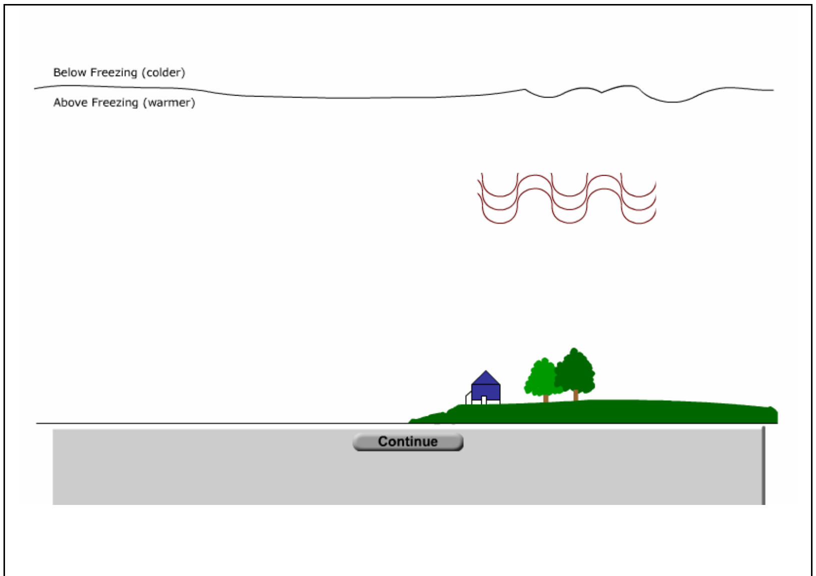
Appendix C

Multimedia Tutorial on the Formation of Lightning

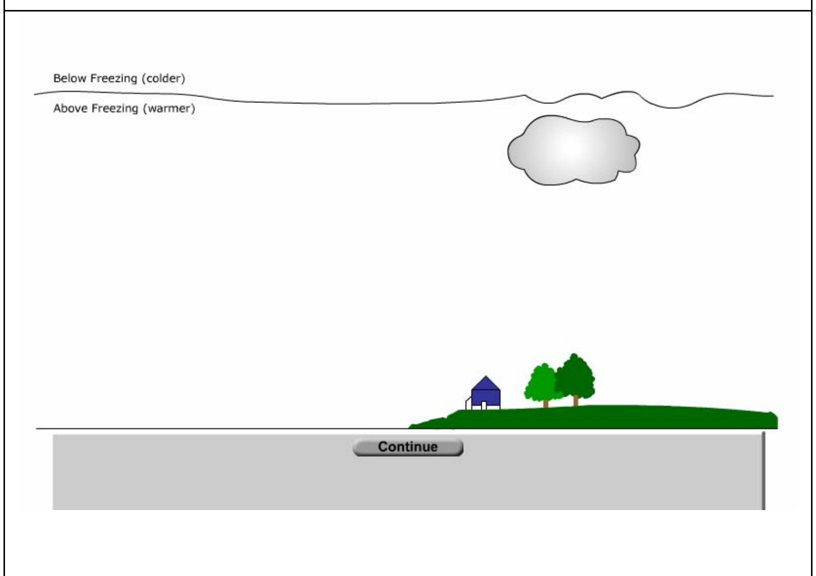
<table>
<tr><th>Animation</th><th>Narration</th></tr>
<tr><td>


</td><td></td></tr>
<tr><td>


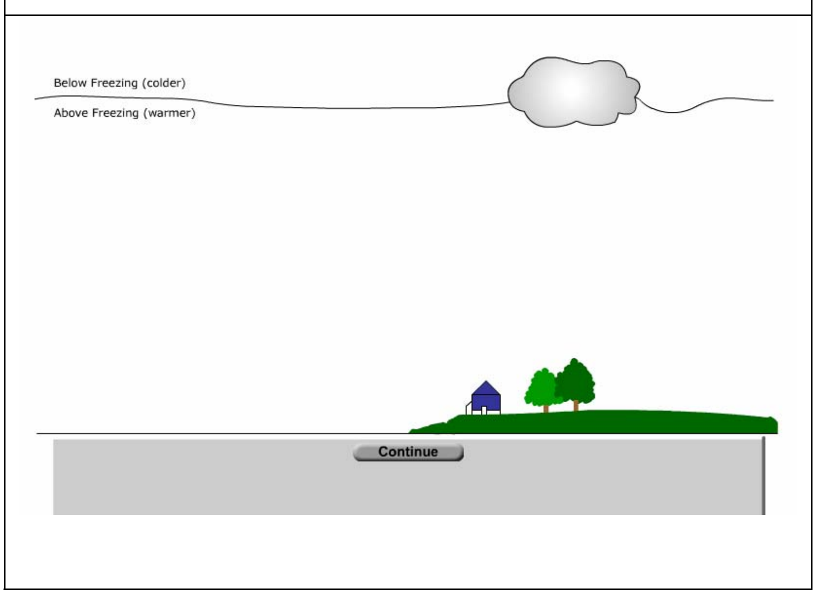
</td><td>Cool moist air moves over a warmer surface and becomes heated.</td></tr>
</table>



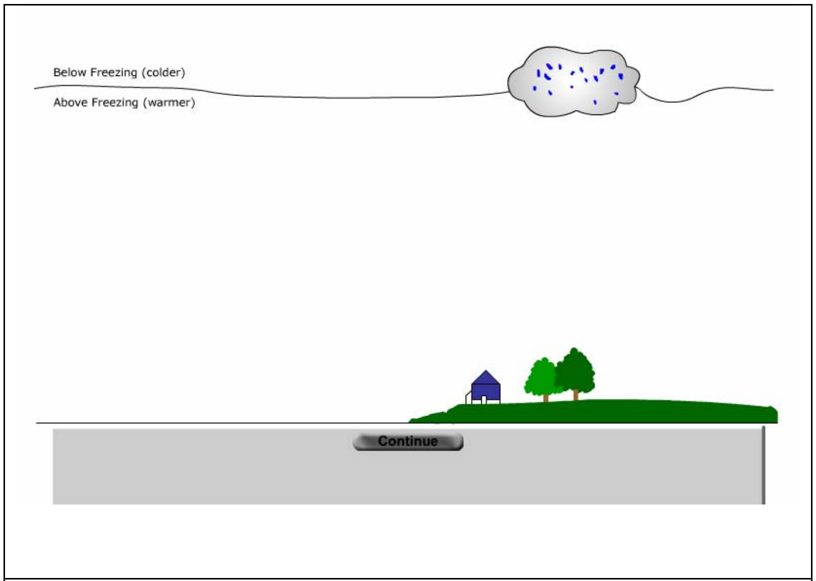
Warmed moist air near the earth's surface rises rapidly.



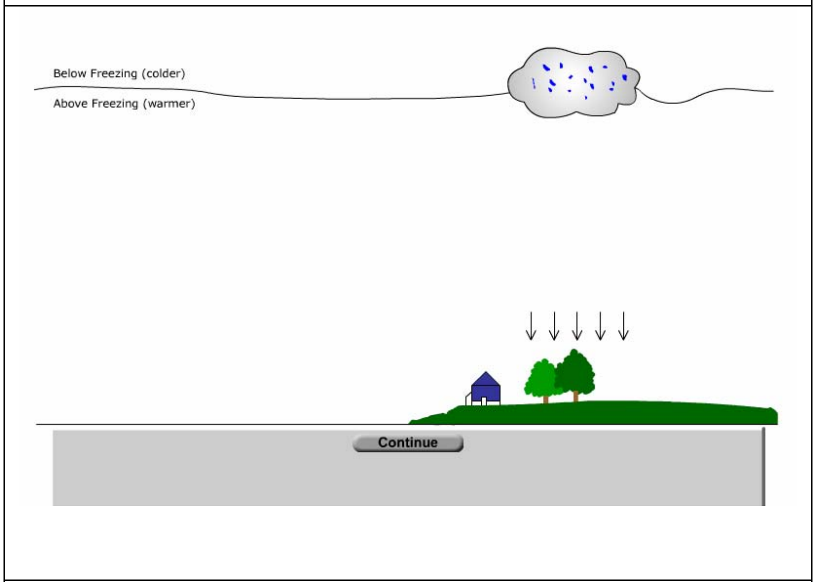
As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud.



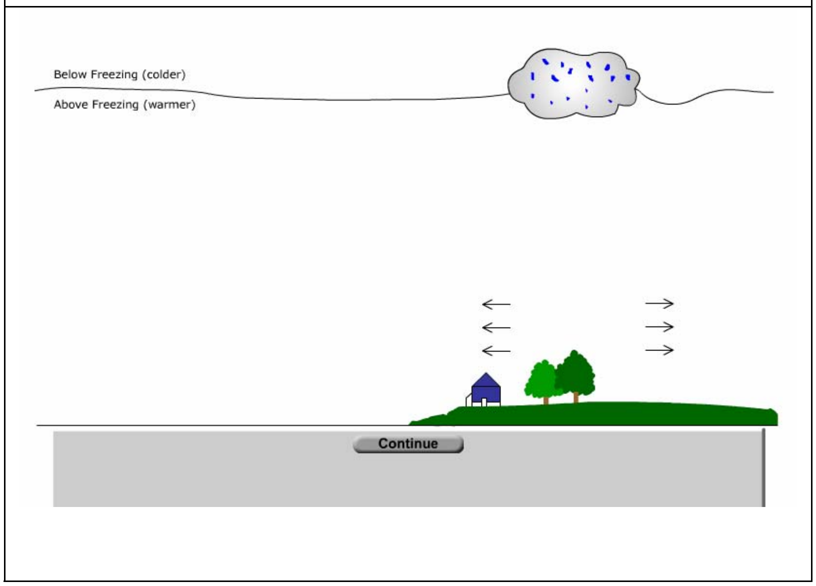
The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals.



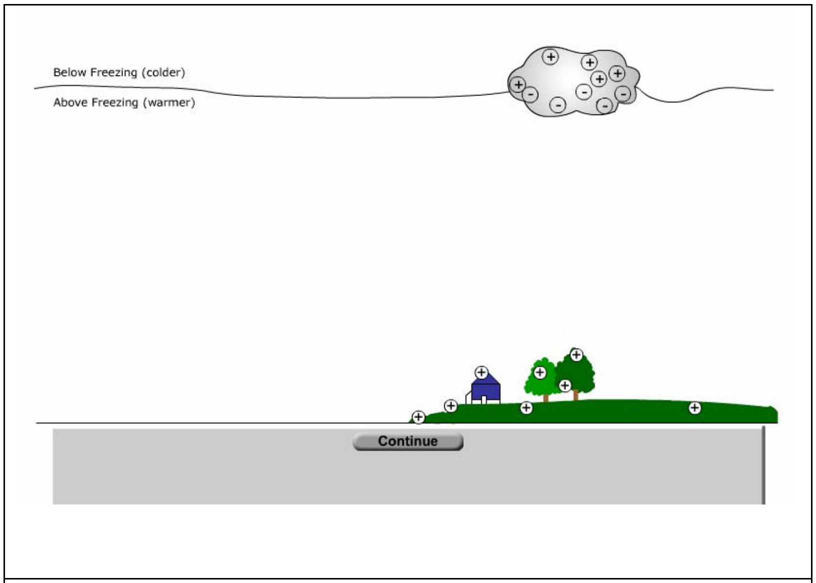
Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts.



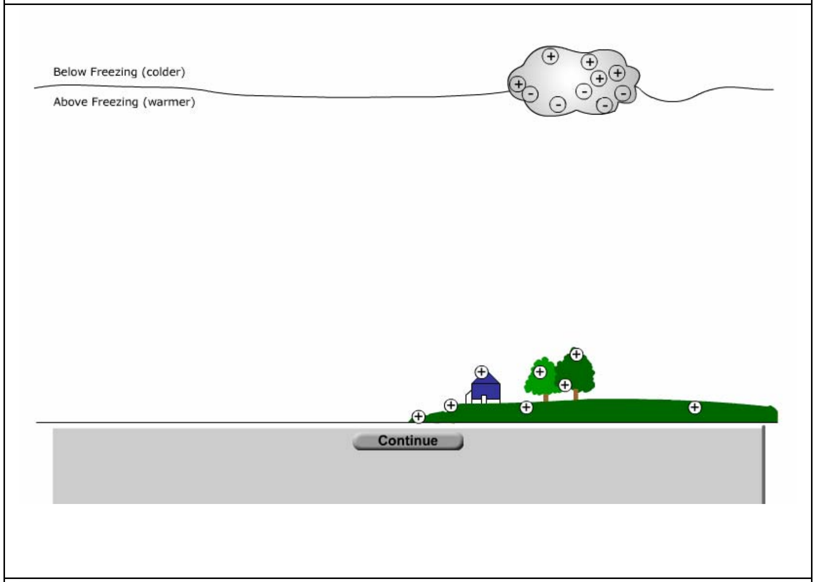
As raindrops and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts.



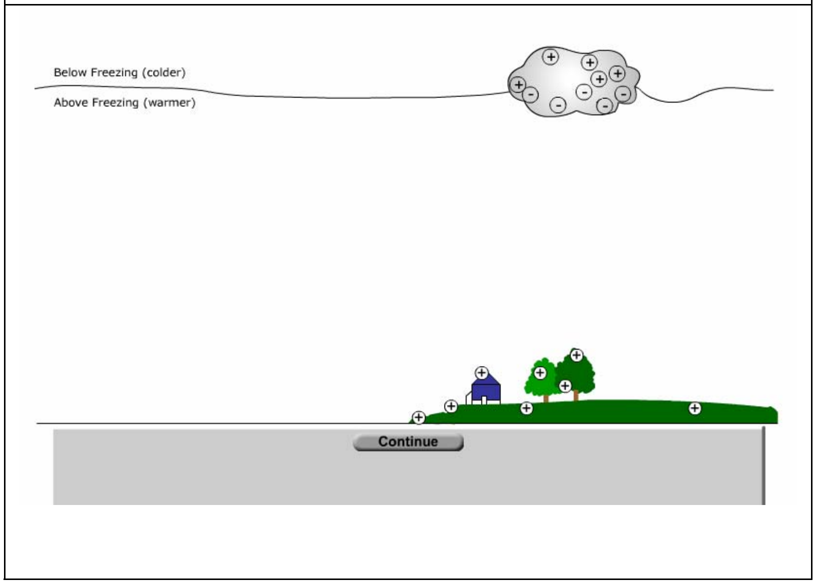
When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain.



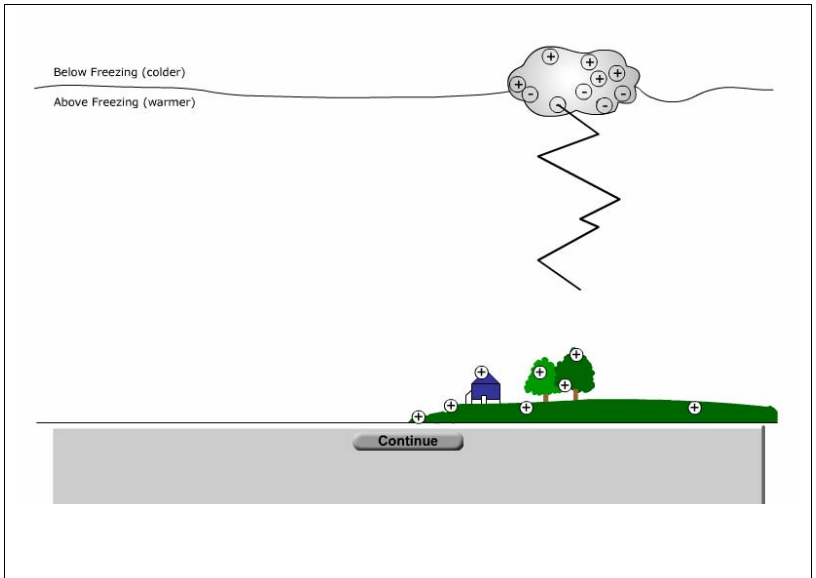
Within the cloud, the rising and falling air currents cause electrical currents to build.



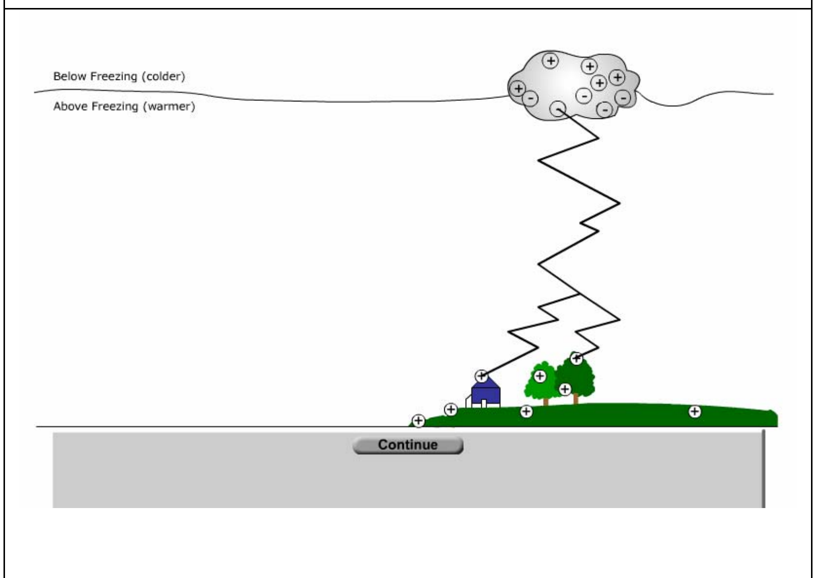
The charge results from the collision of the cloud’s rising water droplets against heavier, falling pieces of ice.



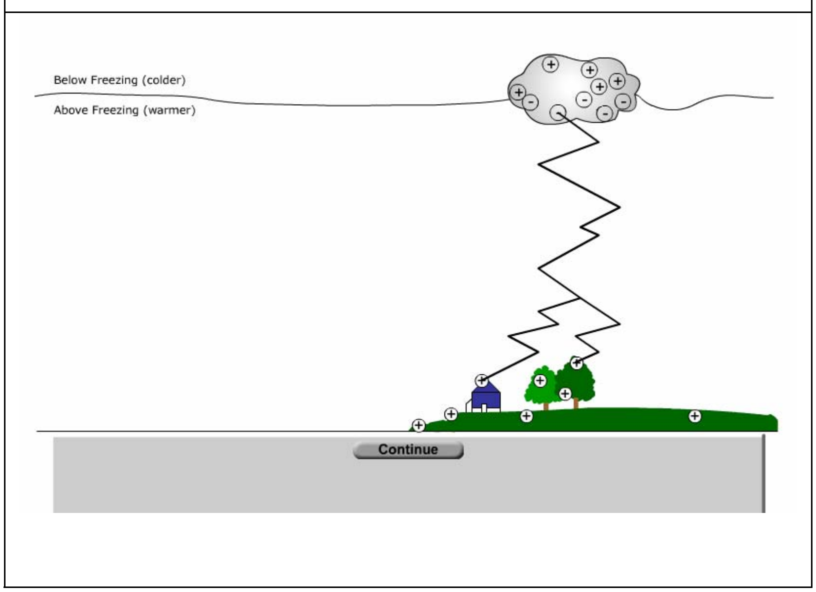
The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top.



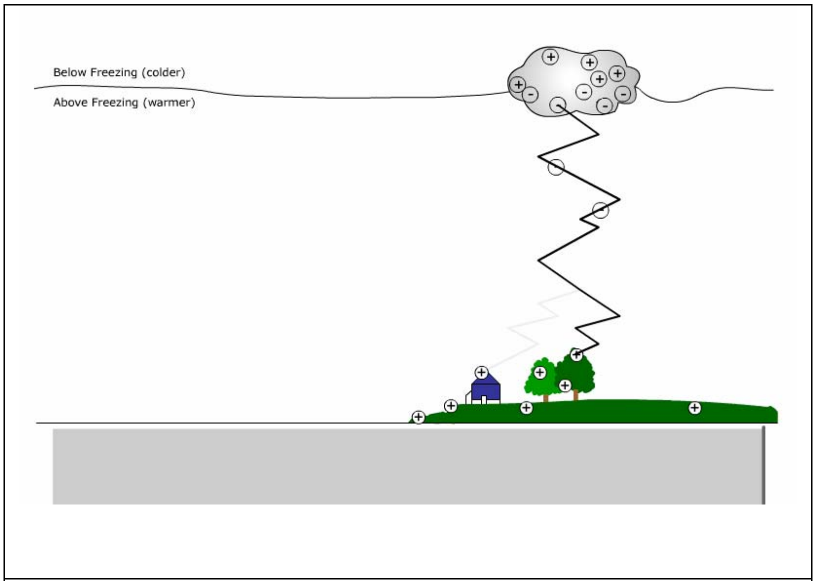
A stepped leader of negative charges moves downward in a series of steps. It nears the ground.



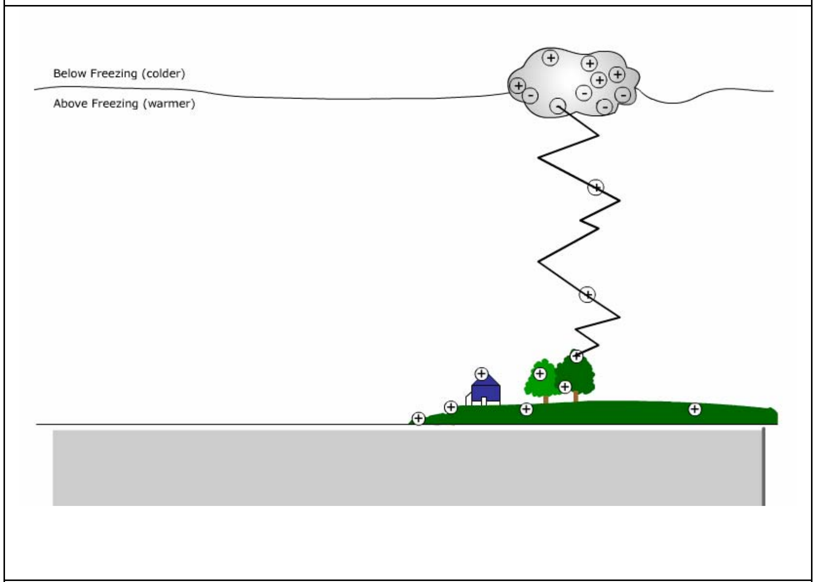
A positively charged leader travels up from such objects as trees and buildings.



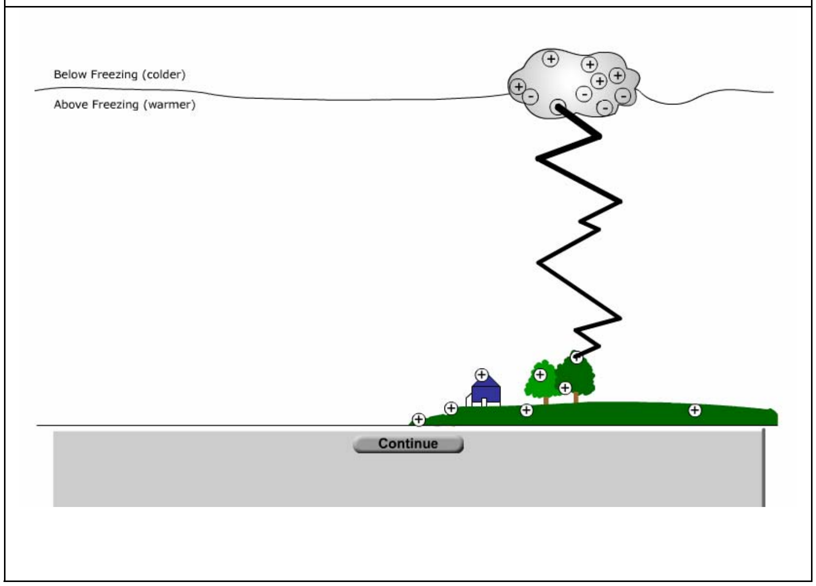
The two leaders generally meet about 165 feet above the ground.



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



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.



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