EFFECT OF MULTIMEDIA DESIGN PRINCIPLES ON SITUATIONAL INTEREST OF
ADULT LEARNERS

by

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(Under the Direction of Robert Maribe Branch)

ABSTRACT

This study investigated the potential effects of two design principles as prescribed by the cognitive theory of multimedia learning on the situational interest of adult learners in a multimedia-based continuing education training program. Participants in the study were randomly assigned to one of three training groups designed to follow modality and redundancy design principles: animation-text, animation-narration, and animation-narration-text. A pretest was administered to participants in segments and presented intermittently during the content in an attempt to reduce unintentional effects on interest, and a posttest was administered after participants submitted the self-reporting survey intended to measure situational interest. An ANOVA was used to analyze the differences in situational interest between the groups, and independent t-tests were used to evaluate differences. The results of the study indicated that combinations of animation, narration, and text do influence the situational interest of learners. However, inclusive evidence was found regarding applicability on learners’ achievement gained.

INDEX WORDS: Cognitive theory of multimedia learning, Situational interest, Multimedia, Motivational Design
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DEDICATION

To Kris,
Thank you, m’anamchara.

To Uncle Dewayne,
You gave me an example to follow,
And I promised you I would go all the way.

To Momma & Daddy,
You always told me I could do anything I put my mind to...
I did it.
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You can have it all, but life keeps moving. Now take it in, but don’t look down. ‘Cause I'm on top of the world, ‘eh. I’m on top of the world, ‘eh. Waiting on this for a while now, paying my dues to the dirt. I’ve been waiting to smile, ‘eh. Been holding it in for a while, ‘eh. Take you with me if I can. Been dreaming of this since a child. I’m on top of the world.
-On Top of the World (Imagine Dragons)

Every journey is made possible through love, support, and help from many people along the way. My journey began in the heart of the Piney Woods in East Texas, where community means something and your neighbor is your lifelong friend. They have watched me grow up and leave, but always welcome me home with open arms and a pride that humbles me.

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I agree with the sentiment that friends are the family we choose. I’m fortunate to be rich in friendship, and without the encouragement of my Cage Family, this journey would have been long and lonely. You girls (and guys) have kept me grounded and cheered me on from a distance. I love y’all.

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CHAPTER 1:
INTRODUCTION

The use of images to enhance learning is a complex undertaking with a myriad of advantages and disadvantages. There are number of limitations and considerations related to static images, animations, or full simulations. Cognitive influences on the capturing of interest through the use of visuals and defining learner interest have been examined by decades of research. Cognitive processing models provide guidelines to be considered when employing media in learning. Nevertheless, little attention has been given to the use of specific multimedia model principles and their affect on learner interest. The problem is that many learners in multimedia learning environments experience a decreased intrinsic motivation to continue or complete lessons due to poor designs that negatively impact interest (Moreno, Mayer, Spires, & Lester, 2001). Therefore, this study seeks to explain the importance of learner interest and potential impact of multimedia design; essentially the way in which cognitive science research about visual images can be effectively applied to learning designs.

A reciprocal relationship exists between research and practice. Technology can enhance instruction which then provides novel opportunities for research to examine the practice and prescribe both future application and continuing research (Salomon & Almog, 1998). As studies in educational psychology continue to adapt to the ever-growing field of instructional technology, it is important that new studies provide practical application of research findings. Keller (2010), for example, noted that research which focuses on learner motivation, has the potential to impact course and
lesson design. Educators have the ability to stimulate students or hinder their motivation all together. Thus, educators who employ designs based on the study of motivation can enhance learners’ desire to learn. Conversely, learning designs that fail to incorporate or consider motivation research findings may prove insufficient for expectations. The increasing prevalence of online learning in today’s educational environment provides an excellent scenario in which to examine the impact of learning design on motivation. Online learning environments serve as an example that is dominated by multimedia instruction. Carr (2000) and Wojciechowski and Palmer (2005) indicated that online learning environments often present negative challenges for learner motivation and completion rates. Meyer (2003) further noted that a number of online learners struggle because of a lack of motivation or self-confidence. Enhancing students’ interest while taking courses in online learning environments seems a probable means of promoting higher learner satisfaction and better completion rates.

Research and practice related to learning design and motivation has a variety of juxtapositions. The placement of images alongside text in manuscripts dates back to the seventh century in the Book of Kells, and represents the conceptual phenomenon behind the use of images to capture interest. Theoretically, there are two major approaches to consider when examining image placement and capturing interest. First, cognitive processing theories explain the ways by which we perform the complex series of actions required to receive and store information. The same theories prescribe ways in which images and media should and should not be used in order to maximize this process. Second, motivation theory provides an explanation for how and why we are driven to perform certain behaviors. Within motivation theory, interest explains a preference for certain activities. A practical application begins to emerge through an analysis of the
theoretical framework wherein cognitive processing theories are informed by interest theory, resulting in prescriptive guidelines for designing media to target interest. The resulting conclusion is an empirical study examining the impact of media design on learner interest.

**Conceptual Framework**

**Capturing Learner Interest Through Images**

More than 20 years ago, newspapers originally addressed the concept of interest in order to better understand how readers perceived charts and graphs published with articles. Tankard (1988) showed that readers did not retain any more information from flashier graphics than from plain images, but findings did support that readers saw these “chartoons” (p. 91) and three-dimensional graphs as more appealing. This groundwork of examining the effectiveness of visuals provided an outlet for further investigation. Austin, Matlack, Dunn, Kesler, and Brown (1995), Delp and Jones (1996), Michielutte, Bahnson, Dignan, and Schroeder (1992), and Morrow and Hier (1998) found that the use of images to enhance the appeal of medical handouts led to a higher probability of the information being read and patients recalling the information provided. Further evidence supports the use of images with text in order to positively impact attention and recall of information. Houts, Doak, Doak, and Loscalzo (2006) examined how pictures improved communication between health practitioners and patients, and found that patients with well-developed language skills found it difficult to process medical information for a variety of reasons, including unfamiliarity with terminology and emotional effects. The use of images and diagrams near medical information mitigated the observed difficulties. However, findings remain unclear about the emphasis on how and where to maximize images’ effects on interest.
The reason for using static and animated images in education is based upon research related to attention and interest. Slough and McTigue (2010) noted that textbooks traditionally use images and illustrations sparingly and in a secondary role to conveying content. As learners who are accustomed to multimedia environments become more prevalent, the traditional method will not be able to gain or hold readers’ attention for very long. One approach to help students understand content is to make the text more interesting through the use of visuals and graphics. Kim, Yoon, Whang, Tversky, and Morrison (2007) reported an emerging trend, which has been reported by teachers to be preferred among learners, to lay out textbooks in a way that mimics websites through use of photographs, tables, textboxes, flowcharts, and drawings. Looking across the various types of images, current technologies have allowed for an increasing use of animations with respect to learning and instructional text. Kim et al. further noted that researchers and educators initially assumed that animations would facilitate an increased interest in learning, and that while the effects of animated images on learning are still a controversial topic, the use of graphics continues to grow in popularity largely due to a belief that animations are more interesting and aesthetically appealing. Aesthetic appeal is influenced by interest, which is commonly divided into two classifications, emotional interest and cognitive interest (Kintsch, 1980). Therefore, interest effects may vary depending upon individual differences, including age and spatial ability (Kim et al., 2007). Specifically, adolescent learners prefer animations over static images and find them to be motivating. Preferences for images present several implications for designing learning content, but image use should be considered carefully, taking into account the characteristics of the intended audience.
Theoretical Framework

The primary theories tested in this study are situational interest of learners and cognitive processing. Situational interest is only one type of interest and falls under the purview of motivation theory. Cognitive processing includes the evolution of research and theory related to how we receive and store information. Related to cognitive processing, specific theories regarding multimedia development have prescribed specific design guidelines aimed at maximizing cognitive systems. The intersection of these two fields results in the testing the effect of multimedia learning design on the situational interest of learners.

Defining Learner Interest

Learner interest as a concept extends beyond the basic feeling or emotion that drives a person to action. Interest is not specifically a type of motivation, but plays a significant role in influencing motivation (Schunk, Pintrich, & Meece, 2008). Further, students interested in a topic may display motivated behaviors, such as choice of the activity, effort, persistence, and achievement. Exploring the effect of motivation on metacognition has indicated that when students attempt to complete a course, they are either interested in the content, motivated to attain a goal of importance, or both (Tobias, 2006). Incorporating motivational variables, such as interest, into multimedia design will become an important task if instruction is to provide learners with relevant learning experiences (Fletcher & Tobias, 2005). Harp and Mayer’s (1997) study aimed at making scientific textbook lessons more interesting found that promoting cognitive interest could be done by adding signals for structural understanding such as summary illustrations with captions. Research is only beginning to fully explore what interest encompasses and to how help designers can incorporate interest into the design process.
Interest, as a theory, is categorized into one of two subgroups; individual interest and situational interest. Individual interest (II) resides within a person, associates positive feelings with a topic or activity, and attributes personal significance to the topic or activity (Rathunde, 1993; Renninger, 2000; Renninger, Hidi, & Krapp, 1992; Schiefele, 1991). Individual interest is also referred to as personal interest, because as Dewey (1913, 1933, 1938) noted, interest is an active state based on real objects with a highly personal meaning. Situational interest (SI) emerges as a response to features or effects within an environment (Hidi & Anderson, 1992; Hidi & Baird, 1986; Hidi & Renninger, 2006; Krapp, 2002). Examining situational interest further, there are attentional and affective reactions that can be differentiated into triggered-SI and maintained-SI (Hidi & Baird, 1986; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Krapp, 2002; Mitchell, 1993). Triggered-SI is the initiation or arousal of interest (Hidi, 2001; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006). Maintained-SI is where interest is held and individuals begin to connect with the content (Hidi, 2001; Mitchell, 1993). The revelation is that the way learning content is displayed has an impact on the triggering of situational interest and how well learners maintain their situational interest throughout the duration of the learning activity.

Learning design strategies that take into account individual and situational interest during the design of instruction have the potential to help students become engaged and focused on the content. The effects of triggered-SI can be temporary if maintained-SI is not adequately considered. The results of a validity study on the Situational Interest Survey by Linnenbrink-Garcia et al. (2010) found that triggered-SI reflects a positive affective reaction to the manner in which material is presented and maintained-SI refers to the reaction learners have to the material. Based upon the
positive affective reaction to material presentation, it will be important to continue to examine situational interest across educational settings to further investigate what instructional practices can be designed to promote situational interest.

**Cognitive Processing and Multimedia**

Multimedia is defined here as the use of multiple types of media, particularly the presentation of words and pictures together, during a presentation of information. Multimedia learning encompasses building mental representations from words and pictures, and multimedia instruction includes words and pictures intended to promote learning (Mayer, 2005a). Baddeley (1986, 1999), Chandler and Sweller (1991), and Paivio (1986, 1991) provided evidence to support the notion that there are separate channels for processing visual and auditory information, and that humans are limited in the amount of information that can be processed by each channel at one time. Wittrock (1989) studied cognitive relationships in reading comprehension and posited that comprehension is a generative process that relies upon signals, strategies, and plans to relate events to one another. Mayer (2001) expounded upon these foundations of cognitive processing to propose that humans actively engage in learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with previous knowledge to be stored in long-term memory. Figure 1 illustrates an overview of the process that occurs when media are processed by sensory memory, working memory, and long-term memory. Multimedia models and guidelines begin to emerge through cognitive processing theories that can inform multimedia development.
Building upon the CTML learning process, there are design implications to take advantage of learner abilities in the context of learning with multimedia. Schnotz (2005) presented an Integrated Model of Text and Picture Comprehension (ITPC) that, in coordination with Mayer’s (2001) CTML, promotes six key principles for consideration in multimedia design. First, designers should combine text with content-related images only when learners have low prior knowledge and possess sufficient cognitive abilities to process both the text and pictures. This combination is known as the basic multimedia principle. Second, the spatial contiguity principle recommends presenting written text in close spatial proximity to related images. The temporal contiguity principle is third and takes the concept of juxtaposition further by suggesting the presentation of spoken words in close temporal proximity to related images. Fourth, the modality principle proposes the use of spoken words instead of written text for animation. Related to modality, the specific redundancy principle clearly states that written text should not duplicate spoken words and represents the fifth principle in multimedia design. Sixth, the coherence principle advises against the use of extraneous words and pictures or unnecessary sound or music. The combination of the six principles represent an array of tools to be used by instructional designers and multimedia designers to maximize learners’ cognitive capabilities to receive and process multimedia presentations.
information; and serve as a framework for testing the *Cognitive Theory of Multimedia Learning*.

**Practical Framework**

**Designs that Motivate**

The problem is that many learners in multimedia learning environments experience a decreased intrinsic motivation to continue or complete lessons due to poor designs that negatively impact interest. Given that positive perceptions may assist in maintaining students’ interest in content, it may be worthwhile to analyze and address learners’ perceptions of multimedia (Moreno, Mayer, Spires, & Lester, 2001). Therefore, there is a need to address the problem of decreased intrinsic motivation in multimedia learning environments and propose updated design guidelines. This study will survey adult learners in a continuing education setting to determine the effect of specific media design principles on learners’ situational interest.

Design principles provided through the CTML are intended to maximize student’s understanding of learning materials. However, Keller (1983, 2010b) and Linnenbrink-Garcia et al. (2010) suggest that motivation and interest have been neglected as an influence on understanding and achievement. Further, it is important to address making the learning experience as positive as possible, ensuring that materials are useful and engaging enough to make the learning process desirable (Yu, Jannasch-Pennell, & DiGangi, 2008; Yu, Jannasch-Pennell, DiGangi, & Kaprolet, 2009). Learners exposed to multimedia in instruction report an enhanced motivation to learn the subject matter, regardless of the topic or level of difficulty (Yu et al., 2009). Similarly, multimedia presentations that incorporate text, graphics, and animations have been
shown to result in increased learner interest (Koeber, 2005; Nowaczyk, Santos, & Patton, 1998; Wekesa, Kiboss, & Ndirangu, 2006; Yaverbaum, Kulkarni, & Wood, 1997). Instructional designers influenced by an increased demand to increase learning opportunities while simultaneously reducing costs without adversely affecting instructional quality face the challenge of finding the right combination of constructive media (Holden & Westfall, 2010). Hence, research to support design considerations that enhance interest may have an impact on both practice and future research.

**Research Questions**

Based upon the outcome of the study, a number of scenarios could occur. If the hypotheses are contradicted by research findings, then future directions for research may recommend altering instruments attempting to measure situational interest or addressing other aspects of the design environment not studied, such as learner preferences or other multimedia design principles. If the proposed hypotheses are supported by research results, then improved design principles that address both cognition and situational interest of learners may be recommended for practice and future research. Implications may also include examining the other multimedia design principles for impact on situational interest. Further, supported hypotheses would strengthen the arguments to design for motivation and interest.

The following research questions and resulting hypotheses were used to test collected data:

1. What are the effects of the *modality* and *redundancy* design principles on *Situational Interest-triggered*?
2. What are the effects of the *modality* and *redundancy* design principles on *Situational Interest-maintained*?
3. What are the effects of media designed to affect *situational interest* on learner outcomes?
CHAPTER 2:
REVIEW OF RELATED LITERATURE

The literature related to studying the impact of multimedia design on situational interest has foundations in both cognitive psychology and learner motivation and interest. Theories that inform learning media selection, design, and implications are presented in order to better understand conceptual and practical frameworks. Cognitive processing theories provide insight into how learners receive and store the content provided in media selection. Further, exploring the idea of designing for motivation and what makes interest a powerful motivator strengthens the practical application of the topic. The purpose of this review is to reveal how the research that has been conducted in multimedia design can inform practice in situational interest and how research that has been conducted in situational interest can inform practice in multimedia design.

Media Selection

Before designers even begin considering how to design media for educational purposes, instructional design guidelines prescribe what to design. Instructional design is a systematic process that focuses on improving the effectiveness and efficiency of learning and instruction in various environments (Lowe & Schwen, 1975). Regardless of application, past research has shown that a systematic approach to instructional design is both logical and useful (Andrews & Goodson, 1980). Instructional designers using a systematic approach follow prescribed guidelines that impact aspects of the learning environment from instructional goals to media selection. Tosti and Ball (1969) noted that steps leading to design include selecting media to fit the prescribed presentation.
Regarding media selection, the importance of this task has not changed over the past 40 years even though processes and models have evolved. Dick, Carey, and Carey (2009) recommend making appropriate decisions regarding media selection after decisions have been made about learning components and content. Additionally, designers are tasked with selecting the best way to “package essential instructional methods based on available resources and the cost-effective qualities of media attributes for specific learners and learning goals” (Clark, 1983, p. 23). Related to media selection, Principle 3 of Merrill’s (2002) First Principles of Instruction establishes a corollary for relevant media that posits, “learning is promoted when media play a relevant instructional role and multiple forms of media do not compete for the attention of the learner” (p. 48). Although instructional design processes recommend careful consideration for selecting media, it becomes evident that the process is complex.

Media selection can be aided by taking into consideration recommended guidelines from researchers. Reiser and Gagné (1982) identified six common factors in media selection; instructional setting, learner characteristics, learning outcomes, events of instruction, physical media attributes, and practical factors of the media. A more recent review of media selection models conducted by Richey, Klein, and Tracey (2010) identified five major elements in media selection; content, learner characteristics, instructional strategies, environment, and management. A comparison and contrast of the two lists reveals that many of Reiser and Gagné’s observations have been combined into broader descriptions, such as the use of management to encompass physical media attributes and practical factors. It is important to note, however, that both lists specifically identify learner characteristics as an element. That the learner is a central component of the two studies conducted 30
years apart denotes a high level of importance in the process. Before addressing how learner characteristics fit within the design framework, it may be helpful to further explore current trends in media selection. Snyder (2009) pointed out that improvements in information technology have provided opportunities and challenges for educators to design, develop, and deliver effective instruction. Further support for this observation comes from Richey et al., (2010) as they found that newer media selection models focus on elearning environments, including web-based and computer-based instruction that facilitates any time, anywhere learning. The authors go on to note that these newer media selection models also emphasize learner activity and engagement, components that are dependent upon learner characteristics. Using the multiple resources available, designers should be well equipped to adequately address media selection.

Selecting media for learners is only the beginning and consideration for designing media must occur simultaneously with selecting media. Anglin, Towers, and Levis (1996) posited that the effective use of graphics in designing instruction is an important facet of instructional message design. This may be due to the finding that up to 40 percent of conceptual learning can be attributed to visual experience (Weber, 1922). Media are largely comprised of visual messages and have historically included photographs, drawings, diagrams, maps, and film. McKenzie (2005) noted that while the medium may not be the message, it is a significant part of the learning experience. Media, and specifically multimedia, can make a significant contribution to curriculum by representing real objects and ideas about reality that may not otherwise be possible (Cohen, 2010). Additionally, using images in instructional materials is effective in supporting learning, because they can help gain a learner’s attention and help learners
interpret and remember the context of illustrated texts (Park & Lim, 2007).
Traditionally, textbooks have used images and illustrations sparingly and in a secondary role to conveying content. As learners who are accustomed to multimedia environments become more prevalent, this method will not be able to gain or hold readers’ attention for very long (Slough & McTigue, 2010). Though advancements in technology have enabled designers to broaden visual messages to include video, animations, and icons, Baker and Dwyer (2000) and Richey et al. (2010) cautioned that not all elements of visuals are equally important for instruction. An example of the variance among visual elements includes the use of color to arouse interest, but using realistic details may distract learners from the primary task. Perhaps most significantly, Cohen (2010) stressed that multimedia selection and design must consider issues of cognitive load. By considering the instructional attributes of multimedia, a foundation can be created to assess when and how to specific elements in courses.

**Cognitive Processing**

As the use of educational technology has grown, seeking effective applications of media for learning, much of the advancements have been due to the influence of cognitive processing theories. Instruction is an art that begins by understanding and diagnosing cognitive and affective processes of learners (Mayer, 2010). Within cognitive psychology, there are a number of learning theories that contribute to the understanding of how multimedia might be presented for effective learning and performance (Lohr & Gall, 2007). Four specific learning theories are explored here in more detail due to their inter-related nature and as a foundation for subsequent research. *Information-Processing Theory* (IPT) is the result of Atkinson and Shiffrin's (1968) work that proposed a model depicting two types of memory, short-term and
long-term. Paivio (1986, 1991) extended the work conducted on cognitive processing to suggest two separate systems of memory, verbal and visual, which is now known as Dual-Coding Theory (DCT). Further application of the core components of the IPT led Sweller, van Merriënboer, and Paas (1998) to focus on the limitations of working memory. Specifically, Sweller et al. found that overloading working memory impairs learning, but underloading does not generate interest, also known as Cognitive Load Theory (CLT). In a further attempt to clarify the capacities of working memory, Baddeley (1999) posited that a central executive function focuses, switches, and divides attention using an episodic buffer to connect visual and spatial memory with auditory memory. Mayer (2001; 2002) then synthesized Information Processing Theory, Baddeley's Memory Model, Dual Coding Theory, and Cognitive Load Theory to propose that humans actively engage in learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with previous knowledge to be stored in long-term memory. Mayer (2005) later used the four learning theories to describe a framework known as the Cognitive Theory of Multimedia Learning (CTML), which is aimed at maximizing optimal learning potential in multimedia environments. Combined, research grounded in cognitive psychology has had a distinct impact on future directions for educational media design.

**Information Processing Theory**

While different models of memory exist, many currently acknowledged models trace their foundation to Information Processing Theory (IPT). Atkinson and Shiffrin (1968) established one of the first theories of human memory that considers multiple components for processing. The model proposes that memory is comprised of a sensory
register, short-term storage, and long-term storage. Figure 2 depicts the relationship described by *Information Processing Theory*.

![Figure 2. An overview of the process described by the *Information Processing Theory* (IPT)](image)

The overall process explained by *Information Processing Theory* starts with incoming sensory information and concludes with storage in *long-term memory*. The *sensory register* recognizes incoming information and begins to process it before transferring it to short-term memory for temporary storage. *Short-term memory* holds sensory information for a period of approximately 30 seconds. Incoming information may be held longer if it is rehearsed. Rehearsal depends upon the frequency of referral to the information during processing. While in *short-term memory*, information begins transference into *long-term memory*, where it is permanently stored for later rehearsal and retrieval. Retrieving information varies with time and competing information contained in *short-term memory*. Further variation is a function of the two purposes of *short-term memory*. The first function provides a separation between information being processed and the environment (Shiffrin & Atkinson, 1969). While the *sensory register* is constantly receiving incoming information from the environment, *short-term memory* is buffered from external distracters. Second, *short-term memory* acts as a working repository, allowing the individual to manipulate information as necessary. Consequently, *short-term memory* is the main component used during cognitive processing. An example of how *short-term memory* functions is the act of remembering...
a persuasive argument until the other person finishes talking. Once the argument has concluded, the information that had been stored in short-term memory is either discharged or transferred into long-term memory for later retrieval. The process explained in IPT presents a distilled rendition of complex transactions required to receive, process, and store information.

**Baddeley's Model of Memory**

During later cognitive processing studies, problems with the IPT began to emerge, leading to the clarification of short-term, or working memory. Where IPT assumed that short-term memory performed a dual role of providing working memory while also retrieving information from long-term memory, Baddeley (1986, 1992a) found that individuals with short-term memory problems possessed normal long-term memory capacity. The idea of working memory, which views the component of cognitive processing as more than just short-term storage arose out of Baddeley's (1986, 1992a, 1992b, 1997, 1999) work to resolve the conflicting explanation of short-term memory. The resulting cognitive processing model was comprised of a primary central executive control, which acts as supervisory system and controls the flow of information to and from two slave systems, and two slave systems known as the phonological loop and visuospatial sketchpad. The central executive performs four functions to control and regulate cognitive processing (Baddeley, 1996):

1. Dual-task performance
2. Retrieval plans switching
3. Selective attention
4. Long-term memory activation
Information that is received into the central executive is processed as either verbal, through the phonological loop, or imagery, through the visuospatial sketchpad (Baddeley, 1986, 1992a, 1992b; Gathercole & Baddeley, 1993). The individual components of working memory in cognitive processing provide a delineation of how specific aspects of cognition work with one another to make sense of, use, and store information.

Through the exploration of individual working memory components, further refinement of cognitive processing is possible. The phonological loop is the more simplistic of the two components and supplies two primary processes to working memory. A phonological storage holds speech-based information for approximately 1-2 seconds while an articulatory control functions as a type of inner speech (Baddeley, 1992a, 1992b). Additionally, the phonological loop uses subvocal repetition to sustain information in storage while also registering visually presented information. Where the phonological loop focuses only on speech-based information, the visuospatial sketchpad works with both visual and spatial information as well as verbal material encoded as imagery (Gathercole & Baddeley, 1993). The storage and manipulation of visual and spatial information is classified as visual, spatial, or kinesthetic in nature (Baddeley, 2000, 2007). The classification is completed in conjunction with episodic and semantic information from long-term memory and was discovered when Baddeley (2000) sought to address issues of connecting working memory with long-term memory by adding a third slave system called the episodic buffer. The buffer also serves as a limited capacity storage system controlled by the central executive and works to interface between visual, verbal, perceptual, semantic, and episodic information that is then accessed by both working memory and long-term memory. The elements of
working memory within a modified cognitive processing model are depicted in Figure 3 below. Short-term memory has been removed as a descriptor, replacing it with working memory, and the central executive with its three slave systems have been incorporated to better illustrate the relationship between working memory and long-term memory.

![Diagram of modified cognitive processing model](image)

*Figure 3.* An overview of the modified cognitive processing model with emphasis on Baddeley’s (1986, 1992a, 1992b) explanation of working memory

**Dual-Coding Theory**

The realization and acceptance of different channels to receive and process information within working memory led to further refinement of cognitive processing. Paivio’s (1971, 1990) Dual Coding Theory (DCT) assumes that the representation and processing of verbal and non-verbal information are conducted via two separate systems. The nonverbal system is responsible for information including what we see, hear, and smell. The verbal system is responsible for information including words and text. Mode-specific representations are related to their respective sensorimotor events, such as seeing pictures or hearing sounds. Once imagery and verbal codes are created, they are processed one at a time, as only one process is active at a time (Clark & Paivio,
While the verbal and nonverbal systems are functionally separate, the two systems are related in that operation of one channel can influence activation of the other system, promoting interactivity (Paivio, 1991). Further, the two systems manage representational units that are derived from information stored in long-term memory that corresponds to objects and activities as identified by each system (Paivio, 1990). Although DCT takes into consideration the ability of working memory to receive and process information via verbal and information channels, the level of detail explained by the theory is not as simple as it seems.

Examination of how processing occurs in DCT and what this means for capacity becomes an important factor in fully understanding the future of cognitive processing. Paivio (1990) explained that DCT first creates a representation of the information before referring the information to the verbal or nonverbal model and finally associates the information with existing knowledge. Referential processing involves cross-system activation where images are processed as words and words are processed as objectives. Associative processing involves activating the representation within either model, triggering association with existing information (Sadoski & Paivio, 2001). Figure 4 illustrates how cognitive processing occurs considering the explanations in DCT. Further exploration of DCT led Clark and Paivio (1991) to indicate that when learners process information that is both verbal and visual, greater learning, retention, and transfer occurs. However, too much of a burden can be placed on the processing system. Doolittle, McNeill, Terry, and Scheer (2005) found that if a system is overloaded, learning, retention, and transfer is hindered. While DCT adds further dimensionality to understanding cognitive processing, the limited capacity nature of the verbal and nonverbal systems presented challenges.
Cognitive Load Theory

The recognition of a limited capacity to *working memory* lead researchers to further refine cognitive processing. Chandler and Sweller (1991) confirmed that the verbal and nonverbal systems are interconnected and that there is a limit to the amount of information that can be processed by each system at a time. Examination of the limited capacity led Mousavi, Low, and Sweller (1995) to posit that there are four assumptions to consider when evaluating cognitive processing:

1. Humans have a limited working memory,
2. *Long-term memory* is essentially unlimited,
3. Learning is primarily conducted through schema acquisition, and
4. Automating cognitive processes can reduce the load on *working memory*.

Sweller (2005) eventually defined cognitive load as “the load imposed on working memory by information being presented” (p. 28). Underlying the definition of *cognitive load* is the assumption that cognitive processing occurs in *working memory*, and if
working memory is overloaded, then learning suffers (Paas, Renkl, & Sweller, 2003). However, the limited nature of working memory is compensated by the ability of long-term memory to store schemas (Paas et al., 2003). The schemas are constructs that organize how existing information is stored and dictate how future information will be processed (Kirschner, 2002; Sweller, 1994). The nature of schemas as constructs to organize complex or multiple ideas into singular structures allows for a reduction of the load on working memory. The added insight of CLT to cognitive processing better explains how information is received and therefore.

Missing from the explanation of cognitive load was an indication of how much information should be processed in order to take advantage of optimal cognitive processing. Paas et al.’s (2003) definition of three types of cognitive load placed on a learner provided a basis upon which load could be better understood. Intrinsic load is defined as the demands on working memory resulting from an actual instructional activity, and cannot be reduced as the load is inherent in the task (Paas et al., 2003; Sweller, 1994). The only way to reduce intrinsic load is to create a learning activity in which elements are learned in isolation. Sweller (2005) acknowledged that designers have little to no control over reducing or increasing the effect of intrinsic load on learners. Extraneous load is defined as the cognitive demand resulting from how information is presented and can interfere with learning (Paas et al., 2003). For example, using multiple sources or modes to present a learning task places a high extraneous load on a learner, who must then assimilate all of the sources in working memory in order to understand the information. (Sweller, 2005) noted that good design, following the many design principles based on CLT, reduces extraneous load. Germaine load is also influenced by how information is presented, but does not interfere
with learning (Paas et al., 2003). Instead, *germane load* is directly related to schemas and automation of cognitive processing and retrieval, which can help learners better comprehend the learning task. This results in a benefit to using multiple sources or modes to present a learning task to increase *cognitive load*. The benefit may be canceled out, however, if the sources overload *extraneous load* (Sweller, 2005). Doolittle et al. (2005) posited that *germane load* is achieved when the sum of *intrinsic load* and *extraneous load* does not exceed the limits of *working memory*. Combined, the three types of cognitive load present a balance that must be achieved in order to prevent exceeding the resources of *working memory*. If overloaded, active processing is hindered and sometimes stopped altogether (Mayer & Moreno, 1998). Thus, instructional designers should take care when structuring complex learning tasks so as to take advantage of the benefits afforded by *cognitive load* while being careful to ensure that *extraneous load* does not overload working memory. A more complete view of cognitive processing, as afforded by CLT, better describes the impact of information presentation on the ability of *working memory* and *long-term memory* to process and store information.

**Cognitive Theory of Multimedia Learning**

The increasing use of images and other media to present learning activities created a novel opportunity to further explore cognitive processing. Mayer's (2005a) investigations into cognitive processing and multimedia defined multimedia learning as a phenomenon that happens when learners form mental representations from words and pictures. Sweller (2005) supported Mayer's work when he noted that pictorial information helps individuals comprehend complex textual information. Considering the groundwork laid by Atkinson and Shiffrin, Baddeley, Paivio, and Sweller, Mayer
(2005b) developed the *Cognitive Theory of Multimedia Learning* (CTML) based on three assumptions. First, information is processed through dual channels. Second, each cognitive processing channel has a limited capacity. Third, learners actively process information in order to construct a coherent mental representation of their experience. Mayer posited five ways in which the active processing occurs through multimedia:

1. Learners select relevant words within an instructional message
2. Learners select relevant images (pictorial) from within an instructional message
3. Learners organize the selected words into logical verbal representations
4. Learners organize the selected images into logical pictorial representations
5. Learners integrate the verbal and pictorial representations into a new coherent representation

The proposed changes to the previous cognitive processing models by the CTML are depicted in Figure 5 and represent the culmination of decades of cognitive processing research with consideration towards the effect of multimedia as a means of presenting information.
An inspection of the process proposed by the CTML reveals multiple relationships between internal components. First, as the learner selects relevant words and pictures, either the eyes or ears in *sensory memory* receive the information. Both eyes and ears process words, because they can be either read or heard. The information is then transmitted from *sensory memory* to *working memory* where the images and sounds are formulated into either verbal or pictorial representations. The formation of mental representations and connections between information are constrained by the limitations on capacity as noted by (Sweller, 2005). Once the representations are formed, however, final processing occurs when the information is connected with prior knowledge and eventually stored in *long-term memory*.

Development of the *Cognitive Theory of Multimedia Learning* has provided a number of design implications for use in practice and further research. The multimedia design principles, as previously mentioned and summarized in Figure 6, are intended to dually support instructional design decisions and effective cognitive processing.
However, the recommendation of multimedia design principles does imply widespread use or a comprehensive view of learning. Mainstream instructional design practices have yet to fully embrace psychological theories (Winn, 2004). Part of the issue may be due to the fact that the CTML and related theories fail to consider other factors that influence learning, such as motivation. It was Clark (1999) who noted that most theories of multimedia learning focus on types of and strategies for knowledge while ignoring motivational issues. Nonetheless, Astleitner and Wiesner (2004) noted that there are elements of multimedia learning environments that are non-cognitive in nature. Although Harp and Mayer (1997), Mayer, Heiser, and Lonn (2001), Moreno and Mayer (2000), and Park and Lim (2007) examined the use of seductive details in multimedia and Kettanurak, Ramamurthy, and Haseman (2001) and Lawless, Brown, Mills, and Mayall (2003) evaluated learner control as a way to arouse interesting, research has continuously assumed that interest is generated as a result of multimedia elements. Although the design principles provide guidance for maximizing cognitive processing, there is no consideration for triggering or maintaining learner interest.
Motivation Theories and Learner Interest

Motivation is derived from a personal desire for specific outcomes or goals. Ryan and Deci (2000) define motivation as the “means to be moved to do something” (p. 54). Lacking an impetus or inspiration to act, a person is unmotivated. Conversely, someone who is excited or aroused towards something is considered motivated. (Deci & Ryan, 2000)’s Self-Determination Theory (SDT) posits that human motivation involves the psychological need for competence, autonomy, and relatedness. Deci and Ryan (1980, 1985, 1991, 2000) further proposed that types of motivation are differentiated based upon the reasons or goals that underlie the action. Intrinsic motivation refers to action based upon an inherent interest or enjoyment and comes from personal interest,
curiosity, or values. *Extrinsic motivation* refers to doing something based upon a separable outcome, such as a reward system, grade, evaluation, or the opinions of others. More than 30 years of research has reinforced the notion that the “quality of experience and performance can be very different when one is behaving for *intrinsic* versus *extrinsic* reasons” (Ryan & Deci, 2000, p. 55). Related, Ryan and Stiller (1991) found that *intrinsic motivation* is an important phenomenon in education. Nevertheless, many learning tasks are designed with *extrinsic motivation* in mind, which can result in resentment, resistance, and disinterest if the motivation is externally propelled (Ryan & Deci, 2000a). When learners self-endorse tasks that are attached to an extrinsic motivator, the impetus to act is derived from internal volition, but the motivator itself is still external to the learner and thus extrinsic by definition.

Understanding the differences between intrinsic and extrinsic motivation are important to researchers and practitioners, because the differences help identify ways in which to foster each type of motivation in learners.

**Interest**

Learner motivation as a consideration within learning design has a mixed history with regard to research and application. Originally, Keller's (1987) motivational design model supported the assertion that increased motivation and time on task increases learning outcomes. However, Brooks & Shell (2006) noted that very few references have been made to motivational design in instructional design literature. Keller’s ARCS model, which is largely extrinsic in design, has historically been the only mention of motivation in design (Morrison, Ross, Kemp, & Kalman, 2011). Perhaps in response to this lack of focus, Keller (2010b) revisited motivational design to produce a generalized, systematic overview of learner motivation in instructional design. The result of Keller’s
work is a book for designers providing an overview of motivational theory, a systematic motivational design process, and tools to support motivational design activities. Keller provides specific detail on the topic of interest as a subset of motivation in terms of establishing a psychological basis for relevance of motivation in learning design. The attention is likely due to the established positive link between individual student interest and academic achievement. Schroff and Vogel (2010) asserted that interest is one of the critical positive emotions in learning contexts. Similarly, Schraw, Flowerday, and Lehman (2001) noted that interest increases learning and believed that promoting interest increases students’ intrinsic motivation to learn. These findings also relate to the correlation between positive emotions, such as interest, and cognitive processes, including cognitive processing, decision-making, and creative problem-solving (Isen, Daubman, & Nowicki, 1987; Isen, Johnson, Mertz, & Robinson, 1985; Picard, 1997).

Taking into consideration earlier challenges identified with technology-enhanced learning, it appears that specifically designing media to enhance learner interest could lead to better achievement. However, first it is important to better understand the theoretical foundations of interest and how it relates to motivation.

Learning as a result of motivation has been attributed to interest. Schunk (2008) has noted that interest plays a significant role in influencing motivation. Further, Fairchild, Horst, Finney, and Barron (2005) found that interest in an activity is actually the result of intrinsic motivation. Students interested in a topic may display motivated behaviors, such as choice of the activity, effort, persistence, and achievement. Hidi and Renninger (2006) suggested that as a motivational variable, interest triggers the engagement of learners with particular classes of objects, events, and ideas over time. Thus, the effect of interest on motivation is amplified since interest is grounded in both
the affective and cognitive abilities of learners. Although Deci and Ryan (2000) proposed that *intrinsic motivation* is based upon inherent enjoyment, coming from within the learner, Hidi and Renninger (2006) found that content and environment can affect the development of interest. The information contained within a learning task, how the task is designed, and where the task is delivered all have the potential to stimulate or discourage the learner’s interest.

**Types of interest.**

The two main types of interest are individual and situational. *Individual interest* (II) refers to an individual’s predisposition towards a topic or activity based on associative, personal feelings (Rathunde, 1993; Renninger, 2000; Renninger et al., 1992; Schiefele, 1991) and *situational interest* (SI) is the result of environmental stimuli (Hidi & Anderson, 1992; Hidi & Baird, 1986; Hidi & Renninger, 2006; Krapp, 2002). Both types of interest have the potential for a positive impact on learners. Hidi and Baird (1988) found that *situational interest*, while intrinsic in nature, is encouraged by extrinsic factors. Attempting to design materials aimed at affecting individual interest is challenging and impractical. However, improving *situational interest* in learning environments should be a fundamental concern (Park & Lim, 2007). One method of designing for *situational interest* is through vividness of text (Schraw et al., 2001), where vividness is defined as “segments that stand out because they create suspense, surprise, or are otherwise distinctive” (p. 217). The effect of vividness was found by Schraw, Bruning, and Svoboda (1995) to be related positively to interest and recall. Hidi and Baird (1988) also noticed an increase in reading comprehension when studying *situational interest* and cognitive performance. There are specific benefits of *situational interest* related to learning. First, *triggered-SI*, which is typically supported
externally, precedes the development of a predisposition to repeated engagement with content. Second, *maintained-SI*, includes focused attention and persistence over time and can be preserved through meaningfulness or personal involvement (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000). Therefore, learning strategies that take *situational interest* into consideration when designing instruction have the potential to help students be engaged and focused. However, the effects of *triggered-SI* can be temporary if *maintained-SI* is not adequately considered (Hidi & Renninger, 2006; Linnenbrink-Garcia et al., 2010). As learners begin to gravitate towards activities that interest them, learning interest will become harder for researchers and practitioners to consider and apply.

**Summary of Related Literature**

This literature review identified research and practice conducted around cognitive processing and interest. The initial development of Atkinson and Shiffrin's (1968) IPT to the CTML from Mayer (2005b), cognitive processing models were thoroughly explored to provide a foundational understanding of prescribed multimedia design principles. Additionally, motivation theories, including SDT from Ryan and Deci (1999, 2000a, 2000b), *situational interest* from Hidi and Anderson (1992), and the relationship between motivation and interest were examined. Combined, these researchers present an intersection of theories that overlap and inform one another. However, cognitive psychology fails to fully address interest in practice (Chan & Ahern, 1999). In short, research that applies motivation theories in cognitive psychology fail to examine interest as a dependent variable.

Can the design principles related to cognitive processing of multimedia affect *situational interest*? The overall purpose of this literature review was to investigate
what was known about designing multimedia and discover any applicability to support designing for interest. Further research into the relevance of multimedia design principles is indicated to enable researchers to answer this question.

**Hypotheses**

The researcher holds a number of expectations regarding the research study outcomes. Specifically, it is postulated that violation of the *redundancy* design principle negatively impacts *SI-triggered*. This prediction is based upon the phenomenon of triggering as a positive reaction to the way material is presented and the negative cognitive impact inherent to narration repeating written text in an animation. If students are inundated with the same material in audio and text format, they may experience a negative reaction that inhibits motivation to continue the lesson, which may also have a long-term effect on *SI-maintained*. Further, the researcher expects a small positive impact on *situational interest* with respect to the *modality* design principle. *Modality* has been positively correlated with cognitive influence in learners. With respect to the existing training materials, a negative impact on *situational interest* is expected as the original training program design fails to take into consideration any form of multimedia design principles. As a result of these expectations, a total of 7 hypotheses were proposed. The researcher also expected that design considerations positively affecting *situational interest* also positively affected learner achievement.

1. What are the effects of the *modality* and *redundancy* design principles on *Situational Interest-triggered*?

   Hypothesis #1 *Situational Interest-triggered* will be higher in the animation-narration (AN) group than the animation-text (AT) group.
Hypothesis #2 Situational Interest-triggered will be the same in the animation-narration (AN) group as in the animation-narration-text (ANT) group.

Hypothesis #3 Situational Interest-triggered will be higher in the animation-narration-text (ANT) group than the animation-text (AT) group.

2. What are the effects of the modality and redundancy design principles on Situational Interest-maintained?

Hypothesis #4 Situational Interest-maintained will be higher in the animation-narration (AN) group than the animation-text (AT) group.

Hypothesis #5 Situational Interest-maintained will be the same in the animation-narration (AN) group as in the animation-narration-text (ANT) group.

Hypothesis #6 Situational Interest-maintained will be higher in the animation-narration-text (ANT) group than the animation-text (AT) group.

3. What are the effects of media designed to affect situational interest on learner outcomes?

Hypothesis #7 Learners in the animation-narration-text (ANT) group will score just as well as learners in the animation-narration (AN) group, which will score higher than the animation-text (AT) group.
CHAPTER 3: RESEARCH DESIGN

The design of the study was a three-group pretest-posttest stratified randomized experiment. The participants were randomly assigned to one of three groups. The independent variables were the multimedia design principles of modality and redundancy. These two design principles were chosen for the treatment redesigns for multiple reasons. First, the two principles are similar in that they both refer to the use of text and narration. In a review of the literature, only a few studies were identified that specifically address modality and redundancy beyond the original collective research prescribing and addressing all of the design principles (Aldalalah & Fong, 2010; Harskamp, Mayer, & Suhre, 2007; Moreno, 2006). Further, even if audio neither hinders nor helps multimedia learning, audio can hold learners’ interest and help develop positive perceptions of the content presented (Yu et al., 2009). The latter findings imply that the use of audio in a learning activity may have specific implications for triggering or maintaining learner interest. The dependent variables in the study were situational interest and learner achievement. All documentation for the study that was submitted to and approved by the Institutional Review Board (IRB) are included in Appendix A. While learner preference for design was considered as a possible variable for the study, it was determined that previous exposure to specific types of training may have skewed participants’ opinion of available options. For example, some participants may have only been familiar with training that is text-based with static images and not realize that other forms of multimedia courses are possible.
Participants

The context for this research study was a continuing education environment. Learners are emergency medical personnel certified at the state level as Emergency Medical Technicians (EMT), Advanced Emergency Medical Technician (AEMT), or Paramedics. To be licensed as an EMT in certain states, the individual must have completed 124 hours of classroom training and 8 hours of clinical experience. AEMTs are required to attend at least 176 hours of classroom training beyond the EMT level and an additional 24 hours of clinical experience. Licensure as a Paramedic requires 504 hours of classroom training beyond the AEMT level and 320 hours of clinical experience (Georgia Emergency Medical Services (EMS), 2008). The learners were all employed by a private emergency medical service based in the southeastern United States, and are required to complete regularly scheduled continuing education and professional development training. Traditionally, all training is designed and delivered internally by the organization. The researcher conducted the study over a period of three months, during which time all emergency medical personnel were required to complete the offered training lesson. All training materials delivered in conjunction with the study were redesigned to accommodate the specified treatment groups. After completing the training, learners answered a self-reporting questionnaire, to measure their reaction to the presentation as engaging (triggered-SI) and meaningful (maintained-SI). Participants were randomly assigned to one of the three groups and were allowed to opt out of the study at any time during delivery. All of the participants were employed by the same emergency medical service, but were based in two different cities. Furthermore, participants were unaware that they were receiving different versions of the training based upon their group assignment. An attempt was made to assign an
equal number of participants at each certification level to each group. Participants were allowed to communicate about their experience, and the researcher collected informal notes from these conversations. A total of 137 individuals participated in the study. However, after removing incomplete survey responses, only 102 responses were used in the data analysis.

**Power Analysis**

Based on the research questions, the researcher sought to examine the main effect of each design principle as well as an interaction effect between the two design principles. Using the software program G*Power (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007) as an a priori analysis tool to input a medium (.06) estimated effect size, $\alpha$ error (.05), predicted power size (.8), and number of groups, the researcher estimated that a total sample size of at least 64 participants was required for the study. Effect size is an estimation of the magnitude of the relationship between the variables. The predicted power size was selected based upon the appropriateness of the value for research in the behavioral sciences (Keppel & Wickens, 2004). Figure 7 illustrates the power analysis conducted to reach this estimate. The result of the power analysis prescribed that each treatment group was assigned at least 21-22 participants.
There were three groups in which study participants were divided. Group 1 was comprised of learners who completed the training materials that incorporated only the use of animations and text (AT) to ensure that the *redundancy* principle was followed. Group 2 was comprised of learners or completed training materials that incorporated the use of animations and narration (AN) to ensure that the *modality* principle was followed. Group 3, was comprised of learners who completed the training materials that incorporated the use of animations, narrations, and text (ANT) to ensure that both the *redundancy* and *modality* principles were followed. Note that the written text present
in the ANT group was less than that of AT group due to continued adherence to the *redundancy* principle. The narration was identical in the AN and ANT groups. Table 1 summarizes the proposed treatment design, emphasizing the presence or absence of the specific multimedia design principles. Figure 8 depicts the various groups; the “lorem ipsum” text represents placeholder text content, the circle containing two arrows represents animation sequences, and the speaker icon in the AN and ANT groups represents audio narration.

Table 1. *Research Design*

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<th>Text</th>
<th>Present</th>
<th>Absent</th>
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<tbody>
<tr>
<td></td>
<td>Group 3 (ANT)</td>
<td>Group 2 (AN)</td>
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| Group 1 (AT) | Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do.
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<tbody>
<tr>
<td>Group 2 (AN)</td>
<td>![Animation and Sound Icon]</td>
</tr>
<tr>
<td>Group 3 (ANT)</td>
<td>![Animation and Sound Icon]</td>
</tr>
</tbody>
</table>

*Figure 8. Visual representation of the research design treatment groups*

The training completed by each of the groups was created in Captivate, focusing on the inclusion of animation in all groups with individual group differences in the presence of narration and text. The AT group contained only animations, static images, and text. There was no narration used in the course. Figure 9 depicts sample content displayed in the course.
Figure 9. Typical animation sequence displayed in the AT group.

The AN group contained only animations, static images, and narration. There was no text used in the course. Figure 10 depicts sample content displayed in the course. The audio transcript of the narration was verbatim what was presented via written text in the AT group.
Figure 10. Typical animation sequence displayed in the AN group.

The ANT group contained animations, static images, narration, and written text, a written text. To avoid violating the redundancy principle, written text summarized the narration with short statements or bulleted lists of relevant information. The audio transcript in the ANT group is the same as it is for the AN group, but the written text is significantly shorter than that present in the AT group. Figure 11 depicts the same content from Figure 9 and Figure 10 as it was redesigned for the ANT group.
Data Collection Procedures

All training materials and data collection tools for the study were hosted online in an installation of the Moodle learning management system (LMS). Using an employee roster provided by the participating agency, user accounts were created and an online randomizer was used to randomly assigned learners to each group. Learners were then emailed the URL to access the study LMS, which included the consent form (Appendix A), all training materials, and the SIS form. Upon logging in, the learner was presented with a link to access their respective training course (see Figure 12). Each course included a short tutorial video that provided instructions about how to navigate the course from beginning to end (see Figure 13). Course content was broken up into six modules based upon the overall course content and structure, with each module
representing a unit or chapter (see Figure 14). The first module provided an introduction and overview of the course, and the sixth module was a conclusion summary. For an example of what a module looked like in the LMS, please refer to Figure 15. Before being permitted to proceed to the subsequent modules, the learner was presented with a one-question quiz (see Figure 16). This question was tied to content presented in the proceeding module and represented a pretest measure. Upon submitting an answer, the learner was allowed to progress to the next module and review related content. This same procedure was repeated in a content-pretest question sequence until the learner completed the sixth module. After completing the final module, the learner was taken to the self-reporting SIS survey (see Figure 17) and finally the posttest (see Figure 18). The posttest measure for the study consisted of a five-question exam that was provided by the participating service. The decision to divide the pretest as individual questions spread throughout the course and presented prior to the review of corresponding content was done to try and eliminate any unintentional impact on situational interest. As a reward for participating in the study, all participants, whether they completed the survey or not, were invited to register for a random drawing for a $50 gift card.
Figure 12. Sample log-in landing page screen.

Figure 13. Sample course navigation tutorial screen.
Figure 14. Sample course menu screen.

Figure 15. Sample module launch screen.
Figure 16. Sample one-question quiz screen.

Figure 17. Sample SIS screen.
Data Collection Instrument

With respect to dependent variables in the study, the researcher was specifically looking for effects on triggered-SI and maintained-SI. The instrument to measure situational interest was adapted for the proposed study context from the Linnenbrink-Garcia et al., (2010) scale known as the Situational Interest Survey (SIS). Participants were asked to respond to a 12-question survey using a 5-point Likert scale, from strongly agree to strongly disagree. Table 2 details the original SIS items and resulting modified instrument statements for the study. The researcher conferred with experts, including the original instrument authors, to evaluate the scale statements, in order to address initial validity concerns related to Standard 1.4 from the Standards for Educational and Psychological Testing, which holds the researcher responsible for using a scale in a way
that has not been previously validated (AERA, APA, & NCME, 1999). The correspondence with experts is provided in Appendix B. Learners’ pretest and posttest scores were captured in order to explore effects of designing for situational interest on achievement for further discussion and validation purposes. Non-interest related items on the survey instrument included age, gender, and certification level of the participant. The purpose of requesting demographic information of the participants was for describing the participant sample.

<table>
<thead>
<tr>
<th>Table 2</th>
<th><em>SIS Items</em></th>
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<tr>
<td><strong>Interest Type</strong></td>
<td><strong>Original</strong></td>
</tr>
<tr>
<td><em>SI-triggered</em></td>
<td>1. My math teacher is exciting</td>
</tr>
<tr>
<td><em>SI-triggered</em></td>
<td>2. When we do math, my teacher does things that grab my attention</td>
</tr>
<tr>
<td><em>SI-triggered</em></td>
<td>3. This year, my math class is often entertaining</td>
</tr>
<tr>
<td><em>SI-triggered</em></td>
<td>4. My math class is so exciting it’s easy to pay attention</td>
</tr>
<tr>
<td><em>SI-maintained</em></td>
<td>5. What we are learning in math class this year is fascinating to me</td>
</tr>
<tr>
<td><em>SI-maintained</em></td>
<td>6. I am excited about what we are learning in math class this year</td>
</tr>
<tr>
<td><em>SI-maintained</em></td>
<td>7. I like what we are learning in math this year</td>
</tr>
</tbody>
</table>
Table 2

<table>
<thead>
<tr>
<th>Interest Type</th>
<th>Original</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI-maintained</td>
<td>8. I find the math we do in class this year interesting</td>
<td>8. I found the information in the multimedia presentation interesting.</td>
</tr>
<tr>
<td>SI-maintained</td>
<td>9. What we are studying in math class is useful for me to know</td>
<td>9. What I studied in the multimedia presentation is useful for me to know.</td>
</tr>
<tr>
<td>SI-maintained</td>
<td>10. The things we are studying in math this year are important to me</td>
<td>10. The things I studied in the multimedia presentation are important to me.</td>
</tr>
<tr>
<td>SI-maintained</td>
<td>11. What we are learning in math this year can be applied to real life</td>
<td>11. What I learned in the multimedia presentation can be applied to my job.</td>
</tr>
<tr>
<td>SI-maintained</td>
<td>12. We are learning valuable things in math class this year</td>
<td>12. I learned valuable things in the multimedia presentation.</td>
</tr>
</tbody>
</table>

Data Analysis Procedures

Three phases of data analysis followed the data collection procedures: descriptive, two-way analysis of variance, and reliability. Data gathered from the study included responses to the SIS and final achievement score were analyzed for descriptive purposes and a multiple analysis of covariance. Furthermore, the SIS instrument was evaluated for reliability. Participants who failed to answer all questions included in the data collection instrument were eliminated from the data set.

Descriptive Analysis

A descriptive analysis was conducted on the SIS responses and pretest/posttest scores to determine the mean and standard deviation of the survey and achievement results.
Analysis of Variance

Analysis of Variance (ANOVA) using SPSS version 21.0 for Mac was conducted. ANOVA was used to investigate between group differences by calculating average item scores based upon the measured constructs (situational interest-triggered and situational interest-maintained) and achievement gained between the pretest and posttest. The dependent variables were situational interest-triggered, situational interest-maintained, and achievement gain, and the independent variable was the training group. The ANOVA was used to identify significant variance between groups, and if found, post-hoc analyses including group t-tests were used to answer the following research questions:

1. What are the effects of the modality and redundancy design principles on situational Interest-triggered?
2. What are the effects of the modality and redundancy design principles on situational Interest-maintained?
3. What are the effects of media designed to affect situational interest on learner achievement?

The Pilot Study

The pilot study for this research project was conducted during the fall of 2011. The purpose of the pilot study was to test the data collection instrument, reveal any issues with the research design, and determine if the data collection procedures are appropriate. The overall research question that framed the pilot study was: Do multimedia design principles apply to the design of multimedia to trigger or maintain situational interest?
**Pilot Study Data Collection Process**

Participants were recruited by contacting eligible EMT-Basics, EMT-Intermediates, and Paramedics via email. The email asked the individual to complete the training program online and encouraged the student to participate in the research study at the conclusion of the training. Participants were directed to a website to read and accept the research study consent form. Upon clicking on one of the four group buttons, the corresponding training program for the selected treatment group loaded. The four treatment groups included: (1) existing training materials; (2) AN redesigned training materials; (3) AT redesigned training materials; and (4) ANT redesigned training materials. At the conclusion of each training program, a screen with the link to a coded survey instrument appeared. Clicking on the link loaded a Google Form corresponding to the treatment group in which the participant originated for tracking purposes. Participants then responded to the 12 situational interest statements on the 5-point Likert scale followed by inserting their final achievement score into the corresponding field.

**Pilot Study Data Analysis**

Pilot study data were analyzed using factor analysis to confirm the presence of two dimensions measured by the SIS survey and ANOVA to gain an understanding of the relationships and differences that existed between the treatment groups, situational interest, and achievement. A total of 43 participants took part in the pilot study. The results of the pilot study were used to adjust and modify the research plan for final data collection. Adjustments included adding a pretest measure, randomly assigning participants to a research group prior to contact, and delivering the training via a LMS.
CHAPTER 4: RESULTS

The primary purpose of this study was to explore the effects of designing multimedia to increase situational interest, specifically focusing on the cognitive theory of multimedia learning’s *modality* and *redundancy* principles. This research study attempted to answer the question, “Do multimedia training courses designed based on the cognitive theory of multimedia learning’s *modality* and *redundancy* principles affect learner’s situational interest?” The study also considered the impact that the design may have had on learner achievement.

**Analysis of Data**

**Participants**

Participants in this study included 102 emergency medical personnel from a private emergency medical service based in the southeastern United States. Participants ranged in age from 22 to 65. There were 34 female and 66 male participants. Two participants declined to identify gender. A total of 38 EMTs, 1 AEMT, and 63 Paramedics participated in the study. Table 3 presents the frequencies of the demographic data collected, and Table 4 presents the ranges and average results of the survey items. It should be noted that a gain of one point on the pre- or posttest represents a twenty percent difference in score. For example, a participant could have scored a 4 on the pretest and a 5 on the posttest, which was a one point gain. The former is 80 percent correct while the latter is 100 percent.
Table 3  
*Participant Age, Gender and Certification Overall and by Groups*

<table>
<thead>
<tr>
<th></th>
<th>All Participants</th>
<th>AT Group</th>
<th>AN Group</th>
<th>ANT Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>22-34</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>35-44</td>
<td>42</td>
<td>12</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>45-54</td>
<td>32</td>
<td>8</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>55-64</td>
<td>20</td>
<td>3</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>≥65</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>66</td>
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<td>21</td>
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<td>15</td>
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<td>Declined</td>
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<td>2</td>
<td>0</td>
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<td><strong>Certification</strong></td>
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<td>14</td>
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<td>AEMT</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Paramedic</td>
<td>63</td>
<td>14</td>
<td>23</td>
<td>26</td>
</tr>
</tbody>
</table>
### Table 4
*Summary of Minimum, Maximum, and Mean Scores by Group*

<table>
<thead>
<tr>
<th></th>
<th>AT</th>
<th></th>
<th>AN</th>
<th></th>
<th>ANT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Pretest</td>
<td>0</td>
<td>3.59</td>
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<td>0</td>
<td>3.65</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>3.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Posttest</td>
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<td>5</td>
<td>3</td>
<td>4.56</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triggered SI</td>
<td>3</td>
<td>3.85</td>
<td>5</td>
<td>1</td>
<td>3.44</td>
<td>5</td>
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<tr>
<td></td>
<td></td>
<td>3.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td>2</td>
<td>3.93</td>
<td>5</td>
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<td>3.24</td>
<td>5</td>
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<td></td>
<td></td>
<td>3.56</td>
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<td>Maintained SI</td>
<td>5</td>
<td>3.56</td>
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<td>1</td>
<td>2.79</td>
<td>5</td>
</tr>
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<td></td>
<td>6</td>
<td>3.52</td>
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<td>1</td>
<td>2.88</td>
<td>5</td>
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<td></td>
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<td></td>
<td>7</td>
<td>3.74</td>
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<td>5</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8</td>
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<td>3.68</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
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<td>5</td>
<td>1</td>
<td>3.62</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td>10</td>
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<td>1</td>
<td>3.85</td>
<td>5</td>
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<td></td>
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<td>4.41</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>11</td>
<td>4.15</td>
<td>5</td>
<td>1</td>
<td>4.24</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.56</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>1</td>
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<td>5</td>
</tr>
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<td></td>
<td></td>
<td>4.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Evaluating Assumptions**

Analysis of Variance (ANOVA) was used to test hypotheses for the research questions; therefore assumptions of ANOVA were tested. The first assumption states
that dependent variables should be normally distributed. The Shapiro-Wilk normality test was used to evaluate variations from normality, and Shapiro-Wilk statistical values closer to zero are evidence of variations from the normal distribution. The Shapiro-Wilk statistic calculated for the AT group ranged from .896 to .955, of which none were found to be statistically significant at the $\alpha = .01$ level. The Shapiro-Wilk statistic calculated for the AN group ranged from .860 to .972, of which the achievement gain was found statistically significant at the $\alpha = .01$ level. The Shapiro-Wilk statistic calculated for the ANT group ranged from .914 to .965, of which the achievement gain was found statistically significant at the $\alpha = .01$ level. Based on these results, we can assume that the data collected for the dependent variables of triggered and situational interest do not significantly depart from normality within groups, but data collected for achievement gain significantly departs from normality within groups (Table 5).

Table 5
Calculated Results for the Shapiro-Wilk Test of Normality Within Groups

<table>
<thead>
<tr>
<th></th>
<th>AT</th>
<th>AN</th>
<th>ANT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic df Sig.</td>
<td>Statistic df Sig.</td>
<td>Statistic df Sig.</td>
</tr>
<tr>
<td>Triggered SI</td>
<td>.938</td>
<td>.109</td>
<td>.967</td>
</tr>
<tr>
<td>Maintained SI</td>
<td>.955</td>
<td>.290</td>
<td>.972</td>
</tr>
<tr>
<td>Achievement Gained</td>
<td>.896</td>
<td>.011</td>
<td>.860</td>
</tr>
</tbody>
</table>

The second assumption is that of homogeneity of variance. Levene’s Test was used to evaluate the homogeneity of variances for the dependent variables. The results of Levene’s Test determined that there was insufficient evidence at the $\alpha = .05$ level to
reject the null hypothesis that there is a difference between the variances in the population for triggered interest and achievement. The results of Levene’s Test for maintained interest, $W(2, 99)=3.518$, $p=.033$, was statistically significant at the $\alpha = .05$ level. The null hypothesis of equal variances was rejected, resulting in the conclusion that there was a significant difference between the variances in the population for maintained interest. The results of Levene’s Test of Homogeneity of Variances are summarized in Table 6.

Table 6
*Calculated Results for the Levene’s Test of Homogeneity of Variances*

<table>
<thead>
<tr>
<th></th>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triggered SI</td>
<td>3.711</td>
<td>2</td>
<td>99</td>
<td>.028</td>
</tr>
<tr>
<td>Maintained SI</td>
<td>3.518</td>
<td>2</td>
<td>99</td>
<td>.033</td>
</tr>
<tr>
<td>Achievement Gained</td>
<td>.277</td>
<td>2</td>
<td>99</td>
<td>.758</td>
</tr>
</tbody>
</table>

The third assumption presumes that there are equal population standard deviations. The assumption of equal standard deviations can only be approximately checked by verifying that the largest standard deviation within a variable is not more than twice the smallest. Table 7 summarizes the means, standard deviations, and reliability measures by group and verifies that this assumption has not been violated. Reliability measures were evaluated by group to evaluate internal consistency. The lowest observed Cronbach’s alpha was .90, indicating that all measures were highly reliable. Further evaluations of the assumption violations were not conducted due to desire to preserve the integrity of the data. Furthermore, there are frequent situations
in which data may have intrinsic non-normality or heterogeneity of variance (Boneau, 1960).

Table 7
*Summary of Means and Standard Deviations, and Reliability Measures by Group*

<table>
<thead>
<tr>
<th></th>
<th>AT</th>
<th>AN</th>
<th>ANT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>$\bar{X}$</td>
<td>SD</td>
</tr>
<tr>
<td>Triggered SI</td>
<td>27</td>
<td>3.732</td>
<td>.747</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>$\alpha =$ .90</td>
<td>$\alpha =$ .95</td>
<td>$\alpha =$ .90</td>
</tr>
<tr>
<td>Maintained SI</td>
<td>27</td>
<td>3.815</td>
<td>.684</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>$\alpha =$ .93</td>
<td>$\alpha =$ .94</td>
<td>$\alpha =$ .94</td>
</tr>
<tr>
<td>Achievement Gain</td>
<td>27</td>
<td>.889</td>
<td>1.188</td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>$\alpha =$ .93</td>
<td>$\alpha =$ .93</td>
<td>$\alpha =$ .93</td>
</tr>
</tbody>
</table>

**Evaluation of Data for Outliers**

The ANOVA statistical analysis used to test the hypotheses for the research questions is sensitive to extreme outliers, and calculations with data including outliers can result in Type II errors. Type II errors occur when the researcher fails to reject a null hypothesis when it is false. Therefore, all data were evaluated for outliers using normal quantile-quantile plots (Q-Q plot) (Figure 19), which is a plot of observed values against expected values in a normal distribution. All points on a Q-Q plot should lie near the straight line. Extreme variables associated with *situational interest* may be attributed to personal influences related to interest, such as personal preference for certain media. Extreme values associated with the pretest and posttest are associated
with perfect scores. Since it would be expected for some learners to attain a perfect score on multiple choice tests, no outliers were deleted from the study.

![Q-Q Plots](image1.png)

**Figure 19.** Analysis of outliers using Quantile-Quantile plots for dependent and covariate variables.

### Research Questions

**Research Question #1: What are the effects of the modality and redundancy design principles on Situational Interest-triggered?**

The first research question sought to investigate how the modality and redundancy design principles would impact triggered interest of learners. The ANOVA
revealed a statistically significant difference between training groups in triggered interest $F(2,99)=4.269, p<.05$, partial $\omega^2=.069$ (Table 8). Given the significant effect, independent t-tests were conducted to further evaluate individual hypotheses.

Table 8
Analysis of Variance for Triggered Interest

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\omega^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>6.352</td>
<td>2</td>
<td>3.176</td>
<td>4.269</td>
<td>.017</td>
<td>.069</td>
</tr>
<tr>
<td>Within</td>
<td>73.646</td>
<td>99</td>
<td>.744</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>79.998</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis #1 Situational Interest-triggered will be higher in the animation-narration (AN) group than the animation-text (AT) group.

An independent-samples t-test was conducted to compare triggered interest in the AN and AT groups. There was a statistically significant difference in the scores for the AN group ($M=3.147, SD=1.070$) and the AT group ($M=3.732, SD=.747$); $t(58.136)=2.508, p<.05$.

Hypothesis #2 Situational Interest-triggered will be the same in the animation-narration (AN) group as in the animation-narration-text (ANT) group.

An independent-samples t-test was conducted to compare triggered interest in the AN and ANT groups. There was a statistically significant difference in the scores for the AN group ($M=3.147, SD=1.070$) and the ANT group ($M=3.628, SD=.731$); $t(56.528)=2.226, p<.05$. 
Hypothesis #3 Situational Interest-triggered will be higher in the animation-narration-text (ANT) group than the animation-text (AT) group.

An independent-samples t-test was conducted to compare triggered interest in the ANT and AT groups. There was not a statistically significant difference in the scores for the ANT group (M=3.628, SD=.731) and the AT group (M=3.732, SD=.747); t(66)=.566, p=.793.

Research Question #2: What are the effects of modality and redundancy design principles on Situational Interest-maintained?

The second research question sought to investigate how the modality and redundancy design principles would impact maintained interest of learners. The ANOVA revealed a statistically significant difference between training groups in triggered interest F(2,99)=5.145, p<.05, partial $\omega^2$=.084 (Table 9). Given the significant effect, independent t-tests were conducted to further evaluate individual hypotheses.

Table 9
Analysis of Variance for Maintained Interest

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\omega^2$</th>
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<tbody>
<tr>
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<td>2</td>
<td>2.811</td>
<td>5.145</td>
<td>.007</td>
<td>.084</td>
</tr>
<tr>
<td>Within</td>
<td>54.096</td>
<td>99</td>
<td>.546</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>59.719</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis #4 Situational Interest-maintained will be higher in the animation-narration (AN) group than the animation-text (AT) group.
An independent-samples t-test was conducted to compare maintained interest in the AN and AT groups. There was not a statistically significant difference in the scores for the AN group (M=3.430, SD=.925) and the AT group (M=3.815, SD=.684); 
\[ t(59)=1.803, p=.077. \]

**Hypothesis #5** Situational Interest-maintained will be the same in the animation-narration (AN) group as in the animation-narration-text (ANT) group.

An independent-samples t-test was conducted to compare maintained interest in the AN and ANT groups. There was a statistically significant difference in the scores for the AN group (M=3.430, SD=.925) and the ANT group (M=3.973, SD=.585); 
\[ t(53.617)=2.963, p<.05. \]

**Hypothesis #6** Situational Interest-maintained will be higher in the animation-narration-text (ANT) group than the animation-text (AT) group.

An independent-samples t-test was conducted to compare maintained interest in the ANT and AT groups. There was not a statistically significant difference in the scores for the ANT group (M=3.973, SD=.585) and the AT group (M=3.815, SD=.684); 
\[ t(66)=1.017, p=.313. \]

**Research Question #3: What are the effects of media designed to affect situational interest on learner achievement?**

The third research question sought to investigate how training designed to affect situational interest of learners would impact learner achievement. The achievement gain variable was calculated by subtracting each subject’s pretest score from their
posttest score. The ANOVA revealed that there was not a statistically significant
difference between training groups and achievement gained $F(2, 99) = .003, p = .997,$
partial $\omega^2 = .000$ (Table 10).

Table 10

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
<th>$\omega^2$</th>
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<tr>
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<td>2</td>
<td>.004</td>
<td>.003</td>
<td>.997</td>
<td>.000</td>
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<tr>
<td>Within</td>
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<td>99</td>
<td>1.364</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>135.020</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Hypothesis #7 Learners in the animation-narration-text (ANT) group will score just as
well as learners in the animation-narration (AN) group, which will score higher than
the animation-text (AT) group.

The ANOVA did not find statistical significance between the training groups and
achievement gained. Therefore, there is sufficient evidence to accept the null
hypothesis.

Summary of Results

Chapter 4 presented the statistical analysis results of the effects of the modality
and redundancy design principles on the situational interest and achievement gained of
learners. The results of the analysis for the three research questions indicated the
following:

1. Training designed using the modality and redundancy design principles did
affect the triggered interest of learners.
2. Training designed using the *modality* and *redundancy* design principles did affect the *maintained* interest of learners.

3. Training designed using the *modality* and *redundancy* design principles did not affect the achievement of learners.

The summary of this research study, discussion, and recommendations for future research are presented in Chapter 5.
CHAPTER 5:
DISCUSSION

This study investigated the effects of training materials created using the Cognitive Theory of Multimedia Learning (CTML) design principles and their potential effects on the situational interest of learners. The basis of the CTML is that individuals “learn better from words and pictures than from words alone” (Mayer, 2009). Training materials developed for this study included the specific application of the modality and redundancy design principles on the triggered and maintained interest of learners as well as achievement gained during the training. The modality principle stated that individuals learn better when spoken words, or narration, are used instead of written text in animations. To adhere to the modality principle, training materials in the animation-narration (AN) and animation-narration-text (ANT) group made use of detailed audio narration in lieu of written text. The redundancy principle indicated that individuals learn better when written text does not duplicate spoken words, or narration. To adhere to this principle, training materials in the animation-text (AT) group did not contain any audio narration and training materials in the ANT group contained summarized text that did not replicate the audio narration. The SIS originally developed by Linnenbrink-Garcia et al. (2010) was adapted for use in multimedia environments and administered to learners at the conclusion of their training program to measure triggered and maintained interest as a result of the materials. A pretest was administered to learners throughout the duration of the training by revealing one question at a time prior to the presentation of relevant content. A posttest was
administered at the conclusion of both the training and Situational Interest Survey for Multimedia (SISM). Do multimedia training materials adhering to CTML design principles affect situational interest?

The present study focused on two design principles of the CTML and impact the two facets of situational interest. The first portion of the analysis investigated the triggered interest differences between the treatment groups, AT, AN, and ANT. The results of the study indicated that overall, materials designed using the modality and redundancy principles did have an effect on the triggered interest of learners.

The second portion of the analysis investigated the maintained interest differences between the treatment groups, AT, AN, and ANT. The results of the study indicated that overall, materials designed using the modality and redundancy principles did have an effect on the maintained interest of learners.

The third portion of the analysis investigated the achievement gained differences between the treatment groups, AT, AN, and ANT. The results of the study indicated that overall, materials designed using the modality and redundancy principles did not have an effect on the achievement gained of learners.

The results of the statistical analysis conducted for the three research questions resulted in three main conclusions. A discussion of this study’s limitations and each of the conclusions follows.

Limitations of the Study

The present study was conducted with a goal of maintaining high levels of rigor and ability to generalize results across populations. However, limitations existed that made this goal difficult. First, targeted participants included emergency medical services personnel employed at a specific service in the southeastern United States. It
may therefore be difficult to generalize the findings of this study to other populations. Related to this limitation, the participants were all employed in the emergency medical field. Therefore, they already possess at least a moderate interest in the subject matter. Further studies should be conducted that seek to investigate target populations whose geographical location and career choice or continuing education needs are diversified.

Second, although the sample size of the study met the minimum requirements as estimated during the power analysis, the overall number of participants (N=102) further limits the ability to generalize results to a larger population. Future studies should be conducted that include a larger number of participants.

Third, variance may have been introduced into the study based upon the setting in which participants completed the training materials and subsequent SISM. Participants were allowed to complete the data collection in a location and manner most convenient for them, which included on the job, at home, in public libraries, or in public locations on mobile devices. Interruptions may have occurred, requiring the participant to lose track of progress or repeat completed materials unnecessarily. Future studies that seek to replicate the conditions of this study and in controlled environments should be conducted for validation purposes.

Fourth, the present study used a redesigned survey instrument that had been modified from its original purpose was used to measure two of the dependent variables. While the instrument was evaluated by experts and a preliminary factor analysis was conducted during the pilot study, validity results of the statistical analysis may have been affected. Future validation studies on the instrument should be conducted.

Fifth, individual learner preferences were not evaluated during this study. Chen and Sun (2012) found that video-based multimedia generates positive emotions for
verbalizers. The current study did not survey participants regarding preferences or seek to identify how many participants are classified as a verbalizer. Therefore, learner preference represents a potential covariate that was not considered during data collection or analysis.

Finally, Type II errors may be indicated in the present study by a lack of statistical significance when comparing groups. These errors may be the result of violations of assumptions, including a lack of normal distribution with respect to achievement gained and homogeneity of variance with respect to triggered interest and achievement gained. Type II errors may also have been caused by variance introduced by allowing participants to complete the study in an uncontrolled environment. However, the presence of Type II errors should not be related to effect size measurements observed in the current study. Two of the three research questions resulted in the predicted medium effect, which estimates a moderate relationship between the variables.

**Effects on Triggered Interest**

The three hypotheses posed by the first research question were analyzed statistically to first identify if a significant effect on triggered interest occurred with relation to the training groups. Triggered interest results from changes in affective and cognitive processing and is the result of introducing environmental changes, including the way information is presented (Hidi & Baird, 1986; Hidi & Renninger, 2006; Renninger & Hidi, 2002; Renninger et al., 2004). A one-way ANOVA revealed that there was statistically significant difference between training groups in triggered interest $F(2,99)=4.269$, $p<.05$, partial $\eta^2=.079$. 

Triggered Interest: AN vs. AT

The first hypothesis sought to further evaluate the specific design effect by examining the difference between the AN and AT groups. Specifically, the researcher believed that learners in the AN group would report a higher triggered interest than learners in the AT group. Much of this hypothesis was grounded in the evidence that individuals learn better when spoken words, or narration, are used instead of written text in animations (Mayer, 2005c). Furthermore, the use of audio narration contributed to the vividness of the animation presentation, which drew upon the findings of Schraw et al., (2001) in an attempt to design for situational interest. However, the findings of the current study suggested that learners in the AT group indicated a higher triggered interest than those in the AN group. This outcome may be related to individual learners’ preferences. Plass, Chun, Mayer, and Leutner (1998) previously concluded that learner preferences related to visualizing versus verbalizing are extremely important considerations related to multimedia learning. These findings were supported by Mayer and Massa (2003), and were found to be distinctly different from cognitive ability. Given that the training materials contained a total of six videos that accounted for 21 minutes and 37 seconds of the training, there may have been an unintended design effect that contributed to a difference in interest among learners. Thus, an individual preference for visual over verbal presentation or vice versa may be responsible for the measured differences between the AN and AT groups.

Triggered Interest: AN vs. ANT

The second hypothesis examined the differences between the AN and ANT groups with respect to triggered interest. Narration was used in both groups to ensure adherence to the modality. Based upon the adherence to the modality principle alone,
the researcher presumed that both groups would report the same level of triggered interest. However, the results of the current study indicated that the ANT group reported higher triggered interest in the learning. This effect may be related to the actual designs of the training. The ANT group also contained truncated text summaries to assist with cognitive processing of the content. The text summaries were intended to reinforce the information presented via narration, but was truncated in order to adhere to the redundancy principle and prevent potential cognitive overload. This combination effect of using both the modality and redundancy principles could have been responsible for a higher interest in the design of the content. Specifically, the use of animations, narration, and text contributed to an overall vividness to the content that was unique and different from anything the leaners had previously experienced, which has been positively correlated with designing for situational interest (Schraw, Bruning, & Svoboda, 1995; Schraw et al., 2001). Thus, learners who experienced both the modality and redundancy principles in design may have a higher interest as opposed to learners who only experienced the effects of the modality design principle.

Triggered Interest: ANT vs. AT

The third hypothesis sought to further examine the specific design effect experienced between the AN and AT groups. Specifically, the researcher expected that learners in the ANT group would report a higher triggered interest than learners in the AT group. However, findings of the current study showed that the opposite outcome occurred. As previously reported, an individual preference for visual over verbal presentation could be responsible for higher triggered interest reported by the AT group. Additionally, informal conversations with the research participants revealed that variance in the setting may have had an impact on the difference between the ANT and
AT groups. Some participants reported that they completed the course on older computers with outdated software, and were therefore unable to experience the full extent of audio and animation afforded by the training in the ANT group. Furthermore, a number of participants attempted the training while on shift and experienced frequent interruptions in the training. These interruptions meant that sometimes the learner would have to repeat content multiple times in order complete a section of the course. Some users were subject to listening to and/or watching the same sequences over multiple attempts before advancing, and may have been less interested as a result of this factor. On the other hand, participants in the AT group who experienced interruptions were able to quickly identify where they last stopped in the training and resume the course at his or her own pace.

**Effects on Maintained Interest**

The three hypotheses posed by the second research question were analyzed statistically to first identify if a significant effect on maintained interest with relation to the training groups. *Maintained* interest follows *triggered* and represents a focused attention that persists over time through meaningful or personal involvement supported by external influence (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Hidi & Renninger, 2006). A one-way ANOVA revealed that there was statistically significant difference between training groups in *maintained* interest $F(2,99)=5.145$, $p<.05$, partial $\eta^2=.094$. The researcher initially believed similar hypotheses as those proposed for the first research question; that learners in the AN group would report higher *maintained* interest than those in the AT group (Hypothesis 4), learners in the ANT group would the same *maintained* interest as those in the AN group (Hypothesis 5), and learners in the ANT group would report higher *maintained* interest than those in the AT group
(Hypothesis 6). These assumptions were based on the idea that emerging interest can be maintained through continued support (Renninger & Shumar, 2004). For the purpose of the current study, continued support was provided via the implementation of the multimedia design principles. The results of the current study did not support any of the hypotheses, indicating that there was no difference in the maintained interest between learners in the AN (M=3.430, SD=.925) and AT groups (M=3.815, SD=.684); \( t(59)=1.803, p=.077 \). Additionally, there was no difference in maintained interest between learners in the ANT (M=3.973, SD=.585) and the AT group (M=3.815, SD=.684); \( t(66)=1.017, p=.313 \). However, learners in the ANT group (M=3.973, SD=.585) reported a higher maintained interest than those in the AN group (M=3.430, SD=.925); \( t(53.617)=2.963, p<.05 \).

Combined, the results of the current study are inconclusive with respect to the effects of modality and redundancy on maintained interest. That the ANT group reported a higher maintained interest than the AN group could indicate that there is a combination effect occurring by adhering to more than one principle at a time. Although, this supposition is contradicted by the equal maintained interest between the ANT and AT groups. Looking more closely at the overall design of the training in the groups, all content was divided into the same sections; Introduction, Vehicle Condition, Vehicle Accidents, Vehicle Positioning, Driving Conditions, and Conclusion. The process by which the content was partitioned is also known as segmenting and is an extended design principle for multimedia (R. C. Clark & Mayer, 2011; Mayer, 2005c). Mayer, Mathias, and Wetzell (2002) found that segmenting used in conjunction with narration had a positive impact on performance. However, in a follow-up study, Schär and Zimmerman (2007) noted that learners provided with navigation controls,
including the ability to pause animations, rarely stopped the content, allowing the sequence to play out in its entirety. Given the previous observation that learners in the current study were often interrupted and unable to complete the training all at once, this forced additional segmenting may have had a compound impact on maintained interest. That is, by having to repeatedly stop and restart content, prolonged or engaged attention to the training was unattainable.

**Effects on Achievement Gained**

The final hypothesis posed by the third research question was analyzed statistically to first identify if a significant effect on achievement gained with relation to the training groups. Seeking to address the concerns of Keller (2010b) and Linnenbrink-Garcia et al. (2010) to understand the influence of motivation and interest on achievement, the pretest-posttest element of research design was implemented in the current study. In order to reduce the possible influence a pretest and posttest may have on the situational interest of the participants, the pretest was divided into individual questions that were delivered just prior to the presentation of relative content. Further, the posttest was delivered after participants completed the SISM. Until recently, previous research studies examining motivation variables related to multimedia learning focused on access to or a choice of instructional media (R. E. Clark & Feldon, 2005). The current study only provided multimedia-based instruction and forced participants into one of the three groups rather than allowing learners to choose which version they completed. This design decision was made in part to separate interest in choice from interest in learning and focus on the designs of the training.

Based upon the previous assumptions that the AN and ANT groups would report higher triggered and maintained interest, the researcher also assumed that these two
groups would have the highest achievement gained. However, a one-way ANOVA revealed that there was not a statistically significant difference between training groups in achievement gained \( F(2,99) = .003, p = .997, \) partial \( \eta^2 = .000 \). The findings of the current study did not support the researcher’s hypothesis regarding achievement gained and indicated that there was no discernable difference in achievement gained among the groups.

Although there was no observed difference in achievement gained between the training groups, there are a number of factors that may have contributed to this finding. Bernard et al., (2004) conducted an exhaustive review of more than 200 empirical studies conducted between 1985 and 2002 where high levels of learner interest were reported and found that the same studies also reported lower levels of learner achievement. While the current study did not indicate low levels of achievement, the dissonance between learner achievement and interest may still be a variable worth exploring. The negative relationship between learner performance and motivation has been explained as relating to preference and expectations (R. E. Clark, 1982; Salomon, 1984). Personal preference and expectations are intrinsic factors within the learner while situational interest is influenced by extrinsic variables. This difference between intrinsic and extrinsic elements may explain why there was no difference in achievement gained at all as opposed to the previously observed negative relationship. The findings then suggest that designing for interest does not impact achievement gained. If there is no gain in achievement, then, why should designing for interest matter? In the specific case of adult learners and continuing education, a conscious choice is made in where to complete training requirements. When given a choice, learners will select the option they prefer or find most appealing (R. E. Clark, 1982; Salomon, 1984). Should the
findings of the current study indicate that achievement will not be influenced one way or the other, meaning the same outcome will occur regardless of design, then it may be assumed that learners would choose the more interesting of the available training. These findings are perhaps most significant to organizations and institutions who charge a fee to learners of continuing education courses. Training providers who have the resources and infrastructure available to design training to be trigger interest may find that learners return to the provider for future training needs. The increasing marketability of education and desire to show a return on investment could be an impetus to design for interest in an effort to attract and maintain customers.

Another possible explanation for an unobserved difference between training groups in achievement gained might be the segmentation effect in conjunction with the division of the pretest. The use of a pretest in the study may have increased students’ sensitivity towards the overall goal or purpose of the training, effectively alerting the learner to attach relevance and meaning to the new information (Hartley & Davies, 1976). However, there may have been an additional benefit created by breaking up the pretest into individual questions presented just prior to relative content. The resulting effect was that of an advanced organizer, or a conceptual framework that helped learners clarify the information about to be presented (Hartley & Davies, 1976). (Novak, 1980) might classify the pretest as providing a capsule of knowledge, and the context in which the pretest was delivered aligns with Mayer's (1979) suggestion that advanced organizers are most effective when “used in situations in which the learner would not spontaneously use them” (p. 415). Therefore, an unintended benefit of designing the pretest and posttest to have the least likely impact on situational interest may have
actually influenced achievement gained and explain why there were no significant differences between the training groups.

Implications for Future Theory and Practice

The prevalence of multimedia in training materials is not a new concept or a passing trend. Whether you consider the current era to be the Information Age, Digital Age, or Knowledge Society (Moore & Kearsley, 2011), educational models are changing and the demand for choices in education is increasing (deWaard et al., 2011). Multimedia still holds the promise of engaging learners in ways that traditional text and images could never deliver, and if we are to meet the increasing demands of learners, we must explore the applicability and influence of design.

Do multimedia design principles impact the situational interest of learners? The results of the present study indicated that training materials designed with the modality and redundancy design principles do have an effect on triggered interest. Overall, the results of the present study indicated that learners presented with animation and text reported the highest triggered interest with learners who received animation, narration, and text reporting slightly lower triggered interest. Learners who received animation and narration reported the lowest triggered interest. The investigation into maintained interest indicated that learners who received animation, narration, and text reported the highest maintained interest with learners who received animation and text reporting slightly lower maintained interest. Similarly, learners who received animation and narration reported the lowest maintained interest. Additionally, there was no evidence to support an effect on achievement gain based upon the design of the training materials.
Additional research is indicated by the results of the present study. Future directions may include investigating the relationship between the combination use of both the modality and redundancy design principles. When used alone, the use of narration does not appear to have as much of an influence on interest as when used in conjunction with text. Furthermore, the variance introduced in to the study by also following the extended principle of segmenting should be investigated more thoroughly. With respect to the influence of the pretest design on achievement, future studies should investigate possible covariance on both achievement and interest. This latter study should provide the pretest all at once or in advanced organizer style to evaluate potential differences. Also, repetition studies may be conducted to gain a deeper understanding of the original research questions. Increasing the number of participants in the study would most certainly provide more substantial evidence to better address the questions and also assist in validating the SISM for future use.

As a direct result of the current research study, the participating emergency medical service has implemented changes to their training procedures. Notwithstanding the statistical analysis, the service noted a marked improvement in how their employees reacted to the training they received as part of the current research study. This positive attitude change has influenced how the training director approaches internal attempts to design and deliver future training programs. Future asynchronous, online training sessions will incorporate more combinations of animation, narration, and text. The lessons developed in coordination with the current research study have been replicated and archived for the service so that all future employees may benefit from the artifacts.
As education continues to evolve to meet the demands of learners, more research on the influence of interest and related motivational factors will be necessary to help inform design decisions. Further research is necessary to understand the complex relationship between design principles and how they impact the *situational interest* of learners. Learning with multimedia will only continue to increase, and the results of this study provide one small glimpse into the possibilities for inquiry and practice.
REFERENCES


Georgia Emergency Medical Services (EMS). (2008). *Course approval-initial education for licensure*. Atlanta, GA.


doi:10.1037//0022-0663.90.1.25

Rathunde, K. (1993). The experience of interest: A theoretical and empirical look at its role in adolescent talent development. In M. Maehr & P. R. Pintrich (Eds.),


APPENDICES
Appendix A: IRB Documentation

Section A: PROJECT INFORMATION

1. Study Title: Effects of Multimedia Design Principles on Situational Interest
2. Application Type: ☐ New Project ☐ Response to Initial Review (All revisions must be in italics or different font color.) ☐ 5-Year Renewal; Previous IRB number:
3. Principal Investigator: (Must be UGA faculty or senior staff. See Eligibility to Serve as PI.)
   Name: Robert Maribe Branch
   Title: Dr.
   Department Name: Educational Psychology & Instructional Technology
   Mailing Address: 630 Aderhold Athens, GA 30602
   Phone: 7065424110 UGA E-mail (Required): rbranch@uga.edu
4. Co-Principal Investigator: (Required only if for thesis/dissertation or other student project.)
   Name: Tonia Douay
   Title: Ms.
   Department: Educational Psychology & Instructional Technology
   Mailing address: 630 Aderhold Athens, GA 30602
   Phone: 7063529459 UGA E-mail (Required): tecdou@uga.edu
5. Anticipated Start Date: (Must be at least 4 weeks after application is received.) 08/15/11

Section B: PROJECT FUNDING

1. Funding Status: ☐ Funded ☐ Pending ☐ No Funding
2. Funding Source: ☐ Internal Account #: N/A
   ☐ External Funding Source: N/A  OSP Proposal or Award #: N/A
3. Name of Proposal or Award PI (if different from PI of IRB protocol): N/A
4. Proposal or Award Title (if different from title of IRB protocol): N/A

Section C: STUDY PERSONNEL / RESEARCH TEAM

Including the PI, identify all personnel who will be engaged in the conduct of human research. Important Note: All researchers listed below are required to complete the CITI IRB Training prior to submission of this application. This application will be returned to PI for resubmission if training requirement has not been satisfied. To add more names, bring cursor to outside of last row, and press “enter” key.

<table>
<thead>
<tr>
<th>Name</th>
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<th>Institution</th>
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</tr>
</tbody>
</table>

*Submit an Individual Investigator Agreement for all study personnel affiliated with an institution that does not have an assurance with the Office for Human Research Protections or OHRP (typically, local schools, private doctors’ clinics).

Section D: PRINCIPAL INVESTIGATOR’S ASSURANCE
As the Principal Investigator, I have the ultimate responsibility for the conduct of the study and the protection of the rights and welfare of human participants. By affixing my signature below,

- I assure that all the information contained in this Human Research Application is true and all the activities described for this study accurately summarize the nature and extent of the proposed participation of human participants.
- If funded, I assure that this proposal accurately reflects all procedures involving human participants described in the grant application to the funding agency.
- I agree to comply with all UGA policies and procedures, as well as with all applicable federal, state, and local laws on the protection of human participants in research.
- I assure that all personnel listed on this project are qualified, appropriately trained, and will adhere to the provisions of the approved protocol.
- I will notify the IRB regarding any adverse events, unexpected problems or incidents that involve risks to participants or others, and any complaints.
- I am aware that no change(s) to the final approved protocol will be initiated without prior review and written approval from the IRB (except in an emergency, if necessary to safeguard the well-being of human participants and then notify the IRB as soon as possible afterwards).
- I understand that I am responsible for monitoring the expiration of this study, and complying with the requirements for an annual continuing review for expedited and full board studies.
- If human research activities will continue five years after the original IRB approval, I will submit a new IRB Application Form. (Exceptions: If the research is permanently closed to the enrollment of new participants, all participants have completed all research-related interventions, and the research will remain active only for long-term follow-up of participants; or if the remaining research activities are limited to analysis of individually-identifiable private information.)
- I understand that the IRB reserves the right to audit an ongoing study at any time.
- I understand that I am responsible for maintaining copies of all records related to this study in accordance with the IRB and sponsor guidelines.
- I assure that research will only begin after I have received notification of final IRB approval.

Signature of Principal Investigator: Robert Maribe Branch
Date: 08/02/21

Section E: CONFLICT OF INTEREST (COI)

1. Is there any real, potential, or perceived conflict of interest on the part of any study personnel (e.g., financial or business interest, stock or stock options, proprietary interest, inventorship, consultant to sponsor)?  ☐ Yes  ☐ No

2. If yes, please identify personnel and explain. Important Note: Please review the UGA Conflict of Interest Policy. Final IRB approval cannot be granted until all potential conflict matters are addressed. n/a

Section F: LAY PROJECT SUMMARY

Briefly describe in simple, non-technical language a summary of the study, its specific aim(s)/objective(s), and its significance or importance. Response should be limited to 250 words and easily understood by a layperson. This study encompasses redesigning continuing education training for paramedics and emergency medical technicians in Georgia to incorporate two multimedia design principles aimed at maximizing cognitive understanding of content. The control group and experimental groups will be asked to complete the 10-question Situational Interest Survey at the conclusion of their training to determine if either of the design principles had any effect on their situational interest. The ultimate purpose of this study is to refine multimedia design principles for practitioners and improve how multimedia is designed for learners.

Section G: HUMAN RESEARCH PARTICIPANTS
1. Provide a general description of the targeted participants (e.g., healthy adults from the general population, children enrolled in an after-school program, adolescent females with scoliosis), and indicate the estimated total number, targeted gender, and age. To add a row, bring cursor to outside of last row, and press 'enter' key.

<table>
<thead>
<tr>
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<th>Total Number</th>
<th>Targeted Gender</th>
<th>Specify age or age range</th>
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<tbody>
<tr>
<td>Paramedics and emergency medical technicians in QA</td>
<td>200</td>
<td>Male and female</td>
<td>18-65</td>
</tr>
</tbody>
</table>

2. Identify the inclusion and exclusion criteria. If two or more targeted populations, identify criteria for each.
   a. List inclusion criteria. None
   b. List exclusion criteria. None
3. If the research will exclude a particular gender or minority group, please provide justification. n/a
4. Will participants receive any incentives for their participation (e.g., payments, gifts, compensation, reimbursement, services without charge, extra class credit)?
   a. Yes
   b. No
   a. If yes, please describe. For multiple sessions, include scheme to pro-rate incentives. n/a
   b. If offering extra class credit, describe a comparable non-research alternative for receiving incentive. n/a

Section I: RECRUITMENT AND ELIGIBILITY OF PARTICIPANTS

1. Describe how potential participants will be initially identified (e.g., public records, private records, etc.). Employees of National EMS
2. Describe when, where, and how participants will be initially contacted. All participants of training programs conducted internally by National EMS after conducted after October 01, 2011 will be asked to participate in this study. The training administrator at National EMS will explain the study at the beginning of each training program. At the conclusion of the training, participants will be asked to voluntarily complete the Situational Interest Survey in addition to their regularly conducted assessment. Participants are not required to complete the survey and there is no penalty if they opt out.
3. Advertisements, flyers, and any other materials that will be used to recruit participants must be reviewed and approved before their use. Check all that apply below and submit the applicable recruitment material/s.
   - [ ] No Advertising
   - [ ] Bulletin boards
   - [ ] Electronic media (e.g., listserv, emails)
   - [ ] Letters
   - [ ] Print ads/flyers (e.g., newspaper)
   - [ ] Radio/TV
   - [ ] Phone call
   - [ ] Other (please describe)
4. Describe any follow-up recruitment procedures. n/a
5. Describe how eligibility based on the above inclusion/exclusion criteria will be determined (e.g., self-report via a screening questionnaire, hospital records, school records, additional tests/exams, etc.). All National EMS paramedics and emergency medical technicians who complete training programs conducted internally will be asked to participate.

Section II: RESEARCH, DESIGN, METHODS AND PROCEDURES

1. Describe the research design and methods of data collection. The design of the proposed study is a two-group posttest-only randomized experiment. The participants will randomly assigned to either a treatment group or a control group. Treatment groups will receive pre-designed training materials that target specific multimedia design principles. Learners will be allowed to opt out of the study at any time during the training program delivery. Learners who decide to complete the study will be administered a posttest survey (attached) that contains no identifying information.
2. If applicable, identify specific factors or variables and treatment conditions or groups (include control groups). The Control Group will receive the original training materials as designed by the training administrator. The M Group will receive training materials that have been re-designed to incorporate the modality multimedia design principle. The RM Group will receive training materials that have been re-designed to incorporate both the redundancy and modality multimedia design principles.
3. Indicate the number of research participants that will be assigned to each condition or group, if applicable. Varies by training program, will be evenly distributed
4. Describe in detail, and in sequence, all study procedures, tests, and any treatments/research interventions. Include any follow-up(s). Important Note: If procedures are long and complicated, use a table, flowchart or diagram to outline the study procedures from beginning to end. All paramedics and emergency medical technicians completing training programs conducted...
after October 01, 2011 will be invited to complete the Situational Interest Survey administered after each training delivery for a period of approximately one year.

5. **Describe the proposed data analysis plan and, if applicable, any statistical methods for the study.** Data will be analyzed with a quantitative method known as ANOVA.

6. **Anticipated duration of participation.**
   a. Number of visits or contacts: 6
   b. Length of each visit: N/A
   c. Total duration of participation: N/A

Section J: DATA COLLECTION INSTRUMENTS

List and describe all the instruments (interview guides, questionnaires, surveys, etc.) to be used for this study. Attach a copy of all instruments that are properly identified and with corresponding numbers written on them. To add a row, bring cursor to outside of last row, and press “enter” key.

<table>
<thead>
<tr>
<th>Number</th>
<th>Instrument</th>
<th>Brief Description</th>
<th>Identify group(s) that will complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Questionnaire</td>
<td>Questionnaire will collect data on participants’ perception of their situational interest with relation to the training materials they receive.</td>
<td>All participants</td>
</tr>
</tbody>
</table>

Section K: RISKS AND BENEFITS

1. **Risks and/or discomforts**
   Describe any reasonably foreseeable psychological, social, legal, economic or physical risks and/or discomforts from all research procedures, and the corresponding measures to minimize these. **Important Note:** If there is more than one study procedure, please identify the procedure followed by the responses for both (a) and (b).
   a. Risks and/or discomforts: N/A
   b. Measures to minimize the risks and discomforts to participants: Participants are under no risks or discomforts, the questionnaires are anonymous.

2. **Benefits**
   a. Describe any potential direct benefits to study participants. If none, indicate so. **Important Note:** Please do not include compensation/payment/extra credit in this section, as these are “incentives” and not “benefits” of participation in research; any incentives must be described in Section 6.4. Students perceive the training materials to be more interesting, thereby increasing motivation to complete the course and/or pay more attention to the content, which may therefore result in higher assessment scores.
   b. Describe the potential benefits to society or humankind: Knowing how multimedia design principles affect learner interest has the potential to help course and media designers improve multimedia used in learning environments.

3. **Risk/Benefit Analysis**
   a. Indicate how the risks to the participants are reasonable in relation to anticipated benefits, if any, to participants and the importance of the knowledge that may reasonably be expected to result from the study (i.e., *How do the benefits of the study outweigh the risks, if not directly to the participants then to society or humankind?*). The knowledge will aid in PI in designing a more effective multimedia and hopefully encourage other practitioners to engage in similar design practices.

4. **Sensitive or Illegal Activities**
   a. Will study collect any information that if disclosed could potentially have adverse consequences for participants or damage their financial standing, employability, insurability, or reputation (includes but not limited to sexual attitudes, preferences, or practices; HIV/AIDS or other sexually transmitted diseases; use of alcohol, drugs, or other addictive products; illegal conduct; an individual’s psychological well-being or mental health; and genetic information)?
   No
   b. If yes, explain how the researchers will protect this information from any inadvertent disclosure. N/A
5. Reportable Information
a. Is it reasonably foreseeable that the study will collect or be privy to information that State or Federal law requires to be reported to other officials (e.g., child or elder abuse) or ethically might require action (e.g., suicidal ideation, intent to harm self or others)? No
b. If yes, please explain and include a discussion of the reporting requirements in the consent document(s). N/A

Section I: DATA SECURITY AND FUTURE USE OF INFORMATION

1. Data Security
Check the box that applies.
- Anonymous – The data and/or specimens will not be labeled with any individually-identifiable information (e.g., name, SSN, medical record number, home address, telephone number, email address, etc.), or labeled with a code that the research team can link to individually-identifiable information.
- Confidential – The responses/information may potentially be linked/traced back to an individual participant, for example, by the researcher(s) (like in face-to-face interviews, focus groups). If necessary, provide additional pertinent information.
- Confidential – Indirect Identifiers. The data and/or specimens will be labeled with a code that the research team can link to individually-identifiable information. If the data and/or specimens will be coded, describe below how the key to the code will be securely maintained.
  - Paper records will be used. The key to the code will be secured in a locked container (such as a file cabinet or drawer) in a locked room. The coded data and/or specimens will be maintained in a different location.
  - Computer/electronic files will be used. The key to the code will be in an encrypted and/or password protected file. The coded data file will be maintained on a separate computer/server.
  - Other (please specify), or provide additional pertinent information.
- Confidential – Direct Identifiers. The data and/or specimens will be directly labeled with the individually-identifiable information.
  - Paper records will be used. The information will be secured in a locked container (such as a file cabinet or drawer) in a locked room.
  - Computer/electronic files will be used. The information will be stored in an encrypted and/or password protected file.
  - Other (please specify), or provide additional pertinent information.

If “Confidential” is marked, please answer all the following:
- Explain why it is necessary to keep direct or indirect identifiers.
- Identify who will have access to the individually-identifiable information and/or the key to the code.
- Public. Information will be individually-identifiable when published, presented, or made available to the public.

2. Future Use of Information
If individually-identifiable information and/or codes will be retained after completion of data collection, describe how the information will be handled and stored to ensure confidentiality. Check all that apply.
- All data files will be stripped of individually-identifiable information and/or the key to the code destroyed.
- All specimens will be stripped of individually-identifiable information and/or the key to the code destroyed.
- Individually-identifiable information and/or codes linking the data or specimens to individual identifiers will be retained. If this box is checked, describe:
  a. Retention period.
  b. Justification for retention.
  c. Procedure for removing or destroying the direct/indirect identifiers, if applicable.
- Audio and/or video recordings (if applicable) will be transcribed/analyzed and then destroyed or modified to eliminate the possibility that study participants could be identified.
- Audio and/or video recordings (if applicable) will be retained. If this box is checked, describe:
  a. Retention period.
  b. Justification for retention.
- Other (please specify), or provide additional pertinent information.
Section M: CONSENT PROCESS

Important Note: The IRB strongly recommends the use of consent templates that are available on the IRB website to ensure that all the elements of informed consent are included (per 45 CFR 116). If more than one consent document will be used, please name each accordingly.

☐ The PI is attaching a copy of all consent documents that participants will sign.
☒ The PI is requesting that the IRB waive requirement to document informed consent. A signed consent form may be waived if one of the following criteria is met, check the box that applies.
   1. The only record linking the participant and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each participant will be asked whether the participant wants documentation linking the participant with the research, and the participant’s wishes will govern; or
   2. The research presents no more than minimal risk of harm to participants and involves no procedures for which written consent is normally required outside of the research context.

The consent script or cover letter that will be used in lieu of a consent form is attached. (Choose YES or NO)

☐ The PI is requesting that the IRB approve a consent procedure which does not include, or which alters, some or all of the elements of informed consent set forth in 45 CFR 116, or waive the requirement to obtain informed consent. An informed consent may be waived if the IRB finds that all of the following have been met:
   1. The research involves no more than minimal risk to the participants;
   2. The waiver or alteration will not adversely affect the rights and welfare of the participants;
   3. The research could not practically be carried out without the waiver or alteration; and,
   4. Whenever appropriate, the participants will be provided with additional pertinent information after participation.

Provide justification for requesting a waiver.

Describe how, where, and when informed consent will be obtained from research participants (or permission from parent/s or guardian/s and assent from minor participants), if applicable.

Section N: VULNERABLE AND/OR SPECIAL POPULATIONS

1. Check if some or all of the targeted participants fall into the following groups. Important Note: Some targeted populations require compliance with additional Subparts and the completion of an Appendix or of specific section (see last column).

<table>
<thead>
<tr>
<th>Population Type</th>
<th>Required to Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant women, neonates, or fetuses</td>
<td>Appendix for Subpart B</td>
</tr>
<tr>
<td>Prisoners</td>
<td>Appendix for Subpart C</td>
</tr>
<tr>
<td>Minors</td>
<td></td>
</tr>
<tr>
<td>Mentally-disabled/cognitively-impaired/severe psychological disorders</td>
<td></td>
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<tr>
<td>Physically-disabled</td>
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<tr>
<td>Terminally ill</td>
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<tr>
<td>Economically/educationally-disadvantaged</td>
<td></td>
</tr>
<tr>
<td>A specific group based on religion, race, ethnicity, immigration status, language, or sexual orientation</td>
<td></td>
</tr>
<tr>
<td>UGA Psychology Research Pool/Other UGA students/employees</td>
<td></td>
</tr>
<tr>
<td>Other (please describe)</td>
<td></td>
</tr>
</tbody>
</table>

2. Explain justification for including the group(s) checked above in this particular study. N/A

3. Is there a working relationship between any researchers and the participants (e.g., PI’s own students or employees)?
   No
a. If yes, please describe.

4. Describe any additional safeguards to protect the rights and welfare of these participants and to minimize any possible coercion or undue influence. For example, amount of payment will be non-coercive for the financially disadvantaged, extra-careful evaluations of participants' understanding of the study, advocates to be involved in the consent process, or use flyers to recruit participants instead of directly approaching own staff or students. N/A

Section Q: COLLABORATIVE PROJECT OR OUTSIDE PERFORMANCE SITE

Check one of the two boxes below:

☐ This project does not involve any collaboration with non-UGA researchers or performance in non-UGA facilities.
☐ This project involves collaboration with non-UGA researchers or performance in non-UGA facilities (e.g., local public school, participants' workplace, hospital). If this box is checked, list all sites at which you will conduct this research. Attach authorization/permission and/or current IRB approval. Checkboxes below are not clickable so place "X" before or over the box. To add a row, bring cursor to outside of last row, press "enter" key, and copy/paste the previous cells.

<table>
<thead>
<tr>
<th>Name of Institution</th>
<th>Location (County/State/Country)</th>
<th>Authorization/permission letter and/or current IRB approval.</th>
</tr>
</thead>
<tbody>
<tr>
<td>National EMS</td>
<td>Clarke County/GA/US</td>
<td>x Attached ☐ Pending</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x Attached ☐ Pending</td>
</tr>
</tbody>
</table>

IMPORTANT NOTE: If none of the following applies to your research, this is the END of the application form.

Section P: METHODS AND PROCEDURES THAT REQUIRE ADDITIONAL INFORMATION

Check all that apply. Important Note: The items listed below are NOT an inclusive list of methods and procedures that may be used in research studies. Some procedures require the completion of an Appendix or of specific sections (see last column).

Method/Procedure Required to Complete
☐ Student research (For student's thesis/dissertation/others) ....................... Section Q (below)
☐ Deception, concealment, or incomplete disclosure ....................................... Section R (below)
☐ Internet research ............................................................................................. Section S (below)
☐ Blood sampling/collection ................................................................................ Section T (below)
☐ Clinical trial (Drugs, biologics, or devices)
☐ Genetic analyses
☐ Data/Tissue repository
☐ HIPAA (Protected health information)
☐ DXA/X-RAY
☐ MRI/EEG/ECG/NIRS/Ultrasound
☐ Other (please describe)

Section Q: STUDENT RESEARCH

Important Note: The IRB recommends submission for IRB review only after the appropriate committee has conducted the necessary scientific review and approved the research proposal.

1. This application is being submitted for: ☐ Undergraduate Honors Thesis ☒ Doctoral Dissertation Research
   ☐ Masters Thesis Research ☐ Other (please describe)

2. Has the student's thesis/dissertation committee approved this research? ☐ Yes ☐ No

Section R: DECEPTION, ConceALMENT, OR INCOMPLETE DISCLOSURE

1. Describe the deception, concealment, or incomplete disclosure; explain why it is necessary, and how you will debrief the participants. Important Note: The consent form should include the following statement: "In order to make this study
a valid one, some information about (my participation or the study) will be withheld until completion of the study."

2. Debriefing Form is attached.  ☐ Yes  ☐ No; If no, please explain.

Section S: INTERNET RESEARCH

If data will be collected, transmitted, and/or stored via the internet, the level of security should be appropriate to the level of risk. Indicate the measures that will be taken to ensure security of data transmitted over the internet. Check all that apply.

☐ A mechanism will be used to strip off the IP addresses for data submitted via e-mail.
☐ The data will be transmitted in encrypted format.
☐ Firewall technology will be used to protect the research computer from unauthorized access.
☐ Hardware storing the data will be accessible only to authorized users with log-in privileges.
☐ Other (please describe), or provide additional pertinent information.

Section T: BLOOD SAMPLING / COLLECTION

If blood will be collected for the purpose of this research, please respond to all the following:

1. Route/method of collection (e.g., by finger stick, heel stick, venipuncture):

2. Frequency of collection (e.g., 2 times per week, for 3 weeks):

3. Volume of blood for each collection (in milliliters):

4. Total volume to be collected (in milliliters):

5. Are participants healthy, non-pregnant adults who weigh at least 110 pounds? (Choose YES or NO)
   a. If no, indicate if amount collected will exceed the lesser of 50 ml or 3 ml per kg in an 8-week period and if collection will occur more frequently than 2 times per week.

6. Will participants fast prior to blood collection(s)? (Choose YES or NO)
   a. If yes, describe how informed consent will be obtained prior to fasting.
07/25/2011

Don Pruitt, Paramedic
Assistant Director of Training
National EMS, INC.

To whom it concerns,

Tonia Dousay has copies of three training classes written by either myself or David Briscoe, Director of Training for National EMS, INC., for the purpose of redesigning them to improve learning outcomes. The titles of the programs are Medical Emergencies & Pharmacology Review, Advanced Airway In-service, and Intraosseous Access. Tonia has permission from National EMS, INC., which owns them, to modify these programs as she sees fit to improve learner outcome.

For further questions or concerns regarding this matter, please contact me, Don Pruitt, at (706) 286-7007, extension 116 or at dpruitt@nationalems.com.

Don Pruitt
Consent Form

Dear Participant:

I am a graduate student under the direction of Dr. Robert M. Branch in the Department of Educational Psychology and Instructional Technology at The University of Georgia. I invite you to participate in a research study entitled Effects of Multimedia Design Principles on Situational Interest. The purpose of this study is to capture your levels of interest as it relates to multimedia lessons presented for continuing education. Your participation will involve completing the survey in the link attached and should only take about 10 minutes. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty or loss of benefits to which you are otherwise entitled. Please note that Internet communications are insecure and there is a limit to the confidentiality that can be guaranteed due to the technology itself. However, once we receive the completed surveys, I will store them in a locked cabinet in my office and destroy any contact information that I have by August 31, 2012. If you are not comfortable with the level of confidentiality provided by the Internet, please feel free to print out a copy of the survey, fill it out by hand, and mail it to me at the address given below, with no return address on the envelope.

The results of the research study may be published, but your name will not be used. In fact, the published results will be presented in summary form only. Your identity will not be associated with your responses in any published format.

The findings from this project may provide a design guidelines for future researchers and instructional designers. There are no known risks or discomforts associated with this research. If you have any questions about this research project, please feel free to call me at (706) 352-9459 or send an e-mail to teedee@uga.edu. Questions or concerns about your rights as a research participant should be directed to The Chairperson, University of Georgia Institutional Review Board, 612 Boyd GSRC, Athens, Georgia 30602-7411; telephone (706) 542-3199; email address irb@uga.edu. By completing and submitting the survey, you are agreeing to participate in the above described research project.

Thank you for your consideration! Please keep this letter for your records.

Sincerely,
Tonia Dousay
Situational Interest Survey

This survey is intended to measure your attitudes about interest in relation to the continuing education training you just received. This process should not take you more than 5-10 minutes of your time, and your cooperation is greatly appreciated. The survey is completely confidential and your participation is part of a graduate dissertation study conducted through the University of Georgia. If you have any questions about your participation in this study or how the survey results will be used, please contact Tonia Dousay at tedee@uga.edu or Dr. Robert Maribe Branch at rbranch@uga.edu.

On a scale of 1 to 5, where 1 is Strongly Disagree and 5 is Strongly Agree, please respond to each of the following statements:

The multimedia presentation was interesting.

1 2 3 4 5
Strongly Disagree Ø Ø Ø Ø Ø Strongly Agree

The multimedia presentation grabbed my attention.

1 2 3 4 5
Strongly Disagree Ø Ø Ø Ø Ø Strongly Agree

The multimedia presentation was often entertaining.

1 2 3 4 5
Strongly Disagree Ø Ø Ø Ø Ø Strongly Agree

The multimedia presentation was so exciting, it was easy to pay attention.

1 2 3 4 5
Strongly Disagree Ø Ø Ø Ø Ø Strongly Agree

What I learned in the multimedia presentation is fascinating to me.

1 2 3 4 5
Strongly Disagree Ø Ø Ø Ø Ø Strongly Agree
I am excited about what I learned in the multimedia presentation.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

I like what I learned in the multimedia presentation.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

I found the multimedia presentation interesting.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

What I studied in the multimedia presentation is useful for me to know.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

The things I studied in the multimedia presentation are important to me.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

What I learned in the multimedia presentation can be applied to my job.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

I learned valuable things in the multimedia presentation.
1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ Strongly Agree

Demographics
What is your age?
- 18-21
- 22-34
- 35-44
- 45-54
- 55-64
- 65+

What is your gender?
- Male
- Female
- Decline to answer

What is your highest level of certification completed?
- Emergency Medical Technician (EMT)
- Advanced Emergency Medical Technician (AEMT)
- Paramedic

If you would like to enter in the random drawing for participating in this study, please enter your email address below.
One participant will be randomly selected from all survey responses to receive a $50 giftcard to Galls.com.

Submit

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Report Abuse - Terms of Service - Additional Terms

https://docs.google.com/spreadsheet/viewform?formkey=dEB0b65yZ2cy4E2Ym5dYjY0c5VHd4LEBM...
IRB Approval - Branch

LaRie M Sylte <lsylte@uga.edu>
To: ROBERT C M Branch <branche@uga.edu>
Cc: Tonia Dousay <teedee@uga.edu>

Thu, Sep 8, 2011 at 10:02 PM

PROJECT NUMBER: 2012-10118-0
TITLE OF STUDY: Effects of Multimedia Design Principles on Situational Interest
PRINCIPAL INVESTIGATOR: Dr. Robert Maribe Branch

Dear Dr. Branch,

Please be informed that the University of Georgia Institutional Review Board (IRB) reviewed and initially approved your above-titled proposal through the exempt (administrative) review procedure authorized by 45 CFR 46.101(b)(2) - Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) the information obtained is recorded in such a manner that human participants can be identified, directly or through identifiers linked to the participants; and (ii) any disclosure of the human participants’ responses outside the research could reasonably place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability, or reputation.

Please note there may still be revisions requested via email during the final approval process. Final approval will be granted by the IRB Chairperson and sent via campus mail.

Please remember that no change in this research proposal can be initiated without prior review by the IRB. Any adverse events or unanticipated problems must be reported to the IRB immediately. The principal investigator is also responsible for maintaining all applicable protocol records (regardless of media type) for at least three (3) years after completion of the study (i.e., copy of approved protocol, raw data, amendments, correspondence, and other pertinent documents). You are requested to notify the Human Subjects Office if your study is completed or terminated.

Good luck with your study, and please feel free to contact us if you have any questions. Please use the IRB number and title in all communications regarding this study.

Sincerely,
LaRie Sylte
Human Subjects
Appendix B: Expert Reviewer Responses

Situational Interest Survey

Lisa Linnenbrink-Garcia <llinnen@duke.edu>
To: Tonia Doussay <teedee@uga.edu>

Wed, Jul 20, 2011 at 8:43 AM

Dear Tonia,

My apologies for the delayed response to your email. I was on vacation when you sent this and I am just now getting caught up with the correspondence that came in while I was away.

Overall - I think you adaptation will work well, but I do have a few suggestions, described by each item below.

A more general comment - for the triggered SI measures, I see that you've substituted 'multimedia presentation' for 'the teacher' - I think this will work - but just to reiterate the point of this triggered scale - the focus is on how the information is presented - it's the method of presentation rather than the content that's triggering attention.

Also - be careful about the tense throughout the items - if you're going to make it past tense - then it all needs to be this way "I am excited about what I LEARNED...." It also seems like you changed some of the items to be past tense, but not all of them.

Best wishes,
Lisa

Lisa Linnenbrink-Garcia, Ph.D.
Assistant Professor
Department of Psychology & Neuroscience
Program in Education
Duke University
247 Soc Psych Bldg.
PO Box 90086
Durham, NC 27708-0086
919-660-5649 (phone), 919-660-5726 (fax)
llinnen@duke.edu

Situational Interest Survey

Amanda Durik <adurik@niu.edu>
To: Tonia Doussay <teedee@uga.edu>

Mon, Jul 11, 2011 at 9:01 AM

Hi Tonia,

Your research sounds very exciting and I hope the scale is useful for you! I think the adaptations are very sensible. My only thought was with regard to past versus present tense. Either is fine, but it should match whether the presentation is ongoing (therefore present tense) or whether it is over (past tense).

Good luck with your research and let me know if you have further questions.

Cheers,
Amanda

Amanda M. Durik, Ph.D.
Department of Psychology
Northern Illinois University
DeKalb, IL 60115
adurik@niu.edu
Phone: 815-753-7069
Fax: 815-753-9888
Office: PM 414
# Appendix C: Raw Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th>Final</th>
<th>TI1</th>
<th>TI2</th>
<th>TI3</th>
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<th>M14</th>
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