EFFECTS OF SEGMENTING, SIGNALING, AND WEEDING ON LEARNING FROM EDUCATIONAL VIDEO

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CHAPTER I

INTRODUCTION

The use of educational video has increased over the past decade. In 2009, it became the third most popular genre for learning and reached 38% of adult Internet users (Purcell, 2010). Empirical research on the use of dynamic audiovisual learning materials in education demonstrates that learners not only prefer instructional video over text, but are also more likely to gain deeper conceptual understanding of the content from video than from words alone (Baggett, 1984; Mayer, 2002, 2003; Mayer & Moreno, 2002). In many learning contexts, knowledge acquisition is better achieved through presenting materials in formats optimized to use both the visual and auditory sensory channels at the same time (Mayer, 2001). Content presented in video is also more memorable than text-based instruction (Jonassen, Peck, & Wilson, 1999). A major assumption underlying this empirical work is that humans can construct a mental representation of the semantic meaning from either auditory or visual information alone, but when instruction is presented in both formats, each source provides complementary information that is relevant to learning (Baggett, 1984).

At the same time, other empirical evidence suggests that video, like other dynamic and complex audiovisuals, may be no better than a series of equivalent content static images because dynamic visuals is difficult for students to perceive and understand, and may interfere with successful learning (Catrambone & Seay, 2002; Hegarty, Kriz, & Cate, 2003; Hegarty, Narayanan, & Freitas, 2002; Mayer, 2005; Tversky, Morrison, & Betrancourt, 2002).

The perceived difficulty of the learning materials may also be increased, in particular for novice students, because they do not possess adequate knowledge to discriminate relevant from irrelevant information (Bromage & Mayer, 1981; Graesser, 1981) and are often distracted by focusing on non-essential features of presentations at the expense of more important information (Lowe, 1999, 2003).

Statement of the Problem

Video requires high levels of cognitive processing to synthesize the visual and auditory streams of information and to extract the semantics of the message (Homer, Plass, & Blake, 2008). This increased processing increases the learner's cognitive load, especially when students are novices in the knowledge domain and lack appropriate prior knowledge to guide their attention (Moreno, 2004; Sweller, 1999). Therefore, a key problem in using video as an instructional device is how to direct learners' attention to relevant information and decrease cognitive load, creating conditions for the learners' cognitive system to meet the processing demands that are needed to organize and integrate knowledge from a stream of visual and auditory information. More specifically, cognitive researchers have identified three major challenges in using audiovisuals in instruction: (1) the transitory nature of the dynamic materials, (2) the difficulty of focusing students' attention on essential information in the complex and fast stream of visual and verbal information, and (3) the inclusion of extraneous content that competes with the essential information for limited cognitive resources (e.g., Ayres & Paas, 2007; Lowe, 1999, 2003; Tversky, et al., 2002).

Theoretical Framework

In an attempt to overcome the challenges associated with processing information from multimedia materials, such as video, cognitive scientists have developed a number of theories to explain learning from materials rich in media and have proposed design principles to manage learners' cognitive load and to enhance knowledge acquisition. Cognitive Theory of Multimedia

Learning (CTML) (Mayer, 2001) and Cognitive Load Theory (CLT) (Sweller, Van Merrienboer, & Paas, 1998) help explain and predict learning from educational multimedia. Both theories were tested in multimedia instructional environments (Moreno, 2006) and are based on assumptions regarding the relationship between cognition and learning from dual representation information formats.

Five of these assumptions are particularly relevant to learning from video. First, *the cognitive architecture assumption* postulates that the human mind consists of an unlimited, long-term memory (LTM) in which all prior knowledge is stored and a limited working memory (WM) in which new information is processed. Second, *the dual-channel assumption* proposes that WM has two channels for visual/pictorial and auditory/verbal processing and that the two channels are structurally and functionally distinct (Clark & Paivio, 1991). Third, *the limited capacity assumption* states that each channel has limited capacity for information that can be processed at one time (Baddeley, 1986; Baddeley & Logie, 1999). Fourth, *the active processing assumption* explains that humans actively engage in the cognitive processes to select relevant verbal and non-verbal information from the learning materials, organize the selected information into cognitive structures, and integrate these cognitive structures with the existing knowledge to construct a new (or update an old) mental representation (Mayer, 1996a). Finally, *the cognitive load assumption* maintains that during learning, humans are typically exposed to three types of cognitive load that compete for the limited resources of WM: (1) intrinsic load is the cognitive processing required to comprehend content, (2) extraneous load is caused by ineffective formats of content presentation, and (3) germane load, which is beneficial to learning, enables learners to engage in deeper cognitive processing of the to-be-learned material (Sweller, et al., 1998).

According to CTML and CLT, integrating complex learning material into LTM may burden the limited cognitive resources of the learner. In the case of learning from video, the human cognitive system can process only small portions of the large amounts of visual and auditory stimuli received. Unlike processing printed text, learners in formal educational contexts typically do not have the opportunity to stop the video presentation and reflect on what was learned and identify potential gaps in their knowledge. Thus, information processing in this situation frequently requires longer and more intense periods of cognitive and metacognitive activity. Regardless of the amount of information presented in each sensory channel, the learner's WM will accept, process, and send to LTM only a limited number of information units (Attneave, 1954; Jacobson, 1950, 1951). Thus, working memory requires direct prompting to accept, process, and send to the long-term storage only the most crucial information (Clark, Nguyen, & Sweller, 2006).

Empirical research informed by CTML and CLT suggested a number of prescriptive principles to help multimedia designers create learning materials that are better aligned with human cognitive architecture. These design principles can be categorized into two groups. The first group comprises strategies aimed at reducing extraneous cognitive load (i.e., processing that is not related to the instructional goal) and increasing germane load (i.e., processing that results in deeper learning). These strategies include adding cues to signal the main ideas (called *signaling*) and eliminating the unnecessary content from learning materials (called *weeding*). In signaling, the presentation's main ideas are summarized and highlighted to aid learners in selecting relevant information and organizing it into coherent mental representations. In weeding, non-essential content is eliminated in order to allow students to engage in processing only the essential content. The second group of design principles is aimed at managing intrinsic cognitive load (i.e., essential processing related to the learning goal), such as dividing the presentation into small units, called *segmentation*. With segmentation, learning material is broken up into several segments of information to help students process one cluster of related information elements before moving to the next one.

Purpose Statement

Prior research on multimedia learning demonstrates that when applied individually segmentation, signaling, and weeding (SSW) can effectively decrease learners' self-reported mental effort (e.g., Mayer, 2001; Mayer, Mathias, & Wetzell, 2002; Moreno & Mayer, 1999; Pollock, Chandler, & Sweller, 2002) and improve knowledge acquisition (Mayer & Chandler, 2001; Mayer & Moreno, 2003; Mayer, Moreno, Boire, & Vagge, 1999). For example, with segmentation, learners are able to process pre-structured information and maintain the cognitive capacity necessary to understand the learning content, which results in improved transfer of knowledge (Mayer & Chandler, 2001). In signaled multimedia presentations, learners can build a mental outline of the presentation, which improves both the retention and transfer of knowledge (Mautone & Mayer, 2001). Similarly, applying weeding to multimedia learning materials was found to reduce extraneous cognitive load and improve learners' transfer of knowledge (Mayer, Heiser, & Lonn, 2001).

While numerous studies applied the segmentation, signaling, and weeding principles to the design of animations, hypermedia, and educational games (Mautone & Mayer, 2001; Mayer & Chandler, 2001; Mayer, et al., 2001; Moreno & Mayer, 2000), little research has examined the effects of these design principles in the context of educational video. Moreno (2007) analyzed the effect of directing attention to relevant information with signaling and segmentation (SS) in dynamic audiovisuals. In this study, instructional video and animation were designed using the SS principles and compared to video and animation designed without SS. The findings showed that, while the non-SS group outperformed the SS group on the retention of conceptual information, the SS group performed better on the test of knowledge transfer and reported lower levels of cognitive load.

Research Questions

The present study builds on prior research in two important ways. First, the study examines how the segmentation, signaling, and weeding design principles in educational video affect students' cognitive load and learning outcomes as compared to students learning from a non-SSW version of the same video. The second contribution is to outline a theoretical and empirical basis for the domain of educational video design. Many of the design techniques that are used in educational video today reflect the subjective perceptions of “what works best” acquired through the designer’s personal experience and what is considered best practices in the field, rather than empirical evidence (Najjar, 1996; Wetzel, Radtke, & Stern, 1994). Another challenge in educational video design has been to identify information presentation techniques that facilitate higher-order learning, such as transfer of knowledge and structural knowledge acquisition (Gerjets, Scheiter, & Catrambone, 2004). Enhancing knowledge transfer is particularly important because successful instruction should not focus exclusively on the retention of knowledge but should also encourage creative applications of newly acquired knowledge in novel situations (Sternberg & Mio, 2009).

Specifically, this study was guided by these three research questions:

1. Will the SSW intervention affect the perceived learning difficulty of novice learners in the context of educational video?
2. Will the SSW intervention affect retention of knowledge, knowledge transfer, and structural knowledge acquisition for novice learners in the context of educational video?
3. Will the SSW intervention improve far transfer of knowledge and structural knowledge acquisition to a larger extent than retention of knowledge for novice learners in the context of educational video?

Research Hypotheses

Research question 1: Will the SSW intervention affect the perceived learning difficulty of novice learners in the context of educational video?

According to CTML, multimedia learning materials designed using signaling and short, concise segments help reduce extraneous cognitive load (as reflected by perceived learning difficulty; Kalyuga, Chandler, & Sweller, 1999) because the learner is primed to engage in the processing of conceptually distinct clusters of information elements (Mautone & Mayer, 2001; Mayer, et al., 2002; Moreno & Mayer, 1999; Pollock, et al., 2002). In contrast, in an embellished and long instruction, extraneous material competes with and consumes the learner's limited cognitive resources and results in increased extraneous cognitive load (Bruenken, Plass, & Leutner, 2004; Cennamo, 1993).

The hypothesis associated with the first research question in this study was that applying SSW in educational video would decrease perceived learning difficulty. Evidence for this hypothesis was reported in a study by Moreno (2007), where participants who studied a segmented version of classroom video (experiment 1) or animation (experiment 2), reported lower mental effort and perceived the learning materials as less difficult than participants who studied using non-segmented versions of the material. Evidence was also found in five studies where students reported low mental effort and demonstrated better learning outcomes when extraneous material was removed from multimedia presentations (Mayer et al., 2001, Experiments 1, 3, and 4; Moreno & Mayer, 2000, Experiments 1 and 2). Similarly, reduction in self-reported mental effort was reported by participants in a study using a segmented narrated animation explaining the formation of lighting, as compared to the control group that learned from a continuously narrated animation (Mayer & Chandler, 2001).

Research question 2: Will the SSW intervention affect retention of knowledge, knowledge transfer, and structural knowledge acquisition for novice learners in the context of educational video?

The dynamic and continuous stream of visual and auditory information in educational video may overwhelm novice learners, who lack adequate levels of prior knowledge in the learning domain to inform the selection of relevant information. Empirical evidence demonstrates that novice learners lack the necessary knowledge to identify the most relevant parts of an instructional animation (Kettanurak, Ramamurthy, & Haseman, 2001) and tend to focus their attention on perceptually salient rather than thematically relevant, information in animations (Lowe, 2003).

It was hypothesized that the SSW intervention in educational video would facilitate students' selecting, organizing, and integrating processes, which will result in improved learning outcomes on the tests of knowledge retention, transfer of knowledge, and structural knowledge acquisitions. Preliminary evidence suggests that novice learners do not seem to have enough time to engage in adequate processing of verbal and visual information when they are exposed to continuous multimedia presentation (Mayer & Chandler, 2001). Supporting evidence for the positive affect of segmentation was found in a study where students who viewed segments of a narrated animation outperformed their counterparts who viewed the non-segmented narrated animation when retention, visual-verbal matching, and knowledge transfer were measured (Mayer, et al., 1999). Another study showed that students who received segmented lessons about electric motors performed better on transfer tests compared to students who received continuous lessons (Mayer, Dow, & Mayer, 2003). Signaling is another multimedia design principle that aides cognitive processing (Boucheix & Lowe, 2010; De Koning, Tabbers, Rikers, & Paas, 2010; Mautone & Mayer, 2001). Because signaling reduces the extraneous processing of irrelevant information, the SSW group in the present study was expected to outperform the non-SSW group on all measures of learning outcomes. Structural knowledge was added as a relevant dependent measure based on the assumption that segmenting and adding signals to the learning materials aids students in recognizing the structure of the main concepts within itself and in relation to other concepts in the video (Tennyson & Cocchiarella, 1986).

Empirical evidence also suggests that novice learners tend to engage in both essential and incidental processing, which together exceed their available cognitive capacity (Mayer, et al., 2001; Moreno & Mayer, 2002). Therefore, weeding (i.e., removal of non-essential content) can hypothetically prevent the learner from engaging in incidental processing so that more cognitive resources can be devoted to the processing of essential content. This result was obtained in a study where a weeded and concise animation aided students in selecting relevant information compared to a narrated animation that included irrelevant material (Mayer, et al., 2001). In two other studies students were presented with an animation and concurrent narration intended to explain the formation of lightning (Experiment 1) or the operation of hydraulic braking systems (Experiment 2). For some students, the authors added background music, sounds, both, or neither. On tests of retention and transfer, the groups receiving both sound and music performed worse than the group that received neither, groups receiving music performed worse than groups not receiving music, and groups receiving sounds performed worse than groups not receiving sounds (Moreno & Mayer, 2000).

Research question 3: Will the SSW intervention improve far transfer of knowledge and structural knowledge acquisition to a larger extent than retention of knowledge for novice learners in the context of educational video?

CTML design principles provide ways of creating multimedia presentations intended to promote deeper learning and provide cognitive support (Mayer, 2005). Prior research on cognitive scaffolding tools, such as advance organizers, demonstrates that most of the empirical studies found no significance difference between the experimental groups on the tests of knowledge retention, but the treatment groups did tend to outperform control groups on the tests of knowledge transfer (e.g., Mayer, 1979, 2003). Therefore, it was hypothesized that students learning from video with SSW would have more cognitive resources to engage in higher-order thinking (analysis, synthesis, evaluation of information) and would perform better on the tests of knowledge transfer and structural knowledge than on the test of knowledge retention. This hypothesis is also supported by the results of a recent study where students in non-signaling and non-segmentation video groups outperformed signaling and segmentation groups on retention tests, but underperformed on transfer of learning measures (Moreno, 2007).

In summary, this study tested the following three hypotheses:

1. Novice learners in the SSW video group will report lower levels of learning difficulty than their counterparts in the control group.
2. Novice learners in the SW video group will improve in overall knowledge acquisition (retention, far transfer, and structural knowledge) in the context educational video.

3. Novice learners in the SSW video group will outperform the control group on the tests of knowledge transfer and structural knowledge acquisition, but not on the test of knowledge retention.

Definition of Terms

Educational Video—a stream of visual and auditory media presented simultaneously and intended to facilitate learning.

Educational Multimedia—educational presentations containing any combination of text, still images, animated images, motion pictures, sound effects, narration and background music.

Signaling—adding cues that signal the main ideas and concepts of the learning materials.

Segmenting—breaking up the learning presentation into short units such as topics or lessons.

Weeding—eliminating unnecessary or redundant content from learning materials.

Structural knowledge—the concepts operational structure within itself and between associated concepts.

Knowledge Transfer—applying knowledge from one context (in which the knowledge was acquired) to another novel context that had a different underlying structure than those presented in the learning materials.

Cognitive Load—mental effort required to process information. The three types of cognitive load are as follows:

- Intrinsic load: the mental effort caused by the inherent complexity of to-be-learned information.
- Extraneous load: the mental effort imposed by the design and presentation of to-be-learned information.

- Germane load: the mental effort exerted by learners to process new information to integrate into existing knowledge structures.

CHAPTER II

REVIEW OF THE LITERATURE

The Benefits of Using Video in Education

Advancements in information and communication technologies resulted in the renewed interest of the educational community in multimedia learning materials. Much of the recent discussion has focused on the educational benefits of multimedia to optimize learners' cognitive processing of essential learning content and to facilitate organization and integration of complex information. One specific multimedia format—educational video—has been described as important in helping students acquire knowledge due to its capability to present learning content dynamically and its use of multiple media, such as still and moving images, audio, and animations (Baggett, 1984; Mayer, 2005; Shepard, 1967). Since the advent of television, multiple empirical studies on the use of dynamic audiovisuals in education have demonstrated that students not only prefer educational video over text, but are also more likely to gain deeper learning from video than from words alone (Baggett, 1984; Mayer, 2002, 2003, 2005; Mayer & Moreno, 2002; Salomon, 1984; Shepard, 1967; Wetzel, et al., 1994). Researchers suggested that because audiovisuals contain two representations, visual that conveys information about objects and its relation to other objects, and verbal that communicates abstract meaning and special attributes of this information, a combination of both representations should increase the learning effect (e.g., Guttormsen, Kaiser, & Krueger, 1999; Hegarty, et al., 2003; Lowe, 1999).

Moreover, watching the changes of visual information, rather than mentally inferring this information, helps learner to free up cognitive resources to organize and integrate information more effectively and efficiently (Hegarty, et al., 2003; Schnotz & Rasch, 2005). Dynamic visualizations are also perceived by students as useful due to their ability to present content that is difficult to verbalize but easy to demonstrate (e.g., Chandler, 2009). For example, videos help students observe complex natural processes (e.g., the formation of lightning; Mayer & Chandler, 2001), mechanical systems (e.g., an electric motor; Mayer, et al., 2003), procedures involved in performing a task (e.g., first aid, Arguel & Jamet, 2009; or solving probability calculation problems; Spanjers & Van Merrienboer, 2010), laboratory experiments, and field observations (DiPaolo, 1995).

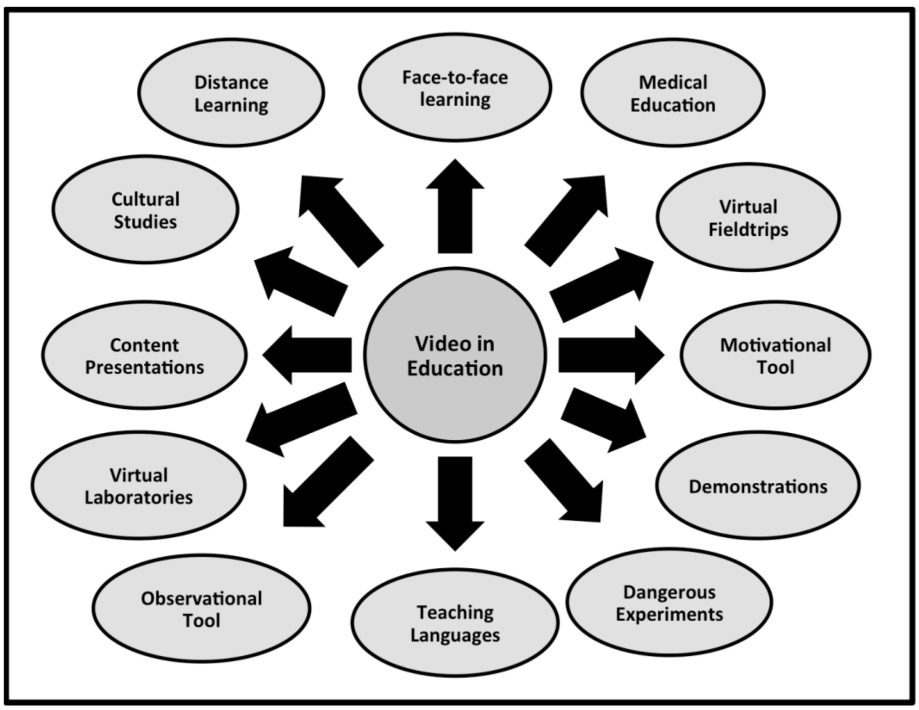

Figure 1: Educational uses of video

Audiovisuals can help students acquire deeper and more flexible knowledge structures in many learning situations. For example, in learning foreign languages, video helps students to hear and see native speakers and acquire skills in reading, writing, speaking and listening (Dhonau & McAlpine, 2002; White, Easton, & Anderson, 2000). In online and distance learning, video can be used to serve a wide geographic area, where it is otherwise impossible for learners to attend face-to-face classes (Carnevale & Young, 2001). Figure 1 provides additional examples of the educational uses of video.

The Challenges of Using Video in Education

Despite the vast amounts of evidence on the benefits of audiovisuals in learning, educational research on the use of video also shows that learning materials using multiple formats of knowledge representation can place increased cognitive demands on learners' WM (Mayer, 2001). In the context of learning from video, students need to process a continuous stream of large amounts of visual and verbal information, focus their attention simultaneously on both representations, select and relate these representations together, organize and evaluate their interactions, and finally construct and integrate coherent mental representations into LTM (Lowe, 1999; Mayer & Moreno, 2003). These mental processes impose a high cognitive load on learners' cognitive systems and impede learning. More specifically, dynamic audiovisual materials place excessive demands on learners' cognition due to (1) their transitory nature; (2) their compositional complexity (i.e., a fast stream of visual and verbal information); and (3) the inclusion of extraneous content, such as background music, that competes with the essential information for learners' limited cognitive resources (Ayres & Paas, 2007; Lowe, 1999; Tversky, et al., 2002).

First, information in dynamic visualizations is transient; that is, information appears briefly and is continuously replaced with new information—what is visible at the present moment has to make way for other information presented in the subsequent moment (Ayres & Paas, 2007). In this condition, students are forced to process information that is shown very briefly and that disappears before it can be consciously selected for further processing, unless some kind of trace in which key points are kept, is available (Paas, Van Gerven, & Wouters, 2007). During the viewing of video, learners not only need to integrate this new information with existing knowledge that is stored in the LTM, but also with previously presented information that has to be kept active in the WM. This transiency in information presentation causes challenges for learners because there is only a limited amount of time in which relevant information can receive attention before it decays and is replaced by other information. Consequently, it becomes more difficult for the learner to recognize what elements of the content are relevant, causing the learner to split his or her visual attention over different components of the presentation. Tversky et al. (2002) suggest that failure to find improved learning from animations may be due to the fact that animations are often "too complex or too fast to be accurately perceived" (p. 247). Several studies have shown empirically that learning from animations is hindered if the presentation speed is too high (e.g., K. Meyer, Rasch, & Schnotz, 2010), or if attention is distracted by irrelevant movements in the animation (e.g., Lowe, 1999). Thus, the transient nature of video is assumed to have serious implications for WM and may result in decreased knowledge acquisition (Ainsworth & Vanlabeke, 2004; Arguel & Jamet, 2009; Ayres & Paas, 2007; Paas, Tuovinen, Tabbers, & Van Gerven, 2003) (see Figure 2).

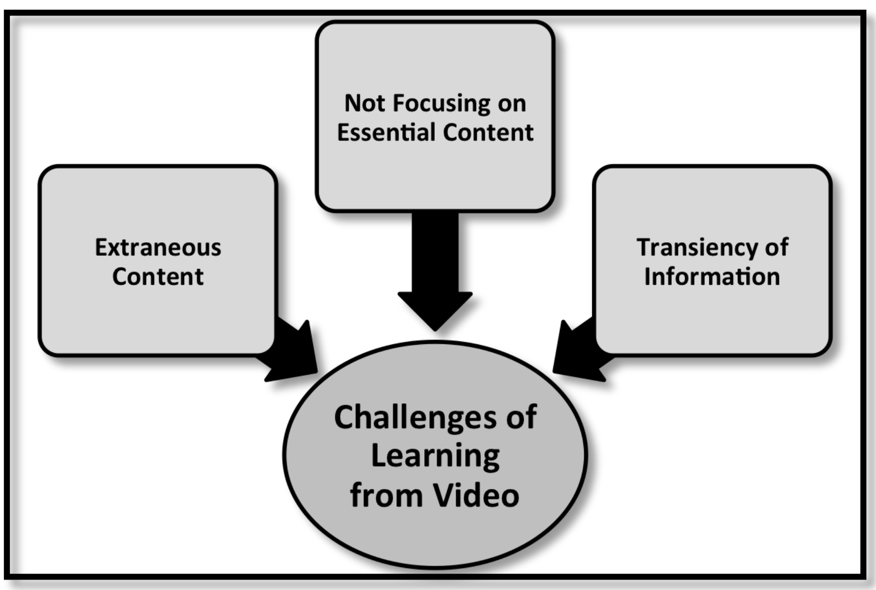

Figure 2: Problems associated with learning from audiovisuals

Second, dynamic audiovisual presentations require students to simultaneously attend to many elements that move from one location to another and might change with respect to different perceptual attributes (e.g., color, form, orientation). Learners are required to organize and integrate new information, while extracting the conceptual and structural meaning behind presented concepts and then use the newly created knowledge representations as the basis for further processing. Learners' abilities to succeed in these tasks largely depends on the proper allocation of attention (Gaddy, Sung, & Van den Broek, 2001). Because novice learners frequently do not possess an adequate knowledge base to discriminate relevant information from irrelevant, they become at risk of focusing on non-essential information and drawing inaccurate conclusions (Bromage & Mayer, 1981; Graesser, 1981). For example, when the learner is unfamiliar with a topic, he or she may find it difficult to recognize the main ideas in a presentation or select the relevant elements in a multimedia presentation. The lack of learners' sustained attention on relevant content is also caused by objects that are high in their perceptual salience. This is especially evident in situations where the thematically relevant aspects are not the most salient in the presented materials (Lowe, 1999, 2003) and with field-dependent students, who do not possess the necessary skills to distinguish relevant information that is "hidden" in a presentation (Witkin, Moore, Goodenough, & Cox, 1977).

Finally, audiovisuals often include much extraneous visual and verbal material (i.e., the so-called "bells and whistles"), such as embellished narration, background music, or graphics, which may be appealing to students but do not contain any essential information. In these situations, learners are forced to simultaneously engage in essential and incidental cognitive processing, which increases the chances of overwhelming the learner's cognitive capacity to understand and internalize essential content. There is ample research showing that essential and incidental processing of content creates a mental burden, rather than improves learning (e.g., Mayer, et al., 2001; Mayer & Moreno, 2003; Moreno & Mayer, 2000). Increased cognitive demands caused by incidental processing leave fewer cognitive resources for essential processing, and, therefore, learners are less likely to engage in knowledge organization and integration that is necessary for meaningful learning.

Although these three challenges may arise independent of each other, they are most likely to interact and cause undesirable outcomes, such as increased cognitive load, that interferes with effective learning (Bruenken, et al., 2004; Hanson, 1989; Homer, et al., 2008). For example, focusing attention seems especially relevant for a novice learner if the information includes essential and extraneous content that is available on screen for a brief time. Clark, Nguyen, & Sweller (2006) argued that extracting a message for novice learners from a fast presentation is often challenging and burdens their WM causing the brain to process only small proportions of the large amounts of stimuli received. Therefore, it is recommended that audiovisual designers use techniques that guide learners' attention at the right moment to the right information in the display (Schnotz & Lowe, 2008).

Multimedia Design Theories and Principles

Cognitive Theory of Multimedia Learning (Mayer, 2001) and Cognitive Load Theory (Sweller, 1999) provide a useful framework to explain the cognitive processing during learning from educational video. This framework is based on the idea that learning occurs when students actively construct knowledge representations, and these knowledge structures are the result of constant interaction between the highly transient sensory store; the limited-capacity WM and LTM, which has a virtually unlimited capacity.

Learners acquire information through the sensory registers (e.g., eye, ear), and store it in the sensory store that briefly holds raw, unprocessed information until the stimulus pattern is recognized or lost. Pattern recognition involves the matching of stimulus information with previously acquired knowledge (Moore, Burton, & Myers, 1996). Sensory registers consist of two separate channels: one for the processing of visual or pictorial information and one for the processing of auditory or verbal information (Baddeley, 1986; Baddeley & Logie, 1999; Paivio, 1986). Because each channel has a relatively limited capacity, it is easy for the cognitive system to become overloaded if more than a few segments or chunks of novel information are processed simultaneously (Baddeley, 1986; Miller, 1956; Sweller, 2003). Presenting unique information in both visual/pictorial and auditory/verbal formats allows the learner to use both information processing channels at the same time and enables the learner to construct integrated mental models that make the retrieval of the information more likely (Paivio, 1986; Plass, Chun, Mayer, & Leutner, 1998).

The information is then retained in the WM. Klatzky (1975) defined WM as a work space in which information may be rehearsed, elaborated, used for decision making, lost, or stored in the third memory structure. Due to these functions, Working memory has also been equated with consciousness (Sweller, et al., 1998). WM is described as the bottleneck of human cognitive system having very limited duration and capacity. It can store information for only about 30 seconds (Peterson & Peterson, 1959), and only about seven, plus or minus two, information segments (chunks), can be processed in it at any given time (Miller, 1956). The exact number of items has been shown to depend upon a number of factors, such as age, level of fatigue, expertise in the content area, complexity of information, and priming (e.g., Baddeley, 1992; Baddeley, Thomson, & Buchanan, 1975; Stoltzfus, Hasher, & Zacks, 1996). Working memory can maintain information longer than the sensory store through a process known as maintenance rehearsal, which recycles material over and over as the cognitive system processes it. Without rehearsal, the information would decay and be lost within seconds. Research has shown that this limited pool affects everything from decision making to the sizes of visual images that can be processed.

The third component of the human cognitive system is the LTM, which is described as a complex and permanent storehouse for individuals' knowledge about the world and their experiences in it (Baddeley, 1986; Moore, et al., 1996; Wyer, Schank, & Abelson, 1995). Long-term memory stores information that has been processed and deemed relevant by WM in the form of schemas (also referred to as schemata). Schemas are memory structures that organize a large number of information elements into a single element. For example, the schema of a house may include such information elements as construction materials, room types and layout, home appliances, etc. A major distinction between WM and LTM lies in that LTM has no known capacity limitations (Paas & Van Merrienboer, 1994; Sweller, et al., 1998). Interactions between WM and LTM allow humans to engage in cognitive activities that can range from the simple memorizing of facts to advanced applications; transferring knowledge; and applying skills, which are characteristic of an expert. Novice learners are typically engaged in learning by employing sensory channels within WM to build new schemas in LTM.

Based on this cognitive architecture, human verbal and visual perception is extremely selective, and learners can focus their attention only on a small amount of auditory/verbal and visual/pictorial presentation at once, and only a small portion of that information can be subsequently processed in WM (Baddeley, 1992). The elements, that learners will select to process are determined by several factors, such as the element's relative importance and the level of detail (Winn, 1993). The analysis of the characteristics affecting the learners' attention helps to identify the properties that enable students to direct their attention to the most relevant elements of the learning materials and to predict the conditions under which the audiovisual presentation may be effective (De Koning, Tabbers, Rikers, & Paas, 2009).

While learner's cognitive capacity available in a specific learning situation is limited and has to be distributed over several cognitive and metacognitive processes, the content to be learned induces more demands on this capacity depending on its intrinsic complexity and element interactivity (i.e., intrinsic load) (Paas, Renkl, & Sweller, 2004). For example, learning individual vocabulary units or words of a foreign language is intrinsically less complex than learning grammar because the latter requires consideration of the interaction of different parts of speech, and is, therefore, intrinsically more complex (Van Merrienboer, Kirschner, & Kester, 2003). Furthermore, different types of learning materials and different instructional designs require different amounts of cognitive capacity, independent of the content of the learning material. The capacity needed to meet these design and presentation related requirements is assumed to make no contribution to the learning process because it has to be used to compensate for a "bad" instructional or informational design (e.g., too much text on a PowerPoint slide), resulting in extraneous demands on the WM (i.e., extraneous load). Finally, cognitive capacity is needed for active knowledge construction, such as schema integration or automation. This type of cognitive load is assumed to be the key factor in the understanding and the storing of the learning material and, thus, it is considered to be germane to learning (i.e., germane load). Cognitive Load Theory proposes that the total available capacity is limited, and that the three types of cognitive load (i.e., intrinsic, extraneous, and germane) are additive in their combined capacity requirements. Therefore, the main implication for the design of multimedia learning materials is that these materials and activities should be designed with minimal extraneous load requirements and maximal potential for germane cognitive processing (Bruenken, Steinbacher, Plass, & Leutner, 2002).

These theoretical considerations and empirical findings in studies informed by CTML and CLT have resulted in the development of various design principles that take into account the processing limitations of WM to manage the cognitive load demands associated with audiovisuals (Mayer, 2001; Paas, et al., 2003). These principles were tested in a variety of learning scenarios, resulting in specific prescriptions regarding when they work, for whom, and for which types of learning materials (e.g., Mayer & Moreno, 2003; Plass, et al., 1998; Plass, Chun, Mayer, & Leutner, 2003). These principles involve the manipulation of characteristics of the audiovisual materials such as SSW. The following section will review the existing research on three of these design principles as they apply to the challenges in using audiovisual presentations in education—transiency of information, difficulty in guiding learners' attention to relevant content, and high amounts of extraneous content (Figure 3).

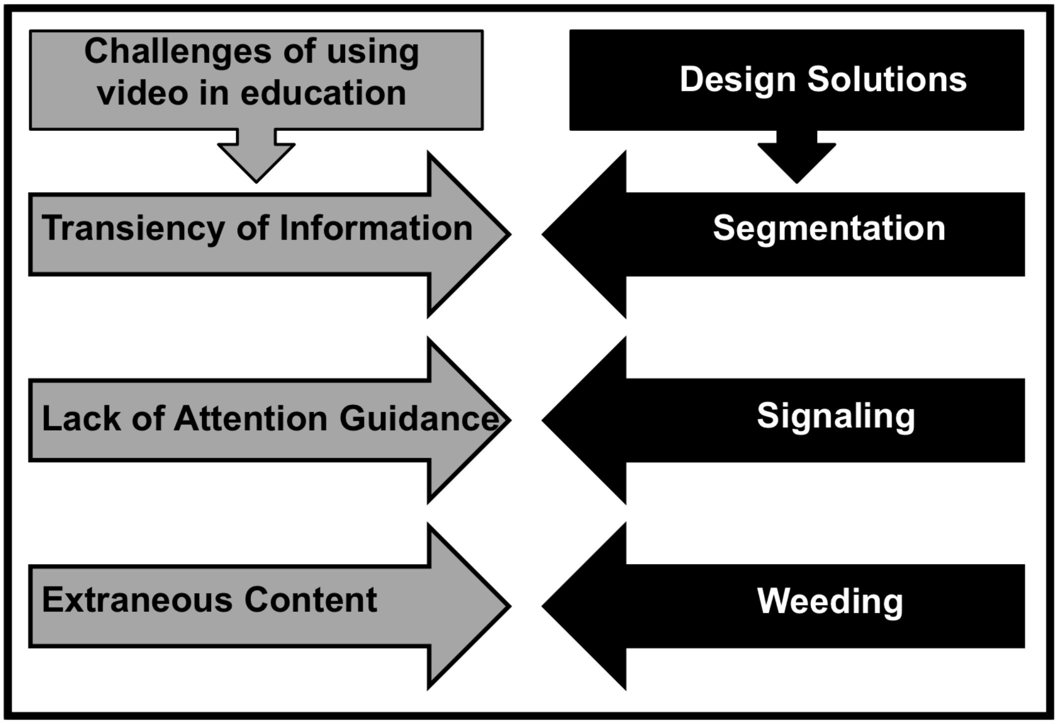

Figure 3: Design solutions

Segmentation

Segmentation is a design principle in which the learning materials are divided into short units and distributed over series of instructional events, such as topics or lessons referred to as segments (Clark, et al., 2006). In video, segments are chunks of dynamic visualizations that have an identifiable start and end point and which are distinguished by inserting pauses between different segments (Boucheix & Guignard, 2005; Hasler, Kersten, & Sweller, 2007; Mayer & Chandler, 2001; Mayer, et al., 2003; Moreno, 2007; Spanjers, Van Gog, Van Merrienboer, & Wouters, 2011). The purpose of this method is to allow learners to intellectually digest manageable pieces of learning materials before moving on to the next segment of information (Sweller, 1999). Segmentation has been described as a possible solution to the problem of information transiency educational video (Spanjers & Van Merrienboer, 2010).

Several studies examined the effects of segmentation of dynamic visualizations on learning and found that this method is helpful for novice learners, when the learning material is conceptually complex and when the pace of the presentation is rapid. For example, Mayer, Dow and Mayer (2003) compared the learning outcomes of students who learned about electric motors using a simulation game in which they interacted with an on-screen agent. In the continuous version, students viewed a continuous animation showing how the electric motor operates. In the segmented version, a list of questions appeared corresponding to each segment of the narrated animation. Results showed that the segmented group outperformed the continuous group on the test of knowledge transfer. Boucheix and Guignard (2005) compared the cognitive effects of different versions of a slideshow with learners' control. One version of the slideshow allowed students to start the next slide or repeat the previous slide and two other versions allowed learners to control the rate of the presentation (fast and slow). The researchers found larger gains from pretest to posttest for students using the segmented version of the slideshow.

Three other studies explored multimedia designs featuring learner control and segmentation (Hasler, et al., 2007; Mayer & Chandler, 2001; Moreno, 2007). In these designs, the presentation stopped automatically at the end of each segment, and the participants could decide when they wanted to continue with the next segment. Moreno (2007) conducted two experiments that had the participants view a segmented version of an exemplary classroom video (experiment 1) or an animation demonstrating teaching skills (experiment 2). In both experiments participants reported investing less mental effort and perceived the learning materials as less difficult than those who learned from non-segmented versions of the material. Mayer and Chandler (2001) examined the effects of a segmented version of a narrated animation that explained lightning formation using sixteen segments. Each segment contained one or two sentences of narration and approximately eight to ten seconds of animation. Investigators found that although students in both groups received identical content, students who viewed the segmented presentation performed better on subsequent tests of problem-solving transfer than did students who viewed a continuous presentation. Finally, Hasler et al. (2007) compared four versions of their learning material on the causes of day and night:

a segmented animation, a non-segmented animation that students could pause at each moment (i.e., with learner control), a non-segmented animation without learner control, and a non-segmented audio-only version without learner control. Learning time was equalized for the conditions by having students study the learning material repeatedly until ten minutes were over. Their results showed that learners who studied the segmented animation or the animation that they could pause performed better on test questions than students who studied one of the two other versions of the material, even though most learners who could pause the animation did not use that option. Although learners in these three studies had less control than the learners in the studies of Boucheix and Guignard (2005) and Mayer et al. (2003), Spanjers et al. (2010) suggested that learner control might still have influenced the effects of segmentation.

Segmentation was also found to help define event boundaries. That is, rather than relying on students' ability to mentally segment the presentation by inferring the topic shift and the presentation structure, designers of the learning materials do it for them (Spanjers & Van Merrienboer, 2010). It was hypothesized that segmentation might enhance learning by aiding students in perceiving the underlying structure of the process or procedure. For example, Catrambone (1995) compared four groups, which differed on whether or not a label for a particular calculation sub-step was provided (i.e., providing meaning to the step) and on whether or not that calculation sub-step was placed on a separate line (i.e., cue of what constituted a step). Learning outcomes were higher, and students mentioned sub-steps more often in their description of the calculation procedure when a label was provided, when the step was visually isolated or both the label was provided and the step was isolated, compared with the control condition in which no segmenting and cueing were provided.

The effect of segmentation on students with different levels of prior knowledge is another relevant area of study. For example, Spanjers et al. (2011) investigated the effects of segmented and non-segmented animations on probability calculation procedures on the learning of students with different levels of prior knowledge, and their segmented animations automatically paused after each segment and automatically continued after two seconds. A significant interaction was found between the effects of segmentation and prior knowledge: students with lower levels of prior knowledge learned more efficiently from segmented animations than from non-segmented animations, while students with higher levels of prior knowledge learned equally efficiently from non-segmented and segmented ones (cf., the expertise reversal effect; Kalyuga, 2007). One potential explanation for this effect is that learners with higher levels of prior knowledge might rely more on their existing knowledge structures of the domain and not use segmentation as temporal cues to break up the content into relevant chunks. Similar findings were reported by Boucheix and Guignard (2005) that show that students with higher levels of prior knowledge do not need additional guidance through segmentation because for students with higher levels of prior knowledge, the amount of cognitive resources they can devote to cognitive activities with a positive effect on learning is reduced when they have to reconcile the instructional guidance with the guidance given by their available cognitive schemas (Kalyuga, 2007).

Signaling

Another design principle that has been studied extensively is signaling. Signaling can help students focus on relevant content in audiovisuals through several methods: increasing the luminance of specific objects in a visual display (e.g., De Koning, Tabbers, Rikers, & Paas, 2007), changing a word's font style to boldface in a text (e.g., Mautone & Mayer, 2001), flashing to connect related elements (Craig, Gholson, & Driscoll, 2002; Jeung, Chandler, & Sweller, 1997), giving related elements the same color (Kalyuga, et al., 1999), providing orienting cues like gestures as guides to related elements (Lusk & Atkinson, 2007), or by adding an outline and headings indicated by underlining and spoken emphasis (Mayer, 2005). Although signals do not provide any substantive information, research found that people learn more deeply from audiovisuals when essential material is highlighted or cued (Mautone & Mayer, 2001; B. Meyer, 1975; Tversky, Heiser, Lozano, MacKenzie, & Morrison, 2008). De Koning et.al (2009) identify three main functions of signaling that might be related to distinct perceptual and cognitive effects: 1) guiding learners' attention to facilitate the selection and extraction of essential information, 2) emphasizing the major topics of instruction and their organization, and 3) making the relations between elements more salient to foster their integration.

Studies on text comprehension have consistently shown that signals improve the recall of the content they emphasize (e.g., Cashen & Leicht, 1970; Dee-Lucas & DiVesta, 1980; Lorch & Lorch, 1996). Other studies showed that memory for uncued content is unaffected (Foster, 1979), inhibited (Glynn & DiVesta, 1979), or sometimes even enhanced (Cashen & Leicht, 1970). These findings suggest that emphasizing particular content may guide learners' attention to essential information but does not necessarily reduce attention for uncued information (De Koning, et al., 2009). Although research on signaling in text-processing produced mixed results, signaling in static illustrations was found to guide students' attention and improve learning (Tversky, et al., 2008). For example, several studies found that redirecting the learners' attention to critical elements of the problem using, for example, color highlights led to more correct problem-solutions than studying the same diagrams without such cues (Thomas & Lleras, 2007). This result is in line with Park and Hopkins' (1993) recommendation to use perceptual features (e.g., color, motion) to guide learners' attention to critical information during visual instruction (De Koning, et al., 2009).

Signaling was also found to reduce extraneous cognitive processing during instruction as indicated by performance on a secondary task and learning outcomes. Evidence of this function comes from a study on text processing, where students read a signaled or a non-signaled text while at the same time their reaction times to a secondary task were measured as an indication of cognitive load (Britton, Glynn, Meyer, & Penland, 1982). Results indicated that texts containing cues about relevant concepts and their relations required less cognitive resources to process than texts without cues. Loman and Mayer (1983) compared students in two groups who studied signaled or non-signaled texts and showed that students in the signaled condition experienced lower cognitive load causing them to construct better representations of the content, as indicated by better retention and transfer performances. The authors suggested that signaling the text reduced students' visual search and the unnecessary load associated with locating relevant information, which freed up WM resources for genuine learning activities.

The effects of signaling were also examined in learning from audiovisuals (Mautone & Mayer, 2001) who found that dynamic cueing may improve learning. For example, Lowe and Boucheix (2007) examined a form of "continuous cueing" by presenting learners with an animation of a piano mechanism with a dynamic spreading color cue. The visual colored path continuously provided a close temporal and visuospatial similarity to related auditory information and occurred synchronous with the visualization of the main causal chains. Results showed that signaling improved students' understanding of the kinematics and functional model of the piano mechanism, suggesting that the spreading color cue effectively enhanced germane cognitive processing (De Koning, et al., 2009). The investigators indicated that the eye movement data collected in the study suggested that the continuous cue produced an altered viewing pattern, that is, it introduced a new way of viewing the animation, which may have stimulated learners to cognitively process the content more deeply. De Koning, et al. (2009) suggested that the success of this type of cueing may lie in the fact that it served not only the function of guiding attention to essential information but also functioned to relate elements within a representation (i.e., it made temporal relations more explicit), which may have increased cognitive engagement and subsequent understanding of the animation.

In another study that used signaling to guide attention to essential information, De Koning et al. (2007) asked learners to study a non-narrated complex animation illustrating the dynamics of the main processes of the cardiovascular system. One group studied the animation with a visual color contrast cue highlighting one specific process (i.e., the valves system), whereas another group studied the animation without visual cues. Results indicate that emphasizing particular content significantly improved comprehension and transfer performance on both the content that was cued as well as on the content that was uncued. No differences were found in the amount of cognitive load, but given the higher learning performances in the cued condition, the investigators argued that visual cueing leads to a more effective use of WM resources. To explain these results, De Koning, et al. (2009) suggested that the effectiveness of visual cues is dependent on the complexity of the instructional animation and only improves learning if learners need cues to assist them in constructing a coherent representation. This suggestion could be found in line with the study of Jeung et al. (1997) that has demonstrated that the degree of visual complexity of instruction seems to be a crucial factor for the effectiveness of cueing.

Despite the generally positive effects of signaling in text and animations, other research demonstrates that visual cueing does not always improve learning. Within this body of work, researchers have focused on the effects of graphical cues on the comprehension of a visual-only animation without text. For example, in an eye-tracking experiment, Kriz and Hegarty (2007) compared two groups of students that studied a user-controlled animation showing the steps in a flushing cistern mechanism using arrows to guide attention to essential information and arrows to emphasize causal relations between components or inferences. Results revealed no evidence of the benefit of cueing on comprehension. Furthermore, while the arrow cues were found to direct students' attention to more relevant information, it did not result in a better understanding of the information presented in the animation than studying an animation without visual cues. Other researchers used eye tracking and verbal reporting techniques to identify the underlying mechanism of attention cueing. For example, a study by De Koning et al. (2007) involved learning from an animation of the cardiovascular system in which none, one, or all of its subsystems were successively cued using a spotlight cue (i.e., luminance contrast). Results were similar to those of Kriz and Hegarty (2007) in that the spotlight cues effectively captured students' attention, however they did not improve the understanding of content.

Research also found that improper use of signaling can even increase the cognitive load of the learner. In a study by Moreno (2007), prospective teachers studied effective teaching skills with, or without visual cues. In the cueing condition, the critical teaching skills that were visualized in the animation were highlighted in a bright red color on a step laddered list containing the labels for each skill. The labels accompanying the skills in the animation were used to guide students' attention to essential information and relating connected elements between representations. Results showed that the cues did not improve learning performance. Moreno (2007) suggested that cueing may have forced learners to spatially split their visual attention between the animation and the highlighted labels that were presented side-by-side therefore may have interfered with the learning process.

Although some studies demonstrate that signaling does not always facilitate learning, Mayer (2001) suggested that signals should produce a strong effect under certain conditions: (1) for students who do not normally pay attention to the outline structure of a passage, (2) for passages that are poorly written, (3) when the goal of instruction is promoting retention of the major conceptual information and creative problem solving, and (4) when the teacher wants to help students recognize topic shifts.

Weeding

Weeding is an instructional design strategy in which irrelevant content is eliminated as a potential solution to reduce the negative effect of the extraneous materials in audiovisuals. Mayer & Moreno (2003) suggested that learning materials are better understood when they include fewer rather than many extraneous words, visuals, and sounds and found that students learn better from a concise summary that highlights the relevant words and pictures than from a longer version of the summary. The inclusion of irrelevant information often primes learners to engage in incidental processing and diverts the limited cognitive resources, which may hinder learning (Brünken, Plass, & Leutner, 2004).

Sweller (1999) referred to the addition of extraneous material in instruction as an example of extraneous cognitive load.

Tabbers (2002) categorized the extraneous information in the learning materials into three kinds. First, it is the information that is irrelevant to learning but interesting to keep students motivated. Multiple studies found that these extraneous details often do more harm than good to learning (Harp & Mayer, 1997, 1998; Mayer, et al., 2001; Moreno & Mayer, 2000). Second, redundant information that is derived from other information elements in the presentation was also found to have a negative effect on learning. Redundant information includes presenting text or a picture accompanying an animation both on-screen and as a narration (Kalyuga, et al., 1999; Kalyuga, Chandler, & Sweller, 2000; Mayer, et al., 2001; Mousavi, Low, & Sweller, 1995), adding explanatory text to a diagram that could be understood on its own (Chandler & Sweller, 1991), or adding the full text to a summary of a text (Mayer, 1996b). Third, redundant information that is familiar to learners who develop expertise in a learning domain can be detrimental to learning. For example, an expert in a certain area will not need the information that is essential to a novice. Researchers suggest that when experts are forced to process information that is already familiar to them, extraneous cognitive load is increased due to processing redundancies, which leads to negative influence on learning (Kalyuga, Chandler, & Sweller, 1998; Kalyuga, et al., 2000).

Research on weeding shows that adding interesting but conceptually irrelevant content in text-based materials reduces the amount of relevant material that the learner remembers (Garner, Gillingham, & White, 1989; Hidi & Baird, 1988; Wade & Adams, 1990). For example, in a study using a free recall test, Mayer (2003) found that students given a weeded version of a text produced 59 facts, while students given the original version produced 35 facts, indicating a 68% improvement for the weeded passage. Students given the concise version also performed better on the comprehension test, answering 46 percent of the questions correctly, whereas students given the original version answered 37 percent of the test items correctly.

Extraneous materials should be excluded from multimedia presentations, even if this extra information contains interesting and potentially motivating elements, such as illustrations or music or sounds (Harp & Mayer, 1998; Moreno & Mayer, 2000). A number of experiments have shown that removing superfluous information from multimedia instructions resulted in more effective learning. For example, in two experiments, Moreno and Mayer (2000) compared two versions of a learning system; one was delivering information as narration and animation, the other delivering the same information with the same narration and animation, but adding interesting yet irrelevant sounds and background music. Investigators found strong evidence for a negative effect of background music on knowledge acquisition. In both experiments, students working with the material without background music outperformed the learners working with the material containing background music. In a similar study, Mayer et al. (2001) demonstrated that adding interesting but conceptually irrelevant video clips to a multimedia explanation can result in negative effects on students' understanding of the explanation. The investigators found that students who viewed video clips added within the narrated animation or placed before the narrated animation displayed poorer problem-solving transfer performance than students who received no video clips.

In computer-based instruction, Mayer (2008) indicated that students performed better on a problem-solving transfer test in 13 out of 14 experiments involving topics like lightning, ocean waves, and brakes after receiving a concise lesson rather than an expanded lesson (Harp & Mayer, 1997, 1998; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer, et al., 2001; Moreno & Mayer, 2000). Mayer explained that including extraneous material caused learners to engage in high levels of extraneous processing. The extraneous material competes for cognitive resources in WM and can divert attention from the important material, disrupt the process of organizing the material, and can prime the learner to organize the material around an inappropriate theme. Mayer (2001) identified three complementary versions for removing the extraneous content from learning materials: (1) student learning is lessened when interesting but irrelevant words and pictures are added to a multimedia presentation; (2) student learning is decreased when interesting but irrelevant sounds and music are added to a multimedia presentation; and (3) student learning is improved when unneeded words are eliminated from a multimedia presentation.

Summary and Implications for the Design of Educational Video

Segmentation and Cognition

According to the cognitivist view of learning, learning involves the construction of cognitive schemas, which are stored in LTM. To construct those schemas, information from the dynamic visualizations must be maintained and processed in WM (Sweller, et al., 1998). That is, information elements need to be selected from the stream of information and then mentally integrated with information that was presented earlier and with prior knowledge in order to form a representation from the shown presentation (Moreno & Mayer, 2007). In this condition, the cognitive activities, complexity of the learning materials and limitations of WM create a bottleneck for learning (Sweller, et al., 1998). Cognitive researchers recommend breaking up the presentation into small units and allowing pauses between these units to reduce its complexity and to provide students with sufficient time to attend to the necessary cognitive activities without having to simultaneously attend to new incoming information, thereby reducing extraneous cognitive load at certain points in time (e.g., Ayres & Paas, 2007; Mayer & Moreno, 2003; Moreno & Mayer, 2007; Schnotz & Lowe, 2008).

Another function of the segmentation method is to enhance students' perception of the presentation's underlying structure. Instead of relying on students' ability to mentally segment the presentation; instructional designers can segment the presentation to optimize learning. Dynamic visualizations present multiple steps or units in an event or procedure across time, and students are required to attain to the structure of these events or procedures (K. Meyer, et al., 2010; Schnotz & Lowe, 2008). According to the event segmentation theory (Zacks, Speer, Swallow, Braver, & Reynolds, 2007) indicates that individuals construct the underlying structure of a procedure or an event from their models in the WM on the basis of incoming sensory information and prior knowledge. Students then use these models to develop predictions about what will happen in the presentation next and compare these predictions with what they perceive through their sensory registers. When students' predictions and the new incoming sensory information do not coincide, a new event or procedure model for the segment needs to be constructed and an event boundary needs to be distinguished. The distinction of event boundaries is a result of the interaction between WM and LTM to interpret the information stored in previously acquired schemas, therefore it can be expected that individual differences in mental segmentation may lead to differences in learning outcomes (Spanjers, et al., 2011). Novice learners, in particular, may experience increased cognitive demands because they have not developed LTM schemas with which to compare incoming information, and should therefore benefit from explicit segmentation in audiovisual materials to a greater extent than advanced learners.

Signaling and Cognition

A crucial part of constructing a coherent representation from instructions is learners' ability to identify and extract main ideas or concepts. Signaling can guide the process of concepts identification by cueing the content that requires intentional processing. Human visual perception is extremely selective allowing learners to focus their visual attention only on a small amount of a visual display at once and only a small portion of that information can be subsequently processed in WM (Baddeley, 1992). Furthermore, the elements learners could attend to are determined by the elements' prominence and their level of detail (Winn, 1993). Thus, carefully signaling the relevant information in the presentation can help students in their cognitive process and enhance learning outcomes.

Cognitive scientists (e.g., Mayer, 1997, 2001; Sweller, 1988, 1999) identify three main functions of signaling that might be related to distinct perceptual and cognitive effects: (1) guiding learners' attention to facilitate the selection and extraction of essential information, (2) emphasizing the major topics of instruction and their organization, and (3) making the relations between elements more salient to foster their integration. Because WM is severely limited in both its duration and capacity to process new information, directing learners' available cognitive resources to the relevant learning content is therefore important to designing instruction.

Signaling can focus learners' attention on the most relevant information leading to decreased visual search and mental resources required to control visual attention. Thus, signaling reduces extraneous cognitive load associated with locating relevant information, freeing up cognitive resources for germane learning processing directly relevant for schema construction. Additionally, information is usually made up of individual parts that together constitute a hierarchical structure (Schnotz & Lowe, 2008). Information comprehension is dynamic and the global structure of the content needs to be updated after each transition between topics (Lorch, Lorch, & Matthews, 1985). However, discerning the topic structure from the whole presentation often fails if learners are not adequately supported with appropriate signals that emphasize the presentation's overall topic structure (Loman & Mayer, 1983; Lorch & Lorch, 1995). Therefore, helping learners identify the individual elements and synthesize them into a coherent knowledge representation is an essential task for instructional designers. Although signaling emphasizes the organization of instructions and helps learners to accurately represent the structure of the presented information, organizational cues are only effective in altering the organization of content in memory if the instructions are complex and do not involve a well-defined structure or contain many topics (Lorch, 1989; B. Meyer, 1975).

Weeding and Cognition

Any instructional activity that requires students to engage in the processing of information that is not directly relevant to learning the content is likely to impair learning by increasing extraneous cognitive load (Paas, et al., 2004). In video-based instruction, visual and auditory materials are processed in different subsystems of WM (the dual-channel capacity assumption) and both subsystems have separate, limited processing capacities that cannot be exchanged between the systems (Baddeley, 1986; Baddeley & Logie, 1999). Extraneous cognitive load occurs when learners are required to engage in irrelevant cognitive activities not directed toward schema acquisition and automation rather than the intrinsic nature of the task (Sweller & Chandler, 1994; Sweller, et al., 1998). Therefore, all aspects of learning materials should eliminate irrelevant cognitive activities, reduce extraneous cognitive load, so the learner is primed to engage only in essential processing and allowed to devote more cognitive resources to essential processing.

CHAPTER III

METHODOLGY

Design Overview

This study used a quasi-experimental, between-subjects design to measure the effect of segmentation, signaling and weeding (SSW, independent variable) on four dependent variables: (1) perceived learning difficulty, (2) knowledge retention, (3) transfer of knowledge, and (4) structural knowledge acquisition. Prior knowledge and metacognitive awareness were included in the model as covariates. The instruction used in the present study was an educational video with two different designs. One group viewed the SSW version of the video (i.e., the SSW group) while the original, non-SSW video was viewed by the second group (i.e., the non-SSW or control group). Each group was randomly assigned to one of the two treatment conditions via a coin toss. To protect the participants' identity, all questionnaires were anonymous and students used the last four digits of their campus wide identification number as identifier. Participants in both groups spent approximately 32 minutes watching the video and 35 minutes for pre- and post-test. Watching the video and testing for both groups were part of the regular class activities and conducted during the same week of class and at the same time of the day.

Participants

Participants were 226 undergraduate, non-science majors enrolled in two introductory entomology courses at Oklahoma State University, ENTO 2003: Insects and Society and ENTO 2223: Insects and Global Public Health. There were 110 students in the SSW video group and 116 students in the non-SSW group. Males totaled 132 (58.4%) and females 94 (41.6%). Average age was 20 years old (*SD* = 3.08), with mean years in college of 2.3 (*SD* = 1.07). All participations were fluent in English and consisted of freshmen, sophomores, juniors, and seniors in non-science majors such as accounting, history, education, business, and political science. Students were given credit for their participation in the study.

Instrumentation

For each participant, the paper-and-pencil materials consisted of two typed packets on 8.5x11 inch sheets of paper. The pre-test (the first packet) was handed to students before watching the video and consisted of a consent form, a one-page demographics survey, a 52-item metacognitive awareness inventory to assess participants' metacognitive awareness and self-regulated use of learning strategies (Schraw & Dennison, 1994), and a 10-item test of prior knowledge to assess the participants' domain-specific knowledge. The test of prior knowledge was developed by course instructors based on the relevant entomology concepts covered in the U.S. high school science curriculum. The post-test (the second packet) was handed out after watching the video and consisted of a one-question instrument of the perceived difficulty of the video as an indirect subjective measure of cognitive load (Kalyuga, et al., 1999), a 20-question multiple-choice test (i.e., knowledge retention measure), a 5-question multiple-choice test (i.e., knowledge transfer measure) and a 20-item sorting task to organize the main concepts covered in the video (i.e., structural knowledge measure). All learning measures were developed by the course instructors and approved by the Oklahoma State University Institutional Review Board (see Appendix A).

Pre-test

Consent form: This form was used to identify volunteers for this study. Participants were free to volunteer in the experiment by signing or decline to volunteer by not signing the consent form. Students who decided to participate signed the form, while students who declined to participate, left the form unsigned (see Appendix B).

Demographics questionnaire: The demographics questionnaire was developed by the investigator to collect information related to the demographic makeup of the participants. The questionnaire includes questions about participants' gender, age, year in college, grade point average, school majors and the preferred learning style. The learning style question was worded in the following way: I prefer learning from 1) lectures, 2) books, 3) videos/movies; 4) hands-on activities (see Appendix C).

Metacognitive awareness inventory (MAI): This instrument contains 52 true/false questions to determine participants' self-regulating use of learning strategies (Schraw & Dennison, 1994). The instrument consists of questions such as the following: I am good at organizing information; I consciously focus my attention on important information; I have a specific purpose for each strategy I use; I learn best when I know something about the topic. Cronbach's α for the MAI with a population of college students was estimated at .86, indicating adequate internal consistency (Hartley & Bendixen, 2003) (see Appendix D).

Prior knowledge test: This measure consisted of 10 questions with four-option multiple-choice responses to assess participants' prior knowledge about insects. Each correct answer yielded one point for a total of 10 points. Scores ranged from zero (no correct responses) to 10 (all correct responses) (see Appendix E).

Post-test

Self-reported video difficulty: This questionnaire consisted of one Likert-scale self-report question to assess participants' perceived difficulty associated with watching the video. The questionnaire asks participants to indicate the degree of difficulty experienced from the video (from 1 = extremely easy, to 9 = extremely difficult). Participants reported the level of their perceived difficulty by placing a check mark next to one of the nine items that applied to them. This questionnaire was based on a survey developed by Paas & Merrienboer (1994) and updated by Kalyuga, Chandler, & Sweller (1999) and has been validated in other studies. Reliability of the scale with a population of college students was estimated with Cronbach's coefficient α at .90 (Paas & Van Merrienboer, 1994) (see Appendix F).

The Retention test: This measure consisted of 20 questions multiple-choice to assess participants' retention of the core concepts from the video. Each segment was covered by five questions (e.g.,: Which is NOT part of insect's breathing system?) Participants could choose from the following responses: Spiracle; Lungs; Branching Tubes. Each correct answer yields 1 point, for a total of 20 points. The score ranged from zero (no correct responses) to 20 (all correct responses) (see Appendix G, questions 1-4, 6-9, 11-14, 16-19 and 21-24).

The test of knowledge transfer consisted of five multiple-choice questions to assess participants' ability to infer the answer based on the information conveyed in the video. The questions covered five concepts from the video with one separate question for each segment. For example, the participants were asked: Could a soldier termite perform the role of a worker termite? The responses they could choose from: a) yes, social insects will likely rotate tasks during their lifespan; and b) no, termites have a short lifespan and are not likely to change the role they perform. The video did not cover this question directly, but the answer could be inferred based on the information about the life of insects from the video. Every correct answer was worth one point and the sum score ranged from zero (no correct responses) to five (all correct responses). These questions were designed to elicit transfer of knowledge by exposing participants to logically equivalent problems that required them to transfer knowledge from one context to another (Barnett & Ceci, 2002).

The structural knowledge test consisted of a numbered list of 20 concepts covered in the video (presented randomly) and a sheet of five columns representing the five conceptual segments of the video. Participants were asked to write the number associated with each concept in the appropriate column. Participants received one point for every correct answer, and the sum score ranged from zero (no concepts arranged correctly) to 20 (all concepts arranged correctly) (see Appendix H).

All learning measurements were developed by the course instructor who did not participate in collection or analysis of data beyond developing these instruments. All self-developed tests of learning were reviewed by two entomology instructors for construct validity. The ratings indicated that the tests adequately reflected and assessed the entomology concepts included in the video and in the tests.

Materials

The video used in the present study was part of the instructors' supplemental materials for the corresponding topic about insects as well as SSW version of the same video. The original video entitled "Insect" was professionally produced by the British Broadcasting Company in 1994. It is part of an educational video series that investigates the insect's life cycle and various tasks insects perform, such as eating, breathing, flying and communicating. The original and the SSW-augmented video included close-up video shots of insects, animations, diagrams, photographs, sound effects, and voice-overs. The investigator obtained a permission to use the video in this experiment through the office of the legal consular of the Learning Resource Center at Tulsa Community College. The TCC legal consular issued a legal justification document stating that the use of this video in this experiment falls under the Fair Use Act for Educators (see Appendix I).

The SSW version of the video was modified by applying the CTML principles of segmenting, signaling, and weeding (SSW). Specifically, the following design manipulations were performed. First, the video was divided into five conceptual segments (i.e., segmentation), each about six minutes long (Table 1). These segments were built-in as part of the video, and students had no control over the sequence of the presentation, playing or stopping them. The order of presenting information was identical for both versions.

Table 1
Segment titles

Segment Title	Duration
1. Basic Facts	6 minutes
2. Insect Body parts	6 minutes
3. Insects' Evolution	6 minutes
4. Aquatic life, visual system & communication	6 minutes
5. Defense techniques & social insects	6 minutes

Each segment was introduced by a static graphic indicating segment's name, which remained visible for about 10 seconds (see Figure 4).

Figure 4: Segment introduction

To maintain a fair design between both groups, the investigator divided the video in the non-SSW condition in the same way as in the SSW condition, with five breaks; however the segment's title was replaced by a static graphic without any mention of the segment's content. The breaks were marked by the following graphic titles: part one, part two, part three, part four and part five.

The signaling method used an introduction and a summary screen for each segment and added cues and signals for the main information (i.e., signaling) (see Table 2).

Table 2:

Concepts signaled in the SSW video

Segment	Topics covered in each segment
Segment 1	• Insects' habitat • Insects in human Mythology • Negative & Positive Aspects
Segment 2	• Common characteristics • Breathing System • Mouths & Eating • Spread of Human Diseases
Segment 3	• Early insects • Pollination & co-evolution • Reproduction • Complete Metamorphosis • Flying
Segment 4	• Aquatic life • Incomplete Metamorphosis • Anatomy & function of the eye • Communication techniques
Segment 5	• Defense techniques • Social life

Each segment began with an introduction showing the segment title and followed by a list of the core concepts presented as a narrated bulleted list for 20 seconds. For example, the second segment began with the title "Insect Body Parts" followed by a list of topics: Common characteristics, breathing system, mouths & eating, and spread of human diseases (See Figure 5).

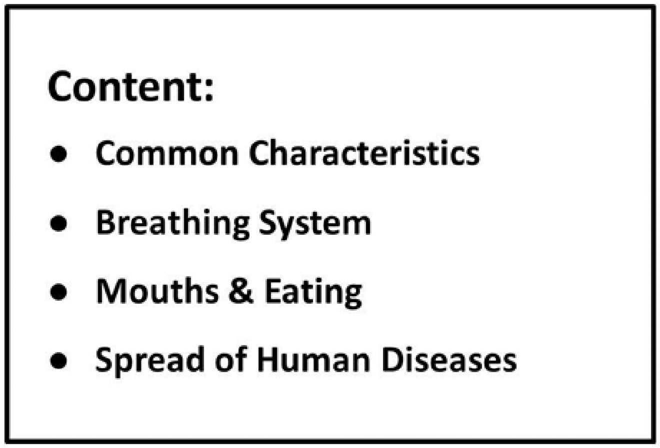

Figure 5: Topics that make up the Insect Body Parts segment

Summaries were presented at the end of each segment as concise narrated bulleted lists of the concepts discussed in each segment and presented for 60 to 90 seconds (see Figure 6). Concepts were also signaled using static diagrams like the one shown in Figure 6.

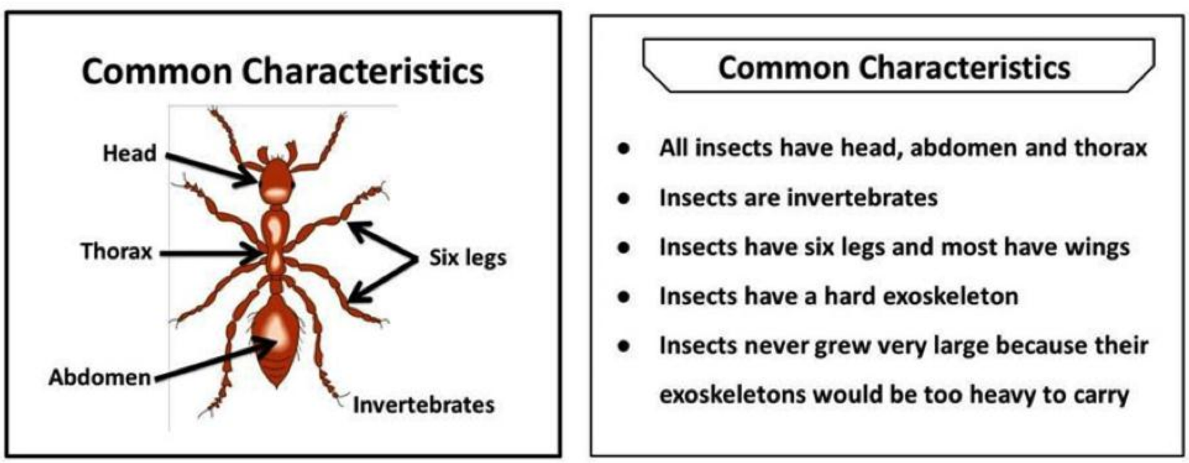

Figure 6: A diagram used for signaling and segment summary

Finally, weeding was performed with the help of the course instructor to eliminate sections of the video that were entertaining but not essential for the understanding of content. For example, the investigator removed an animated section of an insect morphing into a car and a section on folklore involving European insects. Removing these sections from the SSW video did not affect the structure or the meaning of the video content. In the non-SSW video, these sections were left in the video.

The resulting SSW video was 32 minutes long, which matched the duration of the original video viewed by the control group. Videos were presented in the Digital Video Disk (DVD) format. The classroom used in this study was a large lecture hall where students normally attend their lectures. The lecture hall was equipped with a computer, video projector, speakers and a large 12x8 foot screen.

Procedure

First, each section was randomly assigned to either SSW or non-SSW video via a coin toss. Course instructors were present during the experiment to explain the purpose of the research followed by the investigator reading the recruitment script (see Appendix J). The recruitment script included a brief introduction about the investigator, the scope of the study and the confidentiality of the data collected. No sign-up sheet was used. Second, students who expressed willingness to participate in the experiment were given the first packet to complete before watching the video. The first packet consisted of a demographic survey, a test of prior knowledge, and metacognitive awareness inventory. Then, participants in both groups watched the video in its entirety without pausing for questions, discussions, or note-taking. Immediately after watching the video, participants received the post-test packet consisting of the learning difficulty survey and tests of learning.

Data Analysis

The basic data analysis model for this study was a one-way between-groups multivariate analysis of covariance (MANCOVA) to compare the differences between the SSW and control group's means on four dependent variables: the perceived difficulty of the video presentation, retention of knowledge, structural knowledge acquisition, and knowledge transfer. This experiment design controlled for the participants' variances in prior knowledge, learning style, and metacognitive awareness using t-tests and a chi-square test for the learning style variable, which showed no differences between the groups. Prior knowledge was included as a covariate in the MANCOVA analysis. To validate the significance of the model and the interpretation, preliminary analysis of the required assumptions was conducted focusing on the reliability of covariates, normality, homogeneity of variance, and homogeneity of regression. All statistical tests were performed with alpha at .05. MANCOVA has been successfully implemented in similar prior studies (e.g., Moreno, Reisslein, & Ozogul, 2009; Renkl, Atkinson, & Groe, 2004).

CHAPTER IV

FINDINGS

Descriptive Statistics

The basic data analysis model used for this study was a one-way between-groups multivariate analysis of covariance (MANCOVA). Table 3 shows the mean scores and standard deviations for the SSW and non-SSW groups on the measures of difficulty rating, knowledge retention, knowledge transfer, and structural knowledge. Descriptive statistics that characterize the participants are presented in Table 3.

Table 3

Descriptive statistics for the dependent measures

	Learning Difficulty		Knowledge Retention		Knowledge Transfer		Structural Knowledge		Overall Learning	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
SSW	2.31	1.15	15.83	2.53	4.52	.763	11.98	2.44	31.20	6.17
Non-SSW	2.76	1.54	14.74	3.05	3.97	1.04	10.49	3.14	28.82	6.27

Note: Scores ranged from 0 to 9 for the learning difficulty rating, from 0 to 20 for the retention test, from 0 to 5 for the transfer test, from 0 to 20 for the structural test and from 0 to 45 for the overall learning outcomes

Table 4

Descriptive statistics for the participants' demographics

	N	Minimum	Maximum	Mean	Std. Deviation
GPA	226	2.2	4.0	3.3	.42
Gender	226	1	2	1.42	.49
Student's age	226	17	51	20.19	3.08
Years in College	226	1	4	2.3	1.07

Data Screening

Prior to the main analyses, data were screened for out-of-range responses and systematic patterns of missing data (e.g., when no value was stored for the variable within variable sets). Missing data has been reported as one of the most pervasive problems in data analysis (Tabachnick & Fidell, 2008) and can be an issue of concern when it obscures true differences that exist between groups. However, in the present study none of the above concerns were detected. The missing values were found to be scattered evenly across variables and treatment conditions with fairly small number of cases and no apparent patterns or clusters emerging. For example, the investigator observed three cases out of 229 participants where pretest data had been collected, but was not accompanied with posttest data, and vice-versa.

Occasional missing values were dealt with in two phases. First, initial "data cleaning" procedures involved purging any cases that did not contain both pre and posttest data or there was no identifiers for both pre and posttest packets. As a result, the original sample (*n* = 229) was reduced to 226. The second method employed for handling missing data was to insert group mean for that particular variable in the missing data cell (Cohen & Cohen, 1983; Tabachnick & Fidell, 2008).

MANCOVA Assumptions

Normality

MANCOVA and other multivariate techniques are based upon the assumption of multivariate normality, which assumes that sampling distributions of means for the dependent variables are normally distributed. Although with the equal cell size, the data is protected against Type 1 error due to assumption violation, individual item distributions were checked to ensure normal distribution (i.e., no univariate outliers). To check for such normality, each of the study's dependent measures was assessed by constructing histograms and normal probability plots, and by examining the kurtosis values associated with each distribution. The descriptive information revealed that the normality assumption was met according to the conventional criteria (see Table 5).

Table 5

Normality levels for each dependent variable

	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Learning Difficulty	2.54	1.379	1.269	.162	3.230	.322
Knowledge Retention	15.27	2.854	-.939	.162	.964	.322
Knowledge Transfer	4.23	.954	-1.323	.162	1.426	.322
Structural Knowledge	11.22	2.915	-1.058	.162	1.998	.322
Overall Learning	29.98	6.323	-1.099	.162	1.129	.322

Multicollinearity, Singularity and Linearity

Multicollinearity and singularity refer to the assumption that dependent variables are expected to be weakly to moderately associated with one another so as to not contribute redundant information. Redundancy was determined by assessing the degree of relationship between variables and by reviewing within-cell correlation matrices. The results of the correlation values for the dependent variables revealed that perceived learning difficulty ranged from -.16 to -.26, the recall measure ranged from -.26 to .78, the knowledge transfer from -.24 to .64, the structural knowledge from -.16 to .69 and the overall learning outcomes ranged from -.25 to .78. With regard to linearity, scatter plots were examined among each cluster of dependent measures, and no significant deviations, curvilinear relationships, or outliers were noted (see Table 5).

Variable Correlations

To assess the overall relationship between the dependent variables and the pretest of prior knowledge as an appropriate and valid covariate, a correlation matrix was constructed. The matrix revealed that the dependent variables were highly correlated with the pretest and all other dependent variables (i.e., retention, structural, and far transfer, overall learning outcomes, and cognitive load); therefore, the pretest of prior knowledge is an appropriate and valid covariate for this analysis (see Table 6).

Table 6

Correlations among dependent variables and prior knowledge

	Prior Knowledge	Learning Difficulty	Knowledge Retention	Transfer of Knowledge	Structural knowledge	Overall Learning
Prior knowledge	(1)					
Learning Difficulty	-.235*	(1)				
Knowledge Retention	.432*	-.260*	(1)			
Knowledge Transfer	.267*	-.242*	.619*	(1)		
Structural Knowledge	.247*	-.164*	.385*	.273*	(1)	
Overall	.390*	-.245*	.784*	.641*	.685*	(1)

Note: Correlation higher than $r = 0.25$ is significant at $p < 0.05$ level (two-sided)

The shared variability between the covariate and the five dependent variables ranged from -.16 to .818. Pearson Correlation and the significance level was < .01.

Groups Homogeneity

To examine whether there were differences between groups and to control for these differences as a potential confounding effect, independent *t*-tests were conducted on the following variables: pretest of prior knowledge, learning style, and metacognitive awareness. The results indicated that both groups were very similar across these characteristics and the existing differences could not affect the analysis outcomes (prior knowledge: t =.990 (224), p = .323, learning style: t =.357(224), p = .721, and metacognitive awareness: t = -.856 (224), p = .393). Chi-Square revealed that there was no significant difference between participants on the learning style and that learning styles were equally representative in both groups, chi-square = 5.242 (df = 4, N =224), p = .263. These results indicate that any change in learning outcomes from the video was not due to differences in prior knowledge or metacognitive awareness.

MANCOVA Analysis

To assess the main effects of the SSW treatment, MANCOVA was utilized as an initial test of differences. The main MANCOVA was conducted to determine the effect of the video design on students' learning outcomes and perceived learning difficulty as a measure of cognitive load. Dependent variables included retention of knowledge, transfer of knowledge, structural knowledge acquisition, and learning difficulty; the independent variable was video design; and the participants' prior knowledge was included as a covariate. MANCOVA results revealed a significant main effect for the SSW treatment, Wilks' Lambda Λ = .84, F (1,223) = 8.345; p < .01, $\eta 2$ =. 16, which prompted a series of univariate tests for each dependent measure summarized in Table 7.

Table 7

Univariate analyses of the effects of SSW on perceived learning difficulty, knowledge retention, knowledge transfer, structural knowledge, and overall learning

Dependent Variable	Sum of Squares	df	Mean Square	*F*	*P*	*η2*
Learning Difficulty	9.385	1	9.385	5.297	.022	.023
Knowledge Retention	48.358	1	48.358	7.477	.007	.032
Knowledge Transfer	15.281	1	15.281	19.506	.000	.080
Structural Knowledge	110.429	1	110.429	14.614	.000	.062
Overall Learning	239.741	1	239.741	7.235	.008	.031

Research Questions

Research Question 1: Will SSW methods decrease extraneous cognitive load for novice learners in the context of educational video?

Results of the between-subjects analysis showed that the SSW group reported lower learning difficulty (M = 2.31, SD = 1.147) compared to the non-SSW group (M = 2.76, SD = 1.541) and that the difference was statistically significant at (F (1,223) = 5.297, p = .022). The results produced an eta square of .023, indicating that the SSW intervention accounted for a 2.3% decrease in the perception of learning difficulty for students in the SSW group (see Table 7).

Research Question 2: Will SSW methods improve retention, far transfer, and structural knowledge for novice learners in the context of educational video?

Post-hoc analysis revealed group mean differences on four measures of learning. First, the SSW methods group (M = 31.20, SD = 6.173) performed better on gaining overall knowledge compared to the non-SSW group and the difference between the groups was statistically significant, F (1, 223) = 7.235, p = .008. The results also showed an eta square of .031, indicates that the SSW methods had an estimated main effect of 3.1% improvement in the overall knowledge for the participants in the SSW group.

The SSW group scored higher on the retention test (*M* = 15.83, *SD* = 2.526) compared to the non-SSW group (*M* = 14.74, *SD* = 3.051), and the difference between both groups was statistically significant, F (1, 223) = 7.477, p = .007. The results produced an eta square of .032, indicating a 3.2% improvement effect in knowledge retention in the SSW video group.

The SSW group also scored higher on the test of knowledge transfer of (*M* = 4.52, *SD* = .763) compared to the non-SSW (*M* = 3.97, *SD* = 1.038), and the difference was statistically significant F (1, 223) = 19.506, p < .001. The results produced an eta square of .080, indicating that the intervention had an estimated main effect of 8 % improvement in knowledge transfer for the participants in the SSW group.

Finally, the SSW group scored higher on the structural knowledge test (*M* = 11.98, *SD* = 2.442) compared to the control group (*M* = 10.49, *SD* = 3.144), and the difference was statistically significant, F (1, 223) = 14.614, p < .001. The results produced an eta square of .062, indicating that the SSW methods had an estimated main effect of 6.2% improvement in structural knowledge acquisition for the participants in the SSW group.

Research Question 3: When used with novice learners in the context of educational video, will the SSW intervention improve transfer of knowledge and structural knowledge acquisition to a larger extent than retention of knowledge?

The results of this study showed that students who watched the SSW video scored higher on transfer and structural knowledge compared to the retention test. As indicated above, eta square showed an 8% improvement in the results on the test of knowledge transfer (F (1, 223) = 19.506, p < .001), a 6.2% improvement in structural knowledge acquisition (F (1, 223) = 14.614, p < .001), and a more modest 3.2% improvement in knowledge retention (F (1, 223) = 7.477, p = .007).

CHAPTER V

CONCLUSION

General Discussion

Educational video has the potential to make the learning process more engaging and effective, but it can also prove cognitively overwhelming. The present study used CTML and three of its design principles—segmenting, signaling, and weeding—to reduce novice learners' extraneous cognitive load and facilitate knowledge acquisition. The results of this study support previous findings produced in the context of learning from educational animations and hypermedia and provide empirical evidence that validates this theory in several ways.

This finding supports CTML's underlying assumption that WM has a limited capacity, and the human mind can only process small portions of large amounts of visual and auditory stimuli at one time. Furthermore, it is consistent with the evidence that SSW principles reduce perceived cognitive load by focusing students' attention on important aspects of the learning material, providing concise cues about relevant information, and guiding them to engage in organizing and integrating only the essential information (Mautone & Mayer, 2001; Mayer & Moreno, 2003). First, the use of segmenting, signaling, and weeding in educational video reduced perceived learning difficulty for novice learners, which has been associated with extraneous cognitive load (e.g., Kalyuga, et al., 1999; Paas & Merriënboer, 1994).

The segmentation principle used in the present study helped reduce students' perception of the task's learning difficulty by chunking 32 minutes of continuous video content into 5 coherent video segments. Although the SSW and control group spent the same amount of time watching the video (32 minutes), the duration of each segment in the SSW condition was relatively short (about 6 minutes) and segmenting the long video contributed to the optimization of learners' knowledge integration processes during learning. In the non-SSW condition, learners were not able to process information as effectively and efficiently because the continuous stream of novel information without explicit breaks interfered with the organization and integration of individual information segments. Second, signaling helped learners in the SSW condition to organize relevant information into a coherent structure and decreased extraneous cognitive load associated with the extraction of semantic cues that were implicit in the non-SSW video. Finally, weeding reduced the cognitive processing of extraneous material and resulted in decreased perception of learning difficulty and higher levels of sustained attention on relevant aspects of the video (Mayer & Moreno, 2003).

Despite the low scores of the learning difficulty measure for both groups, the participants performed only at an average level on the tests of knowledge retention and had relatively low scores on the measure of structural knowledge acquisition. This indicates that participants in both groups were overly confident in reporting of the learning difficulty and couldn't organize the knowledge effectively with or without the SSW intervention. Nevertheless, the finding that the test scores for the SSW group were significantly higher on all measures of learning suggests that the SSW intervention did improve learning outcomes for domain novices learning from dynamic audiovisual materials, accounting for as much as eight percent of the variance in knowledge transfer.

This result is consistent with prior CTML research, which found that adding entertaining but irrelevant information to a multimedia presentation resulted in poorer understanding of the content (Mayer & Moreno, 2003). In the SSW condition, more cognitive resources were available for the processing of essential content, leading to more effective organization and integration processes, deeper learning and, consequently, higher test scores. In the non-SSW video condition, however, the nonessential information and the necessity to discern the most relevant content may have created extraneous cognitive load either by competing with the essential content for the limited cognitive resources or by demanding more cognitive resources to process the nonessential content. As a result, the processes of organizing and integrating knowledge were hindered (cf., Chandler & Sweller, 1991).

Finally, it was found that SSW principles impacted students' learning outcomes differentially, with the highest scores found in the transfer of knowledge and structural knowledge measures (as compared to knowledge retention), suggesting that SSW principles promote higher-order learning (Mayer, 2005). This result highlights the importance of taking into account the limitations of learners' WM capacity when designing video, especially when learners have not developed domain-specific schemas that help them interpret dynamic visual information (Kalyuga, Ayres, Chandler, & Sweller, 2003; Moreno & Duran, 2004). Unlike processing print text, which allows the learner to control the pace at which information is "fed" to the working memory; educational video presentations are typically long (20 minutes to 1.4 hours) and are shown to learners without interruptions, in their entirety. Thus, more cognitive support, like segmenting, signaling, and weeding, is required in situations with limited learner control over the pace, sequencing, and duration of content presentation.

Scope and Limitations

There are possible limitations related to the sampling and measurement used in this study. First, the investigator employed a convenience sample to focus on one specific student population (i.e., novice, undergraduate, non-science majors enrolled in a science course), one particular domain (i.e., entomology), and a specific presentation format (i.e., long educational video). Furthermore, the fact that the video used in this study was relatively low in conceptual difficulty (i.e., basic information about insect life), suggests that it is possible that researchers working with more complex, and illstructured topics and with other populations may produce entirely different results. For example, it has been consistently shown that cognitive support mechanisms are particularly effective when used with novice learners and complex topics (Shapiro, 2004).

While the investigator attempted to control for as many differences between groups as possible, a quasi-experiment always runs the risk that prior differences exist between the groups on variables not measured, and these differences may cause differences in the outcome variables. However, we had no reason to suspect that the two groups of students would differ, as all students were non-science majors and generally in their junior or senior year of college. Analysis of the basic demographic characteristics, such as gender, year in school, and GPA scores, confirmed this assumption.

Using a self-report to measure learning difficulty and infer cognitive load is considered a limitation because this measure focuses narrowly on the content difficulty and does not include other critical aspects of cognitive load, such as mental effort and response time. However, finding a single valid measure of cognitive load continues to be a challenge for educational psychologists (e.g., DeLeeuw & Mayer, 2008). Finally, the use of a multiple-choice test to measure student learning outcomes is considered another limitation. Short essays could serve as a more accurate measure of participants' knowledge, which might afford better insight into the mechanisms underlying the facilitating or inhibiting effects of each design principle.

Research Implications

The present study used a concept-sorting task as a measure of structural knowledge acquisition. While retention and transfer measures have traditionally been employed in prior studies to assess learning outcomes in multimedia learning, adding structural knowledge provides an important insight into learning from video. Structural knowledge is considered an essential aspect of deep learning (e.g., Jonassen, Wilson, Wang, & Grabinger, 1993), because it not only involves the integration of declarative information into useful knowledge concepts, but also the organization of the implicit patterns of relationships among concepts as well as understanding of the concepts' operational structure within itself and between associated concepts (Tennyson & Cocchiarella, 1986). This study showed that even though structural knowledge scores were relatively low for both experimental groups (students are seldom assessed on structural knowledge), the SSW intervention did produce a measurable effect on this dependent measure of learning. Thus, an implication for educational video researchers and designers is to determine the utility of various design principles in facilitating structural knowledge acquisition and emphasize it in their instruction.

Segmenting, signaling, and weeding appear to be useful design principles to decrease extraneous cognitive processing and enhance student learning from educational videos. However, it should not be assumed that application of different CTML design principles improves all types of learning outcomes equally. They will likely facilitate some learning outcomes and may lose their potency for others. For example, the segmenting principle may be most beneficial in terms of scaffolding structural knowledge acquisition, while signaling may prove more useful for helping learners integrate declarative knowledge. Consequently, educational video designers should have a very clear understanding of the learning goals and then design the video accordingly. The use of segmenting, signaling, and weeding in the present study suggests that the SSW design intervention may be particularly useful in situations where there is little or no guidance from the instructor (e.g., online learning) to explicitly focus and guide students to the essential concepts the video is designed to address.

While prior studies employed short animations that varied from few seconds to few minutes, the video used in this study was 32 minutes long. It is conceivable that in a longer treatment like the one used in this study, participants were able to determine the pattern of the SSW video design and use the signals and summaries provided to support their metacognitive processing relative to the monitoring an summarizing of learning. In a shorter treatment, however, it is possible that learners would not experience the same level of metacognitive support due to the initial adjustment period it would require. This hypothesis should be also empirically tested.

A useful venue for the future study of educational video is to examine the application of other CTML design principles (i.e., modality, pretraining, spatial contiguity, redundancy, temporal contiguity, etc.), and involve participants that differ in their levels of metacognitive awareness, prior knowledge, spatial skills, and learning preferences. This line of inquiry may use these design principles individually or, as in the present study, in combination. For example, according to the expertise-reversal effect, the instructional effects found for novice learners may disappear or even revert as they acquire expertise in the knowledge domain (Kalyuga, et al., 2003). It seems likely that the CTML design principles are more effective for novices than advanced learners. Another promising area of research is to examine the effects that students' prior knowledge may have on learning outcomes when watching video designed based on CTML design principles. According to the expertise-reversal effect, the instructional effects found for novice learners may disappear or even revert as they acquire expertise in the knowledge domain (Kalyuga et al., 2003). Thus, it is possible that SSW methods are more effective for novices than for advanced learners. This hypothesis should be empirically tested.

Finally, a possible future research area is examining the conditions when the learner is in control of the pace of instruction, such as comparing how students learn from video that contains built-in or user-controlled breaks after each segment (as in a DVD). This research might produce more specific design principles for educational video design suited for online or distance learning. These research directions can prove important in improving educational video design and promote the development of more refined research-based design principles.

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APPPENDICES

APPPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL

Oklahoma State University Institutional Review Board

Date:	Tuesday, January 19, 2010
IRB Application No	ED107
Proposal Title:	Effectiveness of Designing Instructional Video Based on Cognitive Theory of ultimedia Learning (CTML) and Cognitive Load Theory (CLT)
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 1/18/2011

Principal Investigator(s):

Mohamed Ibrahim	Pasha Antonenko
4717 East 80th St. apt. 9D	210 Willard
Tulsa, OK 74136	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

[X] The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

APPPENDIX B: INFORMED CONSENT LETTER FOR SURVEY PARTICIPANTS

Last four digit of SS#:

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE:
Effectiveness of Designing Instructional Video Based on Cognitive Theory of Multimedia Learning (CTML) and Cognitive Load Theory (CLT)

INVESTIGATORS:
Mohamed Ibrahim, PhD student, Oklahoma State University, School of Educational Studies.

Pasha Antonenko, Ph.D. Oklahoma State University, Assistant Professor of Educational Technology, School of Educational Studies

PURPOSE:
The purpose of this study is to examine the effect of modified video which has been edited to include an introduction, summary, and cue of important information on students' recall, comprehension and level of difficulty of instructional.

PROCEDURES:
Watching the video and taking a posttest is part of the normal class experience for all students enrolled in ENTO-2003 INSECTS AND SOCIETY. If you choose to participate in the experiment, you will volunteer to complete pretest and to supply some demographic/academic information, in addition to the required posttest. All pre- and posttests and surveys will be anonymous, using the last four digits of your SS# as identifier. There will be one packet for the pretest and one packet for the posttest. Each packet will contain a clearly visible box for the last four digits of the SS# on top of the front page of each packet.
The experiment will involve completion of six surveys and watching a 34-minute video about insects. Surveys and questionnaires will include the following:
First, filling out the Metacognitive Awareness Inventory survey (MAI), which includes true/false questions about how you normally perform a learning task. MAI should take approximately 7 minutes to complete. The second survey will ask for demographic information, such as your age, gender, major, GPA, years in college and personal preferences in video-based instruction, as compared to traditional text-based instruction. This survey should take approximately 3 minutes. The third survey is a 10-question, multiple choice which will assess your prior knowledge pertaining to insects and should take approximately 5 minutes.

After watching the video, you will be asked to complete a survey which assesses the difficulty of the learning materials you experienced while watching the video. This survey is a 9 point scale question and should take approximately 2 minutes to complete. Finally, the posttest will include 25 multiple choice questions and a structural knowledge test to assess what you learned from watching the video. The posttest should take approximately 20 minutes to complete.

Your test results for this study will in no way impact your performance in ENTO-2003 INSECTS AND SOCIETY.

Your participation will take approximately 70-75 minutes.

RISKS OF PARTICIPATION:

There are no risks associated with this project, including stress, psychological, social, physical, or legal risk that is greater, considering probability and magnitude, than those ordinarily encountered in daily life. If, however, you begin to experience discomfort or stress in this project, you may end your participation at any time.

BENEFITS OF PARTICIPATION:

You may gain an appreciation and understanding of how research is conducted.

CONFIDENTIALITY:

All information about you will be kept confidential and will not be released. Questionnaires and record forms will have identification numbers that consist of the four last digits of your Social Security number, rather than names, on them. Research records will be stored securely in a locked filing cabinet and only researchers and individuals responsible for research oversight will have access to the records. This information will be saved as long as it is scientifically useful. It will be destroyed on Dec. 1 2010. Results from this study may be presented at professional meetings or in journal publications. You will not be identified individually; we will be looking at the group as a whole. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

COMPENSATION:

All students, both participants and nonparticipants who attend the class and take the posttest will receive one unit of course credit, this is 1% of the overall class grade, regardless of the posttest grade. Only participants will be entered in a drawing for five $25 Wal-Mart gift certificates.

CONTACTS:

You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Mohamed Ibrahim, 4717 East 80th Street, Apartment 9-D, Tulsa, OK, 74136, (918)606-0012. If you have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:
Your participation in this research is voluntary. There is no penalty for refusal to participate, and that you are free to withdraw your consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:
I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given tome. I hereby give permission for my participation in the study.

______________________________ __________________

Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

______________________________ __________________

Signature of Researcher Date

APPPENDIX C: DEMOGRAPHIC SURVEY

1. **Gender**

   A. Male
   B. Female

2. **Age**

   A. 18-21
   B. 22-25
   C. 26-30
   D. 31-40
   E 41or over

3. **Years in college**

   A. 1 year
   B. 2 years
   C. 3 years
   D. 4 years or more

4. **Your GPA**

   ----

5. **Your major**

   ----

6. **Learning style preferences: I prefer learning from**

   A. Lectures
   B. Books
   C. Video/movies
   D. Hands-on activities

APPPENDIX D: METACOGNITIVE AWARENESS INVENTORY QUESTIONNAIRE

Check True or False as appropriate.

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		
3. I try to use strategies that have worked in the past.		
4. I pace myself while learning in order to have enough time.		
5. I understand my intellectual strengths and weaknesses.		
6. I think about what I really need to learn before I begin a task		
7. I know how well I did once I finish a test.		
8. I set specific goals before I begin a task.		
9. I slow down when I encounter important information.		
10. I know what kind of information is most important to learn.		
11. I ask myself if I have considered all options when solving a problem.		
12. I am good at organizing information.		
13. I consciously focus my attention on important information.		
14. I have a specific purpose for each strategy I use.		
15. I learn best when I know something about the topic.		
16. I know what the teacher expects me to learn.		
17. I am good at remembering information.		
18. I use different learning strategies depending on the situation.		
19. I ask myself if there was an easier way to do things after I finish a task.		
20. I have control over how well I learn.		
21. I periodically review to help me understand important relationships.		
22. I ask myself questions about the material before I begin.		
23. I think of several ways to solve a problem and choose the best one.		
24. I summarize what I've learned after I finish.		
25. I ask others for help when I don't understand something.		
26. I can motivate myself to learn when I need to		
27. I am aware of what strategies I use when I study.		
28. I find myself analyzing the usefulness of strategies while I study.		
29. I use my intellectual strengths to compensate for my weaknesses.		
30. I focus on the meaning and significance of new information.		
31. I create my own examples to make information more meaningful.		
32. I am a good judge of how well I understand something.		

	True	False
33. I find myself using helpful learning strategies automatically.		
34. I find myself pausing regularly to check my comprehension.		
35. I know when each strategy I use will be most effective.		
36. I ask myself how well I accomplish my goals once I'm finished.		
37. I draw pictures or diagrams to help me understand while learning.		
38. I ask myself if I have considered all options after I solve a problem.		
39. I try to translate new information into my own words.		
40. I change strategies when I fail to understand.		
41. I use the organizational structure of the text to help me learn.		
42. I read instructions carefully before I begin a task.		
43. I ask myself if what I'm reading is related to what I already know.		
44. I reevaluate my assumptions when I get confused.		
45. I organize my time to best accomplish my goals.		
46. I learn more when I am interested in the topic.		
47. I try to break studying down into smaller steps.		
48. I focus on overall meaning rather than specifics.		
49. I ask myself questions about how well I am doing while I am learning something new.		
50. I ask myself if I learned as much as I could have once I finish a task.		
51. I stop and go back over new information that is not clear.		
52. I stop and reread when I get confused.		

APPPENDIX E: PRETEST

1. **Which of the following contributes to insects' ability to develop insecticide resistance?**

   A. They reproduce in vast numbers very quickly
   B. They have been dealing with toxins produced by plants for hundreds of millions years
   C. They have genetic variability
   D. All of the above

2. **Scarab beetles are revered in ancient Egyptian culture because….**

   A. They are indicators of a fruitful harvest
   B. They are considered to have medicinal properties
   C. They represent the god Ra, who controls the sun
   D. They are considered a culinary delicacy

3. **Which from the following list is NOT an insect characteristic?**

   A. All insects have 2 body parts, a head and a thorax
   B. Most insects have wings
   C. All insects are invertebrates
   D. All insects have a hard exoskeleton

4. **While most insects have six legs, there are a few with four or eight legs**

   A. True
   B. False

5. **Some insects reproduce genetically varied offspring each year which help them:**

   A. To consume more food
   B. To adapt to environmental change
   C. To diversify their food
   D. To camouflage from their predators

1

6. **What is a characteristic of complete metamorphosis?**

A. Immature insects look like small versions of the adult
B. Immature insects live underwater and adults live on land
C. Immature insects are called larva and do not look like the adult
D. Immature insects are called nymphs and look similar to the adult but do not have wings

7. **Incomplete metamorphosis is:**

A. Larva becomes pupa and then a winged adult.
B. Egg hatches into a winged adult.
C. Egg hatches into larva and becomes a pupa and then a winged adult.
D. Nymph passing through a series of stages in which it becomes like the adult

8. **Which of the following statements regarding insect vision is correct?**

A. Insects are much slower at processing visual information than humans
B. Insects see much sharper images than we do
C. Insects are much faster at processing visual information than humans
D. Insects can only see in “black and white”

9. **An insect that is brightly colored yellow and black or red and black is….**

A. camouflages as a flower
B. Exhibits colors that most predators are incapable of seeing
C. Advertises that it is toxic or can sting
D. The victim of an accidental mutation

10. **Which is NOT a defense technique used by insects:**

A. Using jaws
B. Using hard shell
C. Chemicals
D. None of the above

APPPENDIX F: COGNITIVE LOAD QUESTIONNAIRE

1. **How difficult was this video?**

1 Extremely easy

2 Very easy

3 Easy

4 Somewhat easy

5 Neither easy nor difficult

6 Somewhat difficult

7 Difficult

8 Very difficult

9 Extremely difficult

APPPENDIX G: RETENTION AND TRANSFER TESTS

1. **In which of the following environments do insects live?**

   A. In trees
   B. On animals
   C. Underground
   D. Underwater
   E. All of the above

2. **Which of the following contributes to insects' ability to develop insecticide resistance?**

   A. They reproduce in vast numbers very quickly
   B. They have been dealing with toxins produced by plants for hundreds of millions years
   C. They have genetic variability
   D. All of the above

3. **Scarab beetles are revered in ancient Egyptian culture because….**

   A. They are indicators of a fruitful harvest
   B. They are considered to have medicinal properties
   C. They represent the god Ra, who controls the sun
   D. They are considered a culinary delicacy

4. **Insects are a very essential part of all terrestrial ecosystems on the planet because**

   A. They work collectively
   B. They camouflage as a flowers
   C. They play a major role in the decomposition of dead animals
   D. They live in colonies

5. **Without insects, most of the life forms on our planet would:**

   A. Slowly improve
   B. Slowly disappear
   C. Quickly flourish
   D. Remain the same

1

6. **Which from the following list is NOT an insect characteristic?**

A. All insects have 2 body parts, a head and a thorax
B. Most insects have wings
C. All insects are invertebrates
D. All insects have a hard exoskeleton

7. **Name two reasons, according to the video, that insects do not get larger than the do.**

A. Their exoskeleton is too bulky, so they would be unable to hide from predators
B. Their respiratory and digestive/excretory systems limit how big they can get
C. The wing design of insects would not work if insects were larger than 6 inches, and their exoskeletons are too bulky
D. Their respiratory system is inefficient, and their exoskeleton is too bulky

8. **While most insects have six legs, there are a few with four or eight legs**

A. True
B. False

9. **Which is NOT part of the insect's breathing system**

A. Spiracles
B. Lungs
C. Branching tubes

10. **If the Tsetse fly was strictly a nectar-feeder, it is likely that this disease would be eliminated:**

A. Bubonic plague
B. African sleeping sickness
C. Malaria
D. None of the above

11 **The example of co-evolution provided in this video involved:**

A. Humans and insects
B. Insects and plants
C. Plants and humans
D. Insects, humans and plants

12 **Which of the following characteristics allows insects to adapt to environmental change over many generations?**

A. Their vast numbers
B. Genetic variability among individuals
C. Their small size
D. Their hard exoskeleton

13 **What is a characteristic of complete metamorphosis?**

A. Immature insects look like small versions of the adult
B. Immature insects live underwater and adults live on land
C. Immature insects are called larva and do not look like the adult
D. Immature insects are called nymphs and look similar to the adult but do not ha wings

14 **The earliest known insects (from the fossil record)**

A. Had 2 pairs of independent flight wings
B. Had one pair of flight wings
C. Had 2 pairs of flight wings that linked together to make 2 flight surfaces
D. Did not fly at all – they lived underwater

15 **If one insect reproduced genetically varied offspring and another did not, which insect would have a better chance to adapt to global warming?**

A. Insect which reproduce genetically varied offspring
B. Insect which doesn't reproduce genetically varied offspring

16 **Incomplete metamorphosis is:**

A. Larva becomes pupa and then a winged adult.
B. Egg hatches into a winged adult.
C. Egg hatches into larva and becomes a pupa and then a winged adult.
D. Egg hatches into nymph which goes through a series of molts before becoming adult

17 **Which of the following statements regarding insect vision is correct?**

A. Insects are much slower at processing visual information than humans
B. Insects see much sharper images than we do
C. Insects are much faster at processing visual information than humans
D. Insects can only see in "black and white"

18 **Ants tell other ants where food is by...**

A. Use of vibrations (form of language)
B. A special dance that gives direction and distance
C. Leaving a chemical trail
D. Telepathy

19 **How do insects produce sound?**

A. Rub their wings together
B. Rubbing part of their body against a surface
C. Building acoustic structures
D. All of the above

20. **If you have decided to be a fly for a day, and you went to a theater, you would see the movie:**

A. As normal speed movie
B. As slow motion movie
C. As fast motion movie
D. None of the above

21. **An insect that is brightly colored yellow and black or red and black is....**

A. Camouflaged as a flower
B. Exhibiting colors that most predators are incapable of seeing
C. Advertising that it is toxic or can sting
D. The victim of an accidental mutation

22 **Which of the following statement is correct regarding social insects:**

A. They are poorly skilled architects
B. Social insects live in colonies
C. They work individually
D. All of the above

23 **Which of the following is a defensive technique used by insects:**

A. Camouflage
B. Hide in their hard shell to protect from attackers
C. Using noxious chemicals to deter predators
D. All of the above

24 **All insects are highly skilled architects:**

A. True
B. False

25 **According to the video, could a soldier termite perform the role of a worker termite:**

A. Yes, social insects often rotate tasks during their life span
B. No, social insects do not rotate tasks during their life span

APPPENDIX H: STRUCTURAL KNOWLEDGE TEST

Please write the number for each concept as presented in the video in the appropriate column:

1. Anatomy and Function of the eye
2. Aquatic Life
3. Breathing System
4. Co-evolution
5. Common Characteristics
6. Communication Techniques
7. Complete Metamorphosis
8. Defense Techniques
9. Early Insects
10. Flying
11. Incomplete Metamorphosis
12. Insects Habitat
13. Insects in Human Mythology
14. Mouths & Eating
15. Negative Aspects
16. Positive Aspects
17. Pollination
18. Reproduction
19. Social Life
20. Spread of Human Diseases

Basic Facts	Body Parts	Insects Evolution	Aquatic Life, Visual & Communication	Defense Techniques & Social Insects

APPPENDIX I: PERMISSION MEMO TO USE THE VIDEO

TO: Mohamed Ibrahim
Media Staff, Learning Resources Center (LRC)
Tulsa Community College

FROM: Demetrius Bereolos
LRC Specialist
Tulsa Community College

DATE: May 20, 2009

SUBJECT: Use of BBC and NATURE produced videos in cognitive learning experiment

In your request about copyright clearance, you mentioned that you and your doctoral committee advisor (Pasha Antonenko, Ph.D, Oklahoma State University, College of Education) are planning an experiment to develop a model for designing educational videos based on cognitive science to assist students with their learning while watching video. The experiment plans to use two copyrighted documentaries (on DVD) produced by the British Broadcasting Company (BBC)--*Eyewitness- Butterfly & Moth* and *Eyewitness - Insect* (copyright 1994) and a copyrighted documentary (on DVD) produced by NATURE--*The Queen of Trees.* Clips from these videos will only be used for this experiment and will be shown to college students in a face-to-face classroom setting. The experiment will add introductions, reviews, and summaries to the videos clips, as well as freezing frames to comment on specific content. No frames will be deleted from the videos. The augmented clips from the three videos will only be used in the Fall, 2009 and Spring, 2010. The videos will not be copied or reproduced and will not be broadcast online or using any other medium.

Your request involves seeking an exemption from getting permission from the BBC and NATURE to use to use the videos in the experiment. I believe that there are two possible exemptions. Both exemptions assume that the copies of the BBC and NATURE videos used in the experiment are lawfully acquired.

The first justification for an exemption is that this experiment closely resembles the "face-to-face teaching exemption" from getting copyright permission--as set forth in U.S. Code, title 17, section 110. This experiment, while not an exact match with the instructional activity discussed in section 110, closely enough resembles a situation involving "instructors or pupils in the course of face-to-face teaching activities of a nonprofit educational institution" and taking place "in a classroom or similar place devoted to instruction." There would not be any transmission beyond the place where the copies of the videos are located. For an argument to made that the experiment closely enough resembles the "face-to-face teaching exemption" so as not to require the permission of the BBC and NATURE, the must not be a profit motive for the experiment--it must be performed "without any purpose of direct or indirect commercial advantage."

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The second, and probably more compelling, justification for an exemptior the fair use of the copies of the BBC and NATURE videos for teaching or researc not an infringement of copyright--as set forth in U.S. Code, title 17, section 107 use exemption). The fair use exemption is established by considering four facto: regarding the use of the copyrighted work--the *purpose and character of the use* the *nature of the work*, the *amount* and substantiality of the portion of the work and the *effect of the use upon the potential market* or value of the work.

- Since the BBC and NATURE videos will be used for research and scholarshi the *purpose and character* factor favors a fair use exemption
- Since the BBC and NATURE videos are published works and since the video are documentary or factually-based works, the *nature of the work* factor favc a fair use exemption.
- Since the copies of the BBC and NATURE videos are lawfully acquired, since there will only be one or few copies made of the augmented clips from the BBC and NATURE videos, since there is not a similar product (video clips with the augmentation identified with this experiment) produced by the BBC and NATURE, since it is unlikely that anyone in the marketplace will want t purchase the augmented video clips identified with this experiment (meanin that the augmentation will not impair or have any significant effect on the sale of the BBC and NATURE videos in their normal format), the *effect of the use upon the potential market* or value of the work factor favors a fair use exemption.
- Even though a significant portion of each of the BBC and NATURE videos will become augmented clips for the experiment, it can be argued that the amount of each of the BBC and NATURE videos used is appropriate for the nature of the experiment--establishing that *the amount and substantiality of the portion of the work used* factor favors a fair use exemption.

The four factors can establish that use of the augmented clips from the BBC an NATURE videos is a fair use exemption and not an infringement of copyright

APPPENDIX J: VERBAL SCRIPT TO RECRUIT SUBJECTS

Verbal Script to recruit subjects

"Hello, my name is Mohamed Ibrahim. I am a graduate student at Oklahoma State University in the College of Education, and I am in Stillwater undertaking research that will be used in my dissertation.

The purpose of this study is to examine students' recall and comprehension and level of difficulty of instructional video which has been edited to include an introduction, summary, and cue of important information. Giving your important role as student who uses video in learning, I am interested in the effects of applying an advance organizer, segmenting, signaling, and a summary to a science instructional video on learners' germane cognitive load, conceptual and structural knowledge acquisition, and transfer of learning.
Watching the video and taking a posttest is part of the normal class experience for all students enrolled in ENTO-2003 INSECTS AND SOCIETY, and those who choose to participate in the experiment will volunteer to complete a demographic survey and the pre and posttests. All students, both participants and nonparticipants who attend the class and take the posttest will receive one unit of course credit, this is 1% of the class grade overall, regardless of the posttest grade. Participants will also be entered in a drawing for five $25 Wal-Mart gift certificates.

The information you share with me will be of great value in helping me to complete this research project and the results of which could significantly enhance our understanding of the design of instructional videos for in-class or online learning.

Watching the video, tests and surveys will take about 70-75 minutes of your time.

There is no risk of a breach of confidentiality. I will not link your name to anything you say, either in the results of the tests and surveys or in the text of my dissertation or any other publications.

Participation is voluntary. If you decide not to participate, there will be no penalty or loss of benefits to which you are otherwise entitled. You can, of course, decline to answer any question as well as to stop participating at any time, without any penalty or loss of benefits to which you are otherwise entitled.

If you have any additional questions concerning this research or your participation in it, please feel free to contact me, my dissertation supervisor or our university research office at any time."

(The respondent will be given an information card, when applicable, containing name, institutional affiliation, and contact information.)

"Do you have any questions about this research? Do you agree to participate?

If so, let's begin…."

VITA

Mohamed Ibrahim

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECTS OF SEGMENTING, SIGNALING, AND WEEDING ON LEARNING FROM EDUCATIONAL VIDEOS

Major Field: Educational Technology

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Education at Oklahoma State University, Stillwater, Oklahoma in May, 2011

Completed the requirements for the Master of Arts in Political Science at Oklahoma State University, Stillwater, Oklahoma in 1997

Completed the requirements for the Bachelor of Arts in Archeology at Cairo University, Cairo, Egypt in 1984

Experience:

2007 - Present - IT/Media Department, Tulsa Community College; Tulsa, Oklahoma
2003 - 2006 - Assistant Professor. Faculty of Mass Communication, Modern Sciences and Arts University, Cairo, Egypt
1998 - 2003 - Adjunct Instructor, Journalism and Mass Communication, Tulsa Community College, Tulsa, Oklahoma
1997 - 2003 – Video Producer and Editor Creative Services Department, TV Guide Networks, Inc., Tulsa, Oklahoma

Professional Memberships:

2008 – Present: Member of the American Educational Research Association (AERA)
2010 – Present: Member of the American Educational Studies Association (AESA)

Name: Mohamed Ibrahim Date of Degree: May, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTS OF SEGMENTING, SIGNALING, AND WEEDING ON LEARNING FROM EDUCATIONAL VIDEOS

Pages in Study: 90 Candidate for the Degree of Doctor of Philosophy

Major Field: Educational Technology

Scope and Method of Study:

Informed by the cognitive theory of multimedia learning, this study examined the effects of three multimedia design principles on undergraduate students' learning outcomes and perceived learning difficulty in the context of learning entomology from an educational video. These principles included segmenting the video into smaller units, signaling to direct students' attention to relevant information, and weeding to remove any nonessential content (SSW). It was hypothesized that the SSW treatment would decrease perceived learning difficulty and facilitates transfer of knowledge and structural knowledge acquisition.
This study used a quasi-experimental, between-subjects design to measure the effect of segmentation, signaling and weeding (independent variable) on four dependent variables: (1) perceived learning difficulty, (2) knowledge retention, (3) transfer of knowledge, and (4) structural knowledge acquisition. Prior knowledge and metacognitive awareness were included in the model as covariates. The instruction used in the present study was an educational video with two different designs.

Findings and Conclusions:

Results of the study demonstrate that participants in the SSW group outperformed the non-SSW group on the tests of knowledge transfer and structural knowledge acquisition and reported lower levels of learning difficulty. These findings support the use of segmenting, signaling, and weeding to help novice learners organize and integrate knowledge from complex, dynamic audio-visual media like video.

ADVISER'S APPROVAL: Dr. Pasha Antonenko