EXAMINING INFLUENCE OF INSTRUCTOR PRESENCE IN INSTRUCTIONAL VIDEOS: AN INDIVIDUAL DIFFERENCES PERSPECTIVE

By

JIAHUI WANG

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To my Mom

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Jiahui Wang

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With the continued expansion of online learning, many popular online education platforms use instructional videos that integrate a live recording of a real instructor. The current study aimed to explore how instructor presence in videos influences learning, visual attention distribution, cognitive dynamics, and learner perceptions and how these effects are moderated by individual differences in learners' working memory capacity (WMC) and inhibitory control. This study used a design with the content difficulty as a within-subjects variable and instructor presence as a between-subjects variable. Participants watched two statistics instructional videos of varied content difficulty, each with or without instructor presence, while the experimenter recorded their electrical brain activity via electroencephalography and eye movements using an eye tracker. Afterwards, participants self-reported their cognitive load, perceived learning, satisfaction, situational interest, social presence for both videos and their perceptions of the instructor for the videos featuring a recording of the instructor. Learning from the two videos was measured using retention and transfer questions. Individual differences in

WMC were assessed using the Automated Operation Span task and differences in inhibitory control were measured using the Flanker test before the video session.

Results indicated the instructor frame attracted a significant amount of attention for both easy and difficult topic videos. Instructor-present difficult topic video led to lower level of theta activity, which indicated decreased working memory load. Findings also showed instructor presence improved learners’ ability to transfer information from the difficult topic. Instructor presence produced a positive effect on reducing learners’ cognitive load for the difficult topic, and increasing their perceived learning, satisfaction, and situational interest for both topics. Instructor presence was largely perceived as helpful, entertaining, and engaging for both topics. Besides, participants who had higher WMC scores performed significantly better on the retention test for the easy topic; and those who had higher inhibitory control scores excelled on the transfer test for the difficult topic. Last, process measures such as cognitive dynamics and visual attention distribution predicted product measures such as learning and learner perception. The study provided positive evidence for including an instructor in instructional video, especially for difficult content.

CHAPTER 1
INTRODUCTION

Context

With the continued expansion of online learning in both K-12 and higher education (Allen, Seaman, Poulin, & Straut, 2016), a growing number of instructional units are delivered online using video format on a multitude of platforms such as Coursera™, Khan Academy™, and edX™ (Guo, Kim, & Rubin, 2014). Striving to enhance student learning experience in the online environment, educators are placing much emphasis on designing and developing quality instructional videos (Crook & Schofield, 2017).

Khan Academy™ started out as a resource that offered instructional videos in mathematics, with the intention of improving K-12 mathematics achievement in the United States. One prominent feature of Khan Academy videos is that they are designed without a visible instructor and instead utilize a “pencast” format (Herold, Stahovich, Lin, & Calfee, 2011) to explain mathematics concepts – that is, the learner can see the pen and sometimes the instructor’s hand drawing and writing out formulas, concepts, and graphs. Unlike Khan Academy, many other existing instructional videos (e.g., those created by edX™ and Coursera™) include a video of the instructor as a picture-in-picture effect next to the learning content, with a substantial increase in production cost (Kizilcec, Papadopoulos, & Sritanyaratana, 2014).

On one hand, the presence of instructor can elicit beneficial socio-emotional responses and support learners’ understanding by providing nonverbal modalities of interaction (Clark & Mayer, 2016). On the other hand, the presence of a real instructor on the screen provides a group of complex visual stimuli that might distract learners and add to learners' extraneous cognitive load, especially when the content itself has already imposed a relatively high intrinsic load (Wang & Antonenko, 2017). It is possible that the potential benefits from eliciting socio-emotional responses by adding an instructor to the video may be offset by extraneous visual and cognitive processing associated with attending to the instructor in the video, because it conveys little content related information. Although several studies have found positive influences of showing instructor in instructional videos, other studies revealed no or negative effects of instructor presence on learning or self-reported cognitive load. The empirical evidence for the support of incorporating an instructor in instructional videos is limited and conflicting. Therefore, further study is needed to comprehensively explore the influence of instructor presence in instructional videos.

Instructional videos are generally designed in a "one-size-fits-all" manner, but individual students vary in many ways and individual differences in attention and cognition can affect the way students learn with the same media. Positive (or negative) effects of instructor presence in instructional videos may be especially pronounced when a learner has diminished (or enhanced) working memory and visual attention capacity, processing speed, inhibitory control, and a host of other cognitive and non-cognitive variables. Considering instructional videos are used by millions of learners who exhibit a wide range of attentional and cognitive differences, it is important to examine how the influences of instructor presence are moderated by individual differences in variables such as working memory capacity and inhibitory control and whether and how the design of videos can be improved to accommodate the needs of a wide range of learners.

Statement of Problem

Empirical evidence is limited and mixed concerning the influence of instructor presence in instructional videos. Therefore, further research is needed to explore the influence of instructor presence in instructional videos. Also, it is time to discard the one-size-fits-all approach in designing instructional videos for all learners, and conduct rigorous research to understand how individual differences in learner attention and cognition can moderate the influence of instructor presence in instructional videos.

Purpose of Research

The proposed study aims to explore how instructor presence in videos influences learning, visual attention distribution, cognitive dynamics, and learner perceptions and how these effects are moderated by individual differences in working memory capacity and inhibitory control. Existing evidence suggests learners with differences in attention and cognition might respond to instructor presence in differential ways (Sanchez & Wiley, 2006; Rothbart, & Posner, 1985).

The study focuses on the videos produced by Study Edge™, an online learning community that offers instructional support on multiple topics such as Statistics, Economics, Organic Chemistry and so on. The main frame of each video is devoted to a Khan Academy style pencast, whereas the bottom right-hand corner always shows a shoulder-up view of the instructor. The instructor frame shows the instructor explaining the content and displaying non-verbal cues (e.g., eye gaze, gesturing, and facial expressions).

Research Questions

The current study is designed to explore the following two research questions.

- Question 1. To what extent does instructor presence in easy and difficult instructional videos influence learning, visual attention distribution, cognitive dynamics, and learner perceptions (cognitive load, perceived learning, satisfaction, situational interest, social presence, and perceptions of the instructor)?
- Question 2. How do individual differences in working memory capacity and inhibitory control moderate instructor presence effects in easy and difficult instructional videos?

Significance

The current study is designed to generate evidence on the influence of instructor presence on learning, visual attention distribution, cognitive dynamics, and learner perceptions in instructional videos. The study also contributes to the understanding of how individual differences in important cognitive variables such as working memory capacity and inhibitory control moderate these effects. Findings from this study can advance our understanding of individual cognitive differences' role in relation to the effects of instructor presence in instructional videos. Furthermore, the study will generate design implications for videos that accommodate individual differences and further research on individual differences in multimedia learning.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses the theoretical foundations of multimedia learning and how the multimedia learning principles inform the design of instructional video. Next, I reviewed the empirical studies that examined the effects of instructor presence in instructional video. Following a brief overview of various factors that interact with the influence of instructor presence on learning, perceptions, and engagement, I discussed how individual differences such as working memory capacity and inhibitory control can possibly moderate the influence of instructor presence in easy and difficult topic instructional videos. Finally, I examined methodological considerations and compared the product measures with process measures and what additional information process measures of cognitive dynamics and visual attention distribution can reveal in this study's context.

Theoretical Foundations

Multimedia learning has been defined as learning from verbal and pictorial information (Mayer, 2014). Verbal information can be presented in the form of on-screen text and sound (e.g., narration). Pictorial information can be retrieved from pictures, diagrams, video, animation, and so on. Multimedia learning includes learning from animation, video, screen-casting, games and simulations among other instructional media that involve pictorial and verbal information. A fundamental hypothesis underlying research on multimedia learning is that humans learn better when multimedia is designed based on how human mind works to optimize cognitive processing of complex multimedia information (Mayer, 2009).

An important theoretical perspective informing research on multimedia learning is Cognitive Theory of Multimedia Learning (CTML, Mayer, 2014). It is based on several theoretical frameworks that explain and predict how human memory processes information. They are dual coding theory (Paivio, 1986), cognitive load theory (Sweller, van Merriënboer, & Paas, 1998), and theories of working memory (Baddeley & Hitch, 1974).

Models of Memory

Atkinson and Shiffrin (1968) posited that human memory is divided into sensory, short-term and long-term systems. Sensory memory is a highly transient information store that holds sensory information received via vision, hearing, the olfactory system, and so on. If the information is attended to, it enters the short-term memory. Short-term memory is a central processing unit to process incoming information. This processing involves filtering information by discarding irrelevant information and selecting only the most relevant information units, and organizing these information units for efficient and effective integration with prior knowledge that is stored in the long-term memory. Long-term memory stores schemata, which are mental structures to organize knowledge. This multi-store model of memory has also been referred to as the information-processing model as it conceives human memory system as a computer, which receives input from the environment, processes it, and produces output.

Working memory is a term coined by Baddeley and Hitch in 1974 to describe the processing and storage performed in short-term memory as the central processing unit of human cognitive architecture. Specifically, Baddeley and Hitch (1974) proposed that similar to the overall human cognitive architecture, working memory is multi-component system for the short-term storage and manipulation of information. Working memory was assumed to have sub-units to process different types of information: a) visuospatial sketchpad for storing and processing visuospatial input, b) phonological loop for manipulating auditory information (Baddeley & Hitch, 1974), and c) central executive as an attentional control system to oversee and control the entire working memory system, and perform more integrative and thus cognitively demanding tasks such as problem solving. Later, Baddeley (1992) complemented the working memory system with a fourth component - episodic buffer, which holds representations that integrate phonological, visuo-spatial information, and possibly other information that is not handled by the phonological loop or visuospatial sketchpad, for example, semantic information. The component is episodic because it is assumed to bind information into a unitary episodic representation reflecting the specific context of information processing. Episodic buffer, visuo-spatial sketchpad, phonological loop, and central executive are essential components of the working memory system that altogether temporarily store and process incoming information, as well as integrate information that is deemed most relevant with prior knowledge in the long-term memory. Other theories of working memory have been proposed (D'esposito & Postle, 2015), however, because CTML uses Baddeley and Hitch's (1974) model of working memory, this dissertation focuses on this particular conceptualization.

Cognitive Load Theory

Baddeley and Hitch's (1974) working memory model discussed the structure of working memory and scholars such as Miller (1956) and Cowan (2001) suggested working memory is limited in its processing capacity. Miller (1956) found that our working memory system can process about seven distinct information units. A more recent description of the limited working memory capacity was proposed by Cowan (2001), who experimentally determined that when we have to compare and contrast information, working memory only allows about four chunks of information to be processed at a time. Based on this delineation of limited working memory capacity, cognitive load theory (Sweller, 1988) defines the amount of information being stored and manipulated in working memory as “cognitive load” and explains and predicts how working memory processes information and interacts with long-term memory (Sweller, van Merriënboer, & Paas, 1998). When the information the learner needs to process exceeds the limited working memory capacity, information is not processed optimally and so learning is hindered due to excessive demands on the cognitive system. To account for this, cognitive load theory distinguishes between three types of cognitive load: intrinsic load, extraneous load, and germane load (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Different topics (e.g., solving a Calculus problem vs. adding two single digits) differ in how many information elements they contain and how these elements interact to produce understanding and learning. The amount of information elements and the level of element interactivity (Sweller, 2010) thus impose different levels of intrinsic cognitive load on the learner – some content is more difficult to learn because there are more interacting elements and so the intrinsic load it imposes on the cognitive system is higher. For example, solving an optimization problem in Calculus involves determining the function, identifying the constraints to the optimization problem, calculating the derivatives, and so on, whereas adding two single digits only requires processing two information elements using a single non-complex mathematical operation. Thus, intrinsic cognitive load is determined by the complexity of the material (i.e., element interactivity) and is moderated by the prior knowledge the learner possesses. In contrast, extraneous cognitive load is mainly associated with a poor presentation of information and design of learning materials. For example, presentation slides designed using poor contrast between the text and background, or slides that include a lot extraneous animations that distract the learner from the relevant content, cause high levels of extraneous processing, which results in extraneous load on the cognitive resources and missed opportunities for learning. Finally, germane load occurs when the learning content and instructions are designed to help people concentrate on learning and integrate new information with existing knowledge more effectively and efficiently without overwhelming them. In this sense, one could say that the art of teaching is about designing learning experiences to encourage germane load for all learners in the classroom. To conclude, whereas germane load facilitates learning, intrinsic and extraneous types of load hinder learning (Plass, Moreno, & Brünken, 2010). From the perspective of multimedia learning design, multimedia instructional materials should be designed to minimize extraneous cognitive load and allow more cognitive resources for germane processing of content imposing either high or low level of intrinsic load.

Dual Coding Theory

Because multimedia learning involves processing verbal and pictorial information, another important cognitive theory that underlies CTML is the dual coding theory (Paivio, 1986). The dual coding theory suggests that verbal and pictorial information sources are processed separately by the verbal system and pictorial system of human memory. Dual coding is superior to single coding of information in that pictorial information may elicit an enhanced memory of verbal information and vice versa. As meaningful learning is facilitated when referential connections between the mental representations (e.g., verbal and pictorial representations) are built, learning with both verbal and pictorial information is hypothesized to be superior to learning with verbal and pictorial information alone (Paivio, 1986).

Cognitive Theory of Multimedia Learning

Using the theories of dual coding, cognitive load and working memory, Mayer (1997, 2014) developed Cognitive Theory of Multimedia Learning (CTML), which explains and predicts learning with multimedia. First, CTML suggests that two separate channels of working memory (i.e., visual and auditory channels) are responsible for holding and processing verbal and pictorial information. Second, CTML indicates that each channel of the working memory has a limited capacity and processing is improved when both channels are engaged. Third, CTML posits that cognitively learning is an active process of filtering, selecting, organizing, and integrating information. Extending Paivio's dual coding theory (Paivio, 1986), CTML suggests that learners process verbal and pictorial information in three steps: a) select incoming verbal and pictorial information for further processing in working memory; b) organize selected verbal and pictorial information into mental representations (i.e., verbal model from selected words and pictorial model from selected pictures); and c) integrate the already organized verbal and pictorial models with prior knowledge that is retrieved from long-term memory.

Human Cognitive Architecture and Video-Based Instruction

Selection, organization, and integration of information can be vary based on the number and nature of the media and modalities used in multimedia learning. Some multimedia formats, such as video, consist of multiple information sources using different media and modalities. As a widely used format of multimedia learning, video provides multiple sources of information in different modalities. Verbal information such as narration, captions, and text, as well as pictorial information such as still and animated images, live video, visual effects. Some of this information is presented auditorily and may include sound effects and background music, whereas other information is presented in the visual modality. Information presented in video is also highly transient in that it is presented to the viewer dynamically and unless the video is paused, the learner may miss some important information. Learner control and learner's metacognitive processes play an important role in video-based instruction but are beyond the scope of this study. Although many parameters remain unknown as to what makes a video instructionally effective, affordances and constraints of human cognitive architecture render certain designs of video-based instruction effective or not (Sweller et al., 1998).

As working memory processes information via two channels (i.e., visual and auditory) and dual coding is assumed to be superior to single coding (Paivio, 1986), effective video design should utilize this affordance of human cognitive architecture and allow information to be processed via two channels simultaneously. A typical design of video-based instruction is where the instructor narrates the material while presenting the pictures and words on the screen. Narration (i.e., verbal information) is processed by the auditory channel and on-screen information (i.e., visual information) is processed by the visual channel. As the learner simultaneously integrates verbal and visual information into representational structures in working memory, the construction of referential connections between verbal and pictorial information is facilitated. Dual coding and integration of narration and visual information on the screen could potentially support information processing in working memory resulting in enhanced comprehension of the material (Mayer & Moreno, 2003).

Despite the affordances of working memory discussed above, the working memory system is also subject to the constraint of limited capacity. Cognitive load theory is especially useful in this regard as it influences the design of multimedia instruction to overcome the limited capacity of working memory, which is a major impediment to learning in general and multimedia learning in particular. During the past three decades, Mayer and colleagues have conducted over 100 experimental tests and summarized their findings into several multimedia learning principles aiming to manage cognitive load in multimedia learning (Mayer & Moreno, 2003). In other words, multimedia learning should be designed to decrease extraneous cognitive load and allow more cognitive resources for germane processing of content imposing either high or low levels of intrinsic load. With a strong connection to the three types of cognitive load (i.e., intrinsic load, extraneous load and germane load), the twelve principles of CTML are grounded in the framework of three types of cognitive processing - that is, essential processing, incidental processing, and generative processing. CTML principles based on these types of processing provide guidance for the design of video-based instruction and minimize the negative consequences potentially caused by the constraints of working memory.

Video-based instruction designed to manage essential processing

Essential processing refers to the process of “selecting relevant words and images and organizing them as presented required to represent the essential material” (Mayer & Pilegard, 2014, p. 317). Similar to the conceptualization of intrinsic load, this type of processing is mainly related to the intrinsic complexity of material. Information with high intrinsic load has a higher possibility of affecting essential processing as it can be more cognitively demanding. Management of essential processing is proposed to be guided by three relevant multimedia learning principles : segmenting, pre-training, and the modality principle (Mayer & Pilegard, 2014).

The modality principle states people learn better from animation and narration than from animation and on-screen text (Mayer & Moreno, 2003). On-screen text and pictures both constitute visual information, and they compete for cognitive resources in the visual channel, potentially overloading the visual channel. Alternatively, conveying information through both visual and auditory channels by using on-screen pictures (i.e., animation) and narration will utilize visual and auditory channels more efficiently, decreasing the possibility of either channel being overloaded. Several studies found that the performance on problem-solving transfer was better when scientific explanations were presented in the form of animation and narration compared to animation and on-screen text (Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, Spires, & Lester, 2001). The modality principle easily extends to video-based instruction. Instead of presenting on-screen text, video-based instruction can use narration to deliver verbal information auditorily, while allowing the visual channel to process only on-screen pictorial information.

Besides allocating verbal and pictorial information to be processed by the two channels of working memory, multimedia instruction can also be designed to decrease the amount of information to be processed at a time. The segmenting principle states people learn better when multimedia material is presented in smaller segments rather than as a larger continuous unit (Mayer & Moreno, 2003). This principle particularly applies to complex topics. Intrinsically complex material consumes a significant amount of cognitive resources at a time, potentially overloading the working memory. Instead, breaking the large presentation of content down into several manageable segments relieves the burden on working memory. Empirically, Mayer & Chandler (2001) broke a narrated animation explaining lightning formation into 16 segments and found that compared to students who watched the whole presentation continuously, students who received the segmented instruction performed better on the test of problem-solving transfer. In terms of video-based information, presenting information in shorter and manageable segments can facilitate learning and lead to deeper understanding of materials. By examining videos in Massive Open Online Courses (MOOCs), Guo and colleagues (2014) found that shorter videos (e.g., within 6 minutes long) were more engaging than longer videos.

Both the modality principle and the segmenting principle aim to ensure working memory functions under its capacity. Another approach to prime essential processing is to allow the learner to receive training on components preceding instruction (Mayer & Moreno, 2003), dubbed as pre-training principle. Pre-training allows schema in the long-term memory to be activated prior to instruction to improve construction of mental models integrating new information and schema in long-term memory, which otherwise often overload the working memory. In previous studies, students were presented animations on how brakes and pumps work and it was found that students who had received pre-training about the names and behavior of the components performed better on problem-solving transfer tests (Mayer, Mathias, & Wetzell, 2002; Pollock, Chandler, & Sweller, 2002) than those who had not received any pre-training. Extending these findings to video-based learning, preview of key information can be provided prior to presenting instruction.

To summarize, the modality principle and the segmenting principle take the limited capacity of working memory into account and aim to avoid overloading the cognitive system. The modality principle also utilizes working memory’s capability of dual channel processing and maximizes essential processing. Pre-training benefits essential processing in that pre-training facilitates integrating information in working memory with existing prior knowledge in long-term memory.

Video-based instruction designed to reduce extraneous processing

Extraneous processing refers to “the processing of extraneous material” (Mayer & Fiorella, 2014, p. 281). For example, supplementing an animation with unnecessary background music can increase extraneous processing, as the learner needs to devote extra cognitive resource to process this type of extraneous information. Extraneous processing of material will cause extraneous cognitive load to be increased. Extraneous processing can be minimized using the CTML principles including the redundancy principle, the coherence principle, spatial contiguity, temporal contiguity, and the signaling principle (Mayer & Fiorella, 2014).

The redundancy principle is derived from the modality principle which states people learn better when animation is accompanied by narration rather than on-screen text (Mayer & Moreno, 2003). In the case of the redundancy principle, it is emphasized that people learn better from animation and narration than from animation, narration, and on on-screen text because on-screen text serves as redundant information source given that the same information is already presented via narration (Mayer & Moreno, 2003). Studies found that students who learned from non-redundant presentations performed better on problem solving transfer tests than those who were provided with the redundant version of presentation (Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2002). A possible explanation is that the learners who are presented with narration and on-screen-text need to compare and contrast information for each source to establish whether they convey the same or different information and synthesize these two sources of verbal information as they process the learning materials. This type of extraneous processing can overload the working memory, as working memory is also responsible for integrating verbal information with on-screen pictures. According to the redundancy principle, video-based instruction should eliminate redundant on-screen text when it can be delivered by narration.

The coherence principle highlights that people learn better when interesting but irrelevant words, pictures, and sounds are excluded (Mayer & Moreno, 2003). Interesting but irrelevant visual and auditory stimuli can distract the learner from the focus of the instruction, and so they need to be excluded rather than included in instruction. Students who received a concise narrated animation performed better on problem-solving transfer tests than those who watched an embellished narrated animation, which consisted background music and irrelevant video clips in the middle of the animation (Mayer, Heiser, & Lonn, 2001; Moreno & Mayer, 2000). According to the coherence principle, video-based instruction should consider removing or minimizing all irrelevant and distracting information that may result in unnecessary extraneous processing.

Unlike the redundancy principle and the coherence principle, which aim to minimize unnecessary information processing, contiguity principles keep extraneous processing to a minimum by aiding the learner in integrating verbal and pictorial information and building referential connections between the modalities (Mayer & Moreno, 2003). The contiguity principle requires verbal and pictorial information to be presented together, either in proximity (mandated by spatial contiguity principle) or simultaneously (stated by temporal contiguity principle). The spatial contiguity principle suggests people learn better when corresponding words and pictures are presented spatially near rather than far from each other on the page or screen (Mayer & Moreno, 2003). The temporal contiguity principle states that people learn better when corresponding words and pictures are presented simultaneously, at the same time, rather than successively (Mayer & Moreno, 2003). Presenting words and pictures far from each other either in time or space requires the learner to devote extra cognitive resources to search for verbal or pictorial information, while holding the other type of information in mind (i.e., pictorial or verbal). This often causes a negative consequence in learning, referred to as “split attention” (Ayres & Sweller, 2014). Mayer and colleagues (1999) found that students performed better on a problem-solving transfer test when they learned from integrated presentations (consisting of animation with integrated on-screen text) than did students who learned from separated presentations (consisting of animation with separated on-screen text). The same study also found that students who learned from simultaneous presentations performed better on tests of problem-solving transfer than those who learned from successive presentations. According to contiguity principles, video-based instruction should consider presenting verbal and pictorial information in an integrated manner, either simultaneously or in close spatial proximity with each other.

The signaling principle states that better transfer occurs when narrations and on-screen animation are signaled (Mayer & Moreno, 2003). A signaled version of instruction can direct learner's attention to the essential facets of instruction by stressing key words in narration or providing visual cues (i.e., arrows) in on-screen animation (Mautone & Mayer, 2001). On the other hand, a non-signaled version of instruction will increase extraneous processing in that learner will likely focus to a larger extent on nonessential aspects of the instruction (Mautone & Mayer, 2001). To illustrate this principle empirically, Mautone and Mayer (2001) constructed a four-minute narrated animation explaining how airplanes achieve lift in a signaled and a non-signaled version. Students who received the signaled version of the narrated animation performed better on a subsequent test of problem-solving transfer than did students who received the non-signaled version. According to the signaling principle, video-based instruction can employ visual cues to direct learner's attention to important instructional components during the video presentation. The presenter can also stress important words in the narration.

Video-based instruction designed to foster generative processing

Multimedia instruction can be designed not only to manipulate the amount of essential processing and extraneous processing, but also foster generative processing. Generative processing helps the learner to mentally organize new information into structures and integrate it with schemata in long-term memory (Moreno & Mayer, 2010). Generative processing results in germane load, which according to cognitive load theory, occurs when assimilation or accommodation of presented information is encouraged rather than hindered. The evidenced-based instructional strategies for fostering generative processing are based on the multimedia principle, personalization principle, voice principle and interactivity principle (Moreno & Mayer, 2010).

First and foremost, extending the dual coding theory, Mayer & Sims (1994) posited that people learn better from words and pictures than from words alone, referred to as the multimedia principle, the core principle of CTML. The memory enhancing effect of pictures encourages the assimilation of presented verbal information. When verbal and pictorial information are both presented, learners have the opportunity to build verbal and pictorial models and integrate them with each other. Numerous studies conducted by Mayer and other scholars have demonstrated the efficacy of the multimedia principle and supported integrative use of pictures with words (Mayer & Sims, 1994). Mayer (1997) reviewed eight studies that had been conducted to compare multimedia instruction with single-media instruction, and consistently found the positive effect of multimedia instruction. Learners who received multimedia instruction performed significantly better on subsequent problem-solving transfer tests than those who received verbal instruction alone. Nowadays, video-based instruction generally adopts multimedia presentation and provides both pictures and words, which allow assimilation and integration of verbal and pictorial information.

With the recent advancements in media design and information technology, other instructional elements in multimedia instruction can be manipulated to foster generative processing. For instance, people learn significantly better when the verbal information is presented in conversational style (e.g., first or second person) rather than formal style (e.g., third person), referred to as the personalization principle (Moreno & Mayer, 2010). Moreover, people learn better when narration in multimedia instruction is spoken in a friendly human voice rather than a machine voice, referred to as voice principle. Video-based instruction can utilize a real-human friendly voice in a conversational style to satisfy both personalization principle and voice principle.

The interactivity principle states that people learn better when they have control over the pace of the presentation (Moreno & Mayer, 2010). Mayer & Chandler (2001) found that learners performed better on transfer tests when they had control over the pace of the narrated animation, compared to those who watched the same narration without any learner control. Video-based instruction can easily fulfill the interactivity principle as most video players provide the affordances to pause, rewind, or fast-forward the video.

These multimedia learning principles have offered important implications for the design of multimedia learning, especially video-based instruction. Taking the affordances and constraints of human cognitive architecture into consideration, video-based instruction can be designed to foster essential processing and generative processing, while minimizing extraneous processing.

Instructional Video with Instructor Presence

Positive and Negative Influences of Instructor Presence

The instructor embedded in the video is a source of visual information that provides primarily nonverbal communication cues to the learner. It is acknowledged that nonverbal communication plays an important role in interpersonal interaction (Argyle, 2013) and facilitates face-to-face learning (Goldin-Meadow, & Alibali, 2013; Holler, Shovelton, & Beattie, 2009; Knapp, Hall, & Horgan, 2013), including language learning (e.g., Church, Ayman-Nolley, & Mahootian, 2004) and mathematics learning (e.g., Alibali & Nathan, 2012). The utility of nonverbal communication also extends to online learning. In the context of instructional video, the image/video of the instructor may result in deeper engagement and cognitive processing of learning content due to the activation of social interaction schema that people employ during traditional, face-to-face communication and learning (Clark & Mayer, 2016). The instructor typically provides such means of nonverbal communication as mutual gaze, gesturing, and facial expressions. These nonverbal cues can possibly support the cognitive processing of verbal information that is narrated by the instructor, thus improving comprehension. As these nonverbal cues constitute visual information, processed primarily by the visuospatial sketchpad, it will not interfere with the processing of auditory information (e.g., narration), which is handled by the phonological loop. In fact, based on the dual coding theory (Paivio, 1986), instructor's narration and visual presence from the instructor should theoretically complement each other as they are processed by different channels (e.g., auditory and visual) and support information processing in two separate channels resulting in enhanced comprehension of the material.

The presence of instructor should not only facilitate deeper processing of learning content, but also improve students' learning experience by encouraging deeper engagement with the content. Social agency theory suggests social cues in multimedia presentations lead learners to feel as if they are interacting with another person (Cui, Lockee, & Meng, 2013). The basic assumption is that social cues replicate the social aspects of human interaction, and this may induce beneficial socio-emotional responses in the learner. Thus, social cues provided by the instructor should result in enhanced positive affective responses externalized, for example, as high satisfaction or engagement ratings, while learners watch instructional videos featuring instructor presence.

In addition to providing nonverbal information, the instructor's face can also attract a significant amount of attention (see Yee, Bailenson, & Rickertsen, 2007 for a review of research on the effects of faces in human-computer interfaces). Human attraction to faces has been shown to already develop in infants who attend favorably to faces and face-like configurations (Johnson, Dziurawiec, Ellis, & Morton, 1991). As face relevant stimuli can assist people in seeking social cues such as gaze, facial expression, and so on, people are attracted to face as a source for information that facilitate social interaction and communication (Farroni et al., 2005). Consequently, it is reasonable to expect that showing the instructor's face in video will have a substantial impact on the distribution of learners' visual attention. While it is understandable why the instructor's face would attract a considerable amount of attention, the video frame provides other important instructional components on the screen such as text, diagrams, pencasts and so on, and so instructor's face may also serve as a distractor and hinder cognitive processing of the essential learning material. Based on Baddeley and Hitch's (1974) working memory model, both the instructional components on the screen and the instructor need to be processed by the visual-spatial sketchpad structure of working memory, which has severe limitations in terms of both capacity and duration (Paivio, 1991). The instructor frame will then compete for visuo-spatial focused cognitive resources with other instructional information and possibly overload the visual channel. From a cognitive load perspective, the instructor video may result in increased extraneous cognitive load, which will hinder the processing of the information on the rest of the screen. Emerging evidence for this hypothesis was provided by Djamasbi and colleagues (2012), who found images of human face had a negative impact on users' performance on tasks that are based on the information located in close proximity to the face suggesting that face imagery was too distracting for many users to handle.

The two types of visual stimuli – that is, the instructor and the text, diagrams and other content in the rest of the screen - will likely result in split attention (Sweller, Ayres, & Kalyuga, 2011). Split attention occurs "when learners are required to split their attention between and mentally integrate several sources of physically or temporally disparate information, where each source of information is essential for understanding the material" (Ayres & Sweller, 2014). If the learner needs to mentally integrate the two sources of information that are either temporally or spatially isolated, learning materials will impose high extraneous cognitive load on the learner. Split attention is a particular issue in the case of content with high element interactivity (i.e., high intrinsic load), whereas its effect within content with low element interactivity may not be as pronounced (Kalyuga, Chandler, & Sweller, 2011). In the video-based instruction with instructor presence, split attention could occur when attention is switched between the instructor and the rest of content in the video frame (Johnson, Ozogul, Moreno, & Reisslein, 2013; Schmidt-Weigand et al., 2010). Empirically, Kizilcec and colleagues (2014) examined how adding an instructor to the video frame affected learners' visual attention distribution. They observed that participants switched between the instructor frame and the rest of the screen every 3.7 seconds. Thus, it is reasonable to hypothesize that this level of split attention could interfere with the effective processing of the important instructional information presented in the rest of the frame and impede learning.

Bringing it all together, the presence of instructor in instructional video could elicit beneficial socio-emotional responses and support learners' understanding by providing nonverbal modalities of interaction (Clark & Mayer, 2016). On the other hand, the instructor presence also provides a group of complex visual stimuli that might distract learners, especially when a high level of cognitive processing is involved due to high intrinsic load imposed by the complex learning content. Limited empirical evidence suggests a tradeoff between the costs and benefits of presenting the instructor in video but the findings are not consistent.

Several studies have examined the influence of instructor presence on learning and perceptions; however, these findings are largely inconclusive. Evidence of positive effect was provided by Chen & Wu (2015), who used an experimental design and compared the influence of three types of videos on learning document writing: voice over (instructor’s video in the upper left corner of the screen), lecture capture (i.e., a video recording of the lecture) and picture-in-picture video that includes an instructor frame in the bottom right-hand corner. The results indicated that performance on recall and transfer of learning with lecture capture and picture-in-picture formats were superior to that associated with the voice-over format. The intensity of positive and negative emotions elicited by the three video formats did not appear to significantly differ from each other. They also found the self-reported cognitive load related to the lecture capture and picture-in-picture types of video was significantly lower than that of the voice-over video. Additional positive evidence was provided by Pi and Hong (2016), who examined the effects of video presentation types on learning a topic in developmental psychology. The researchers compared four different video types, PowerPoint™ slides alone, instructor video alone, PowerPoint™ slides with instructor video, and classroom recording (including PowerPoint™ slides, instructor, and students in the classroom). Learning from the video was measured by recall and transfer. The findings showed although the participants distributed a significant amount of attention to the instructor (62.3%), the PowerPoint™ slides with instructor condition resulted in significantly higher learning test scores compared to the other three video types.

Besides using experimental designs, researchers have also mined Massive Open Online Course (MOOC) interaction logs and examined the influence of instructor presence on student engagement (Guo, Kim, & Rubin, 2014). In a large-scale study of MOOC based videos in 6.9 million video watching sessions across four courses on the edX™ MOOC platform, Guo and colleagues (2014) examined two proxies for engagement: engagement time (i.e., video watching session length) and problem attempt at follow-up multiple choice problem. They found students were engaged more with videos that included an instructor, compared to videos with PowerPoint™ slides alone.

At the same time, other studies revealed no or negative effects of instructor presence in video on learning or cognitive load. Homer, Plass, & Blake (2008) conducted an experiment in which undergraduate students viewed one of two versions of a computer-based multimedia presentation on The Millennium Dialogue on Child Development: one included slides with instructor's video, and the other only slides with audio narration. They compared two conditions by measuring recall and transfer of knowledge, as well as using a social presence questionnaire. They found no significant difference in learning or social presence between the two conditions. However, the study also found participants self-reported a significantly higher cognitive load in the condition with instructor present on the screen, compared to the audio narration condition. Kizilcec and colleagues (2014) investigated how adding the instructor to instructional video influences undergraduate and graduate students' learning on a topic in Organizational Sociology. Although learners strongly preferred video instruction with instructor presence and perceived it as more educational, they did not perform significantly better or worse on knowledge recall tests compared to the control condition without instructor presence.

While several studies have found positive influence of providing instructor presence in instructional videos, other studies revealed no or negative effects of it on learning or self-reported cognitive load. The empirical evidence for the support of incorporating an instructor in the instructional video is limited and conflicting. The current study is designed to further examine the effect of instructor presence on learning, visual attention distribution, cognitive dynamics, and learner perceptions in instructional videos.

Factors That Influence the Efficacy of Instructor Presence

Empirical evidence suggested that adding the instructor to instructional video is not always beneficial and potential positive effects of instructor presence depend on several factors. These factors include type of knowledge to be learned, content difficulty, the frame size of the instructor, interactional style of the instructor, and whether instructor presence is permanent or intermittent.

Types of knowledge to be learned

Hong and colleagues (2016) examined the influence of instructor presence in video on declarative knowledge (a topic in educational technology) and procedural knowledge (perform an action in Adobe Photoshop™). The videos on these two topics were presented in two different styles: PowerPoint™ slides or PowerPoint™ slides with a picture-in-picture video of the instructor. The findings indicated that adding the instructor to the PowerPoint™ slides only facilitated declarative knowledge development. In the video on a procedural knowledge topic, the learning test scores were no different between the two conditions; however, learners who watched the video with instructor presence reported a significantly higher level of cognitive load. The authors explained that a higher level of cognitive resources was required when learning procedural knowledge than declarative knowledge and thus the instructor video could possibly interfere with the learning process and overload learners. The findings were important as they suggested the positive effects of instructor presence in instructional videos varied depending on the type of knowledge being taught. It is possible learners who watched the video on declarative knowledge with instructor presence showed greater learning due to the benefits of non-verbal communication provided by the instructor presence; however, this positive effect could be reduced by additional cognitive processing of the instructor's video, when learning a procedural knowledge topic.

Content difficulty

The type of knowledge is not the only variable that has been found to moderate the effects of instructor presence in instructional video. Another highly relevant factor that has been examined is content difficulty because it relates directly to the levels of intrinsic load imposed by the learning content. Wang and Antonenko (2017) found the effects of instructor presence on learning, visual attention distribution, and students' perceptions were moderated by the content difficulty of the topics. Undergraduate participants were assigned to watch two videos on an easy mathematics topic (similar triangles) and a difficult topic (Trigonometry), each with the instructor present or absent in a counter-balanced design. The findings generally supported the use of instructor presence in the videos, but the influence of instructor presence varied for the two topics. Showing the instructor improved recall of information when it was present in the easy topic, but there was no difference in recall for the difficult topic with the instructor present or absent. The eye movement analysis also indicated instructor frame attracted significant amount of visual attention, especially for the easy topic video (25%). The instructor presence version of the video was perceived as less demanding (lower mental effort ratings) for the difficult topic video, but this effect was not demonstrated for the easy topic when the instructor was present. This study provided some evidence that the decision of including an instructor in instructional video should also be made based on content difficulty.

Frame size of the instructor

In addition to exploring the moderating effect of type of knowledge and content difficulty, researchers such as Pi and colleagues (2017) examined if there was any differential effect of the instructor's image size on learners' perceptions of social presence, cognitive load, learning performance, and satisfaction. Learners watched video on adjusting a curve in Adobe Photoshop™ that included a small, medium or large image size of the instructor. The results demonstrated the small size of instructor facilitated learning compared to the other two conditions. Learners were also more satisfied with the instructional videos including a small size of the instructor's image. The perceived level of social presence and cognitive load were the same across the three videos. The researchers suggested that a small size of the instructor's image required fewer attentional resources compared to a larger image size, while preserving the non-verbal cues and eliciting social responses.

Interactional style of the instructor

The interactional style of the instructor style also played a role based on evidence from extant literature. Bhat and colleagues (2015) used clickstream data from one Coursera™ course to analyze the engagement (i.e., video watching time, discussion forum visits following a lecture view), motivation (i.e., certificate-earner proportion, fraction of lectures and quizzes that the learner viewed and submitted) and navigational patterns of learners upon being presented with videos incorporating the instructor in two styles: first, where the instructor was situated right next to the slide and seamlessly interacted with the content and second, where the instructor appeared in a window in a fixed portion of the presentation window. The results showed that learners preferred to watch videos in the mode where the instructor seamlessly interacted with the course content. It was suggested that the video integrating the instructor seamlessly offered access to the instructor's eye-gaze and gestures in close proximity to the lecture content that resulted in a better learning experience for the learners via the availability of more realistic social cues (Bhat et al., 2015).

Intermittent vs. permanent instructor presence

It has been argued the instructor can be strategically presented to keep the non-verbal social cues while not causing a significant amount of distraction (Kizilcec, Bailenson, & Gomez, 2015). Kizilcec and colleagues (2015) conducted a 10-week field experience where they compared the permanent presentation of the instructor with the intermittent presentation of the instructor (where the instructor was not always shown on the screen). The results revealed learning did not differ between the permanent and intermittent presentation conditions. In fact, the perceived mental effort was higher in the intermittent presentation condition than in the permanent presentation condition.

Learner Cognitive Differences

The previous studies all examined how the influence of instructor presence can be moderated by the video and its design. It is likely that the mixed findings of instructor presence’s influence may be explained by learner variabilities. So far, a limited number of studies that have examined the effects of individual differences on learning in the context of video with instructor presence. Considering the fact learners in general and undergraduate students represent a variety of cognitive and attentional differences (Jonassen & Grabowski, 2012) and individual differences possibly moderate the influence of instructor presence in video, it is important to examine the moderating effects of individual differences on the influence of instructor presence.

Decades ago, research within the aptitude-treatment-interaction (ATI) tradition revealed strong interactions between individual learner characteristics and instructional interventions (Cronbach & Snow, 1977; Snow, 1989). So, it is highly possible that individual differences may lead to different patterns of interaction and learning within videos that integrate instructor presence. There are very few studies on how individual differences among learners moderate the effect of the instructor presence in instructional video (Kizilcec et al., 2014; Chen & Wu, 2015, both focusing on learning styles).

Individual differences in working memory capacity and inhibitory control are theoretically important moderators of visual attention, cognition, and learning in this context. Picture-in-picture instructor video and the learning content in the rest of the frame in an instructional video represent two potentially competing sources of information on the screen and they can place different demands on learners' attentional control and working memory processes. So, the variability in these two individual differences will likely moderate learners' distribution of attention to the stimuli on the screen, their cognitive dynamics, and ultimately their learning of the content, especially when the content is difficult, imposing a high level of intrinsic load.

Working memory capacity

One relevant individual cognitive difference that could possibly moderate the effects of instructor presence is working memory capacity. Working memory capacity affects the ability to control one's attention (Conway & Engle, 1994), maintaining relevant information and ignoring irrelevant information (e.g., salient sensory stimuli). It has been found that individuals with high working memory capacity are better at directing attention when they are encoding information from the environment (Bleckley, Durso, Crutchfield, Engle, & Khanna, 2003; Kane, Conway, Bleckley, & Engle, 2001). In other words, people with high working memory capacity are better at utilizing executive control to focus on relevant stimuli and ignore distractions in the environment (Sanchez & Wiley, 2006).

Several studies have examined the role of WMC related to multimedia learning conditions and these studies focused on the influence of seductive details in multimedia learning (Sanchez & Wiley, 2006), learning from animation with cueing (Skuballa, Schwonke, & Renkl, 2012), learning underlying conceptual relationships across multiple documents (Banas & Sanchez, 2012), learning from scrolling and paginated text (Sanchez & Wiley, 2009) and so on. Sanchez & Wiley (2006) examined the role of WMC in relation to the seductive details effect, which was operationalized as intriguing but irrelevant information in the form of illustrations. The results indicated that, as expected, learners with high WMC were less susceptible to seductive information and performed better than low-WMC groups in the seductive details condition on the inference verification and argumentative essay tasks. Interestingly, they also found that high-WMC individuals performed best under the seductive illustration condition compared to conditions which provided conceptually relevant illustration or no illustration at all. The eye movement analysis indicated that low-WMC learners allocated attention to seductive details more often and for a longer duration than high-WMC learners and they performed more poorly on the tests of learning than their high-WMC counterparts. In another study by Skuballa and colleagues (2012), learners with high and low WMC were presented a narrated animation to learn how a parabolic trough power plant works. Participants were randomly assigned to one of the three experimental conditions: one group supported by verbal instruction in the narration, one group supported by spotlight cues in the animation and one control group (no support). Verbal instruction and on-screen spotlight cues were used to direct learners' attention to important on-screen information in the animation. Participants' learning was measured by open-ended questions, following the Function–Process–Structure framework which describes knowledge about technical devices. The findings indicated the spotlight cues facilitated learning for low WMC participants, whereas high WMC participants' learning were impeded by the spotlight cues. The authors suggested that high WMC learners maintained their own control of attention to information and thus the spotlight cues became redundant and distracting resulting in expertise reversal. These studies suggested the high-WMC learners can better control their attention to relevant and important information in multimedia learning.

The prior work allows us to make hypotheses about how WMC might affect students' processing of instructor video and the rest of the screen in an instructional video. While attending to the instructor in the video, it is likely that learners with high WMC will overcome the split attention effect caused by the instructor video because they can manage their attention more effectively and allocate more cognitive resources to process instructional content in the rest of the frame. On the contrary, the amount of visual attention allocated to the instructor is expected to increase for participants with low WMC. This exacerbated split-attention effect for learners with low WMC could be more detrimental to learning in a video that requires a higher level of cognitive processing (e.g., a video on a difficult topic with higher intrinsic complexity). This hypothesis has yet to be tested empirically.

Working memory capacity can be measured via complex span tasks, which differ from simple span tasks in that they require simultaneous storage and manipulation of information (Bayliss, Jarrold, Gunn, & Baddeley, 2003). For example, in the Operation Span task, learners need to verify the correctness of math operations while memorizing letters. Commonly used complex span tasks include Operation Span (Turner & Engle, 1989), Reading Span (Daneman & Carpenter, 1980), and Counting Span (Case, Kurland, & Goldberg, 1982). The Operation Span task has been used widely in previous studies to measure working memory capacity (Conway et al., 2005) and has been shown to be a reliable measure to assess individual differences in WMC (Unsworth et al., 2005). The Operation Span task could predict participants' verbal abilities and reading comprehension even though the subjects were solving mathematical problems. Engle and colleagues have argued that this implies a general pool of resources that is used in every type of working memory processing situation. As the proposed study examines learning from videos on Statistics topics which involve mathematical operations, the Operation Span task appears more appropriate in this context. This study will employ the Automated Operation Span task (AOSPAN, Unsworth, Heitz, Schrock, & Engle, 2005), which is a computerized version of the original Operation Span task (Turner & Engle, 1989).

Inhibitory control

When discussing the ability to control attention during media rich information processing, another relevant individual difference is inhibitory control. Inhibitory control is the ability to selectively attend and suppress attention to irrelevant stimuli while focusing on the task goal (Rothbart & Posner, 1985; Diamond, 2013). Empirically, Ophir and colleagues (2009) found that younger adults who are heavy media multitaskers (cf., “digital natives”, Prensky, 2001) perform worse on the inhibitory control test compared to light media multitaskers. Heavy media multitaskers were found to be more susceptible to interference from irrelevant environmental stimuli. In a recent study, Homer and Plass (2014) investigated the interaction between instructional format and learner’s ability in inhibitory control of attention among high school students. In this study, participants’ ability in inhibitory control was gauged using the Stroop task, where a color word was displayed either in a congruent color (e.g., color word “green” displayed in green) or an incongruent color (e.g., color word “green” displayed in red). Participants were instructed to choose a color from a list of color words that matched the color of the displayed word. In incongruent trials of the Stroop task, learners reacted slower and committed more errors as they had to inhibit their attention to the meaning of the color words and focus their attention on the color attribute only (MacLeod, 1991). After participants’ degree of inhibition was measured, they were assigned to learn with a web-based simulation of an intrinsically complex topic (i.e., ideal gas law) that varied in instructional format (exploratory simulation or worked examples). In the simulation with worked examples, learners navigated the simulation by following step-by-step instructions provided by an expert. Learning was measured by comprehension and transfer. Results indicated that the exploratory simulation facilitated transfer for students with higher levels of inhibitory control whereas students with lower levels of inhibitory control benefited more from the guided simulation with worked examples in learning transfer. It was suggested the participants with high inhibitory control used their cognitive resources more efficiently, thus resulting in enhanced learning with the exploratory simulation; whereas the intensity of interaction in this condition may increase cognitive load for participants with low inhibitory control and poorer control of attention. The findings implied this negative effect may possibly be mitigated or reversed in the worked example simulation for this group of learners.

Thus, it is reasonable to hypothesize that inhibitory control is an important individual difference variable mediating college students' processing of information in an instructional video. Instructional video includes multiple sources of stimuli and requires inhibitory control to certain elements on the screen at some time. It is possible that the visual of the instructor becomes irrelevant when attention should be focused on the instructional content in the main frame and the variable ability of the learners to block out irrelevant (or, rather less relevant) stimuli should play an important role in the efficient use of cognitive resources in such a learning situation. This hypothesis has yet to be tested empirically.

Inhibitory control can be measured using the Flanker test (Eriksen & Eriksen, 1974), Attention Network Test (Fan et al., 2002), Stroop Task (MacLeod, 1991), Go/No-Go tasks (Cragg & Nation, 2008), and Stop-Signal tasks (Verbruggen & Logan, 2008).

For the purpose of the proposed study, Flanker test (via NIH toolbox) will be administered to measure learners' inhibitory control. This measure has been used in multiple studies (Christ, Holt, White, & Green, 2007; Poarch & van Hell, 2012) to examine participants' inhibitory control and has been validated to be a sensitive measure of variations in inhibitory control (Zelazo et al., 2013).

Measurement Considerations

Product Measures

Prior research has relied on traditional product measures to identify the influence of instructor presence in videos. These product measures include learning outcome and self-report measures, such as cognitive load.

Learning

Retention and transfer have been two typical product measures of learning. Retention tests measure students' ability to recall and recognize information from the learning material (Tulving, 1968). Recall questions are typically presented as either cued recall where cues are provided to facilitate retrieval of information (e.g., fill-in-the-blank questions), or as free recall where learners are asked to recall everything they remember from the lesson or learning materials without any cues to aid with their recall. Previous studies in the context of instructor presence in videos employed retention measures in the form of both recall and recognition to test learners' comprehension of key concepts covered in instructional video (Homer et al., 2008; Kizilcec et al., 2014; Pi & Hong, 2016). On the other hand, transfer measures test students' ability to apply acquired knowledge to novel situations (Bransford & Schwartz, 1999). Transfer of knowledge is differentiated into far transfer or near transfer. Near transfer involves applying what was learned to a context that is closely related to the initial learning situation. Far transfer, however, refers to the ability to apply knowledge acquired in a novel context that is very different from the original one (Mestre, 2002). Several studies adopted transfer tests to measure learners' ability to apply knowledge from instructional video to novel situations (Homer et al., 2008; Pi & Hong, 2016).

The current study will address both retention and transfer aspects of learning. Retention items will include cued-recall and recognition questions to assess learners' ability to recall and recognize information presented in the video. Near and far transfer questions will be used to measure participants' ability to apply the information from the two videos to new situations that are either close to or distinct from the situations covered in the videos.

Learner perceptions

Perceived cognitive load. Cognitive load has been traditionally assessed using subjective measures (Paas, Tuovinen, Tabbers, & Van Gerven, 2003) relying on the assumption that learners can introspect on the amount of mental effort they expend on a task (Antonenko, Paas, Grabner, & van Gog, 2010). For example, National Aeronautics and Space Administration-Task Load Index (NASA-TLX) has been used to elicit participants' perception of the experienced cognitive load. NASA-TLX includes ten workload-related factors and consists of six subscales, including mental demand, physical demand, temporal demand, frustration, effort, and performance, which represent cognitive load in task performance (Hart & Staveland, 1988). Later, Paas (1992) developed a one-item 9-point rating scale, which allows learners to self-report on the mental effort they perceive during a task. The responses range from "very, very low mental effort" to "very, very high mental effort". This scale has been employed and validated in many prior studies on instructor presence as a subjective measure of cognitive load (Kizilcec et al., 2014; Wang & Antonenko, 2017). In the proposed study, the researcher will adopt this widely-used subjective measure of cognitive load to measure overall load.

Besides overall cognitive load, the proposed study will also measure intrinsic load, extraneous load, and germane load as reflected by subjective measures of learner perceptions. To measure intrinsic load, Ayres (2006) scale will be used. It asks participants to rate the difficulty of the content they perceive in each video. To measure extraneous load, the researcher will use the scale from Cierniak (2009) and ask participants to rate how difficult it is to learn the material. To measure germane load, Salomon's (1984) question of how much learners concentrated during each video will be asked. At the end of each video, participants will respond to four questions assessing participants' subjective perceptions of different types of cognitive load (i.e., overall load, intrinsic load, extraneous load, and germane load).

Perceived learning, satisfaction, and social presence. As instructor presence in instructional video has been hypothesized to provide socio-emotional cues and elicit social responses, the researcher will examine the influence of instructor presence on participants' perceived learning, satisfaction, and social presence in the proposed study. For perceived learning, participants will self-report the amount of learning they acquire from the video on a Likert scale. For satisfaction, participants will be asked to rate their level of satisfaction with instructor presence on a Likert scale as well. To measure the degree of social presence with regard to the presence or absence of the instructor in the video, participants will indicate the level of agreement with five statements that examine the degree of social presence perceived (Kizilcec et al., 2015).

Process Measures

One limitation of previous research in multimedia learning is the almost sole reliance on product measures (Sanchez & Wiley, 2009). While these measures may be useful and efficient in gauging global performance, they may not be sufficient to study the complex attentional and cognitive processing that occurs during multimedia learning. Using the product measures, educational researchers obtain little insight into the underpinning processes students engage in while they watch video and it is usually not very clear, at least from the empirical standpoint, why learners end up with a particular score on the learning test or why they report a high level of cognitive load. As the current study adopts an individual differences perspective, it is especially important to understand the mechanisms underlying learning by examining learners' visual attention distribution and cognitive dynamics while they watch an instructional video with or without instructor presence. Visual attention distribution will be measured using eye tracking, and cognitive dynamics will be assessed using novel EEG methodology. The complementary use of EEG and eye-tracking can reveal how learners with individual differences processed the videos with or without instructor presence learning easy and difficult topics.

Visual attention distribution

As learners with individual differences in working memory capacity and inhibitory control are hypothesized to display different patterns of interaction with the visual stimuli on the screen (i.e., instructor frame and other on-screen visual content, it is important to understand the visual attention distribution exhibited by learners with individual differences in working memory capacity and inhibitory control. The eye-mind hypothesis (Just & Carpenter, 1980) suggests that eye movement recordings can reveal where the person's attention is directed to and where the person is engaged in cognitive processing. Eye tracking can be used to understand the dynamics of visual attention during multimedia learning (e.g., Mayer, 2010).

Visual attention distribution is typically inferred using gaze fixations and saccades. Fixation occurs when the eye focuses on a visual target for a short period of time (around 300 ms). Fixation duration is longer on a difficult or unfamiliar word during reading (Rayner, 1998). An aspect of problem that requires more cognitive processing will receive more and longer fixations (Carpenter & Shah, 1998; Duchowski, 2007). Saccade is a rapid eye movement between two fixations and saccades range in amplitude from small movements to large ones.

Empirically, eye-tracking methodology has been used to explore the attentional and cognitive process during learning with multimedia. Some of these studies helped determine that (a) a strong link exists between eye fixations and learning outcomes (Boucheix & Lowe, 2010); (b) visual cues guide learners' visual attention (Boucheix & Lowe, 2010; de Koning et al., 2010); (c) prior knowledge guides visual attention (Canham & Hegarty, 2010; Jarodzka, Scheiter, Gerjets, & Gog, 2010); and (d) learners who view animation and on-screen text must split their attention between graphics and printed words (Schmidt-Weigand et al., 2010). Eye tracking has been shown to be a useful tool to study visual attention distribution (van Gog & Scheiter, 2010) and it is very suited to study differences in attentional processes evoked by different types of multimedia (Holsanova, Holmberg, & Holmqvist, 2009). Compared to traditional outcome measures, eye tracking is a process measure that can shed light on the mechanism of split attention that occurs when attention is divided between the instructor and the rest of learning content in the video frame (Johnson, Ozogul, Moreno, & Reisslein, 2013; Schmidt-Weigand et al., 2010).

So far, few empirical studies have used eye tracking to study the role of instructor presence in instructional videos to shed light on the mechanisms by which learners interacted with this instructional medium. Kizilcec and colleagues (2014) investigated how adding the instructor to video instruction affected the distribution of visual attention, by means of tracking participants' eye movements. Participants spent about 41% of time looking at the instructor and switched between the instructor and slide every 3.7 seconds. In another study where an instructor was added to PowerPoint™ slides (Pi et al., 2017), it was found that the participants spent significantly more time fixating on the instructor (62.3%) than on the PPT slides (37.7%). In addition, the mean fixation duration in the area of the instructor was shorter than in that of the PPT slides. Similar findings were reported in a context where human instructor was replaced by an animated pedagogical agent. Louwerse and colleagues (2008) found that even when pedagogical agents only make up around one-fourth of the display, participants contributed 56% of visual attention to the agent.

For this study, eye tracking will help understand the visual attention distribution that occurs as learners with individual differences in working memory capacity and inhibitory control learn from a video with and without instructor presence. In the study, the portion of the frame showing the instructor will be defined as one interest area and the rest of the screen will be defined as another interest area. Participants' visual attention distribution will be inferred by examining participants' number of fixations, average fixation duration, and dwell time in these two interest areas. As visual attention is hypothesized to be split between the instructor and the content when the instructor is present, the number of transitions (saccades) between the two interest areas will also be calculated to infer this split attention effect caused by instructor presence.

Cognitive dynamics

It has been suggested that self-reported measures of cognitive load are confounded (e.g., it is difficult to separate the effects of cognitive load from fatigue) and relatively insensitive to variations in cognitive load over time (Xie & Salvendy, 2000). The use of objective online measures of cognitive dynamics can provide greater insight into the cognitive load fluctuations that occur at different stages during a task, that is otherwise not evident using simple self-reports of cognitive load (Antonenko, Paas, Graber, & van Gog, 2010). Among these objective online measures of cognitive load, neuroimaging tools can be used to provide insights into the underlying cognitive dynamics while learners watch the instructional videos. Electroencephalography (EEG), compared to other neuroimaging techniques (e.g., fNIRS), can be used as a measure of cognitive dynamics that yields high temporal resolution (Antonenko, van Gog, & Paas, 2014; Antonenko & Keil, in press). The high temporal resolution of EEG enables it to reflect the fluctuations in brain's electrical activity on a millisecond scale. EEG has been widely adopted as a measure of process in educational research on reading, mathematics and problem-solving (Antonenko et al., 2014). For example, EEG has been used to examine the influence of page previews on learner's cognitive process in a hypertext learning environment (Antonenko & Niederhauser, 2010). The findings showed page previews led to a higher decrease of brain wave activity associated with extraneous cognitive processing, compared to the condition without page previews. However, few empirical studies have used EEG to examine learners' underpinning cognitive process in the context of multimedia learning (e.g., Gerě & Jaušcvec, 1999). Gerě and Jaušcvec (1999) employed EEG to examine cognitive activity involved in multimedia learning between typically developing and gifted students under text; text, narration, and image; and text, narration and video conditions. The results indicated the typically developing and gifted students demonstrated different patterns of cortical activity while processing the multimedia presentations. Gifted students displayed higher alpha power (i.e., less mental activity) during all three formats of presentation and the difference was most pronounced in the text, narration and video condition. The authors suggested that the strength of mental activity under cognitive load was negatively associated with intelligence.

So far, few empirical studies have used EEG to study the cognitive dynamics during learning with instructional video. Chen and Wu (2015) used EEG to measure sustained attention while participants were placed in one of the three conditions of instructor presence in video (instructor's voice over, lecture capture and picture-in-picture types of videos). The instructor's voice over condition contained three windows in the presentation: instructor's image in the upper left pane, table of content for the slides in the lower left pane of the screen, and PowerPoint™ slide on the right side of the screen. Using NeuroSky's EEG headset and adopting its algorithms for calculating the level of sustained attention, the researchers found that sustained attention induced by the voice over type is markedly higher than that of the picture-in-picture type. It was suggested that the higher sustained attention was related to increased cognitive load in the voice over condition. In this condition, learner's attention was split by the instructor frame, the table of content, and the slides. The process of integrating information from these three windows possibly exceeded learner's limited working memory capacity and thus resulted in increased cognitive load. Using EEG, Diaz and colleagues (2015) examined the effect of instructor presence on cognitive load and emotional states. Each participant was exposed to three video conditions: instructor always present, only instructor's voice present, and instructor present only at the beginning of the video (mixed condition). They found a significantly higher event-related desynchronization in alpha band power (a proxy of cognitive load) in the mixed condition. It was suggested as the instructor disappeared after initial appearance on the screen in the mixed condition, participants had to look for a new media for attending the presentation, thus causing the increment in cognitive load.

In the current study, EEG can noninvasively provide insights into the underlying cognitive dynamics that occur during the learning process, and thus inform the influence of instructor presence on learners with individual differences, that is otherwise not evident comparing learning test scores or self-report responses.

CHAPTER 3
METHODOLOGY

The current study is designed to explore the following two research questions.

- Question 1. To what extent does instructor presence in easy and difficult instructional videos influence learning, visual attention distribution, cognitive dynamics, and learner perceptions (cognitive load, perceived learning, satisfaction, situational interest, social presence, and perceptions of the instructor)?
- Question 2. How do individual differences in working memory capacity and inhibitory control moderate instructor presence effects in easy and difficult instructional videos?

Research Design

Given the theoretical perspectives and empirical evidence on instructor presence in instructional videos, the purpose of the current study is to explore how instructor presence in videos influences learning, visual attention distribution, cognitive dynamics, and learner perceptions and how these effects are moderated by individual differences in working memory capacity and inhibitory control.

This study manipulated video design that differentiates content difficulty (easy topic vs. difficult topic) as a within-subjects variable and instructor presence (instructor present vs. instructor absent) as a between-subjects variable. Based on the results of working memory capacity and inhibitory control tests, participants were assigned to watch two videos in one of the two conditions: 1) the easy topic video with instructor present and the difficult topic video with instructor absent; 2) the difficult topic video with instructor present and the easy topic video with instructor absent. This way, the balancing of the groups could be controlled to include both low WMC and low IC vs. high WMC and high IC in the sample for each condition (compared to random assignment). Half of the participants watched the easy topic video with instructor present and the difficult topic video with instructor absent. The other half of the participants watched the easy topic video with instructor absent and the difficult topic video with instructor present (Figure 3-1). To avoid the order effect, participants watched the easy topic and the difficult topic videos in randomized order. The variables in the current study are summarized in Table 3-1.

Participants

Using a priori power analysis for multiple linear regression (G-Power), with an alpha level at α = .05, an estimated medium effect size, three predictor variables (i.e., instructor presence, working memory capacity, and inhibitory control), and a desired power of 0.8, the study required approximately 77 participants (Cohen, 1992, p. 158). Given the challenges of recruiting this many freshman students and using complicated data collection methods like Electroencephalography (EEG) and eye tracking, this study recruited 60 participants from the University of Florida. The possibility was high that these participants would watch these instructional videos for their Statistics courses at UF.

As the topics in the two videos are not covered in high school Advanced Placement (AP) statistics, the recruited freshman students were presumed to have no prior knowledge on the topics selected for the current study. Inclusion criteria were as follows: (a) all participants should be between 18 and 27 years old, (b) all participants should have normal or corrected to normal vision, (c) participants should have no history of brain trauma or neurological disorders, (d) candidates for the study cannot be using depression and anxiety medications as they alter brain activity, e) candidates with Autism Spectrum Disorder were excluded from the study as they respond to face differently. A pre-screening instrument included these questions.

Materials

The two videos covered an easy and a difficult topic in Statistics as determined by Statistics Education experts. Statistics is important to college students, as it can "prepare students to handle, use, or interpret research or statistical data in their academic or professional discipline" (Gal, Ginsburg, & Schau, 1997, p. 39). The easy topic video focused on the terminology associated with experiments and observational studies. The easy topic video covered information on the definitions of experiment, observational study, explanatory variable, response variable, factor, levels, treatments, subjects and replication. The details of the content covered in the easy topic are provided in Appendix A. The easy topic video lasted approximately 3 minutes. The difficult topic focused on the rationale for conducting the Analysis of Variance (ANOVA). The instructor explained concepts such as the purpose of ANOVA, null hypothesis, alternative hypothesis, between group variance, within group variance, and F test statistics. The details of the content covered in the difficult topic are provided in Appendix B. The difficult topic video lasted 4 minutes and 30 seconds. Both videos were within six minutes long, which has been suggested as a median engagement length for online instructional videos (Guo et al., 2014).

Both the easy topic and difficult topic videos were designed in two versions: instructor present or instructor absent. The main frame of each video was devoted to a Khan Academy™ style pencast, whereas for the instructor present videos, the bottom right-hand corner always showed a shoulder-up view of the instructor. The instructor frame showed the instructor explaining the content and displaying non-verbal cues (eye gaze, gesturing, and facial expressions). The same instructor (a middle-aged white male) was present in the easy and difficult topic videos with instructor presence and the amount of his non-verbal cues (eye gaze, gesturing, and facial expressions) was kept consistent across these two videos. The instructor narrated the same script for the instructor absent videos as he did in the instructor present videos. In situations where pencast was produced on the screen, the instructor was writing with a purple pen on the screen in the two instructor present videos whereas the pencast was produced using a tablet pen in the instructor absent videos without showing the hand of the instructor as students could be wondering where the hand came from. Screenshots of the videos with and without instructor presence for the easy topic are provided in Figure 3-2. Screenshots of the videos with and without instructor presence for the difficult topic are provided in Figure 3-3.

The two videos were displayed using Experiment Builder software (SR Research, Ontario, Canada). The software captured participants' eye movement data and is compatible with Data Viewer, the eye movement data analysis software from the same company (SR Research, Ontario, Canada).

Apparatus

Participants were seated in a comfortable chair approximately 55 cm from the computer screen in a laboratory with controlled lighting. The instructional video with or without instructor presence was displayed on an external 20-inch flat panel monitor, with a resolution of 1600 by 900 pixels and a refresh rate of 60 Hz. Participants used a chinrest (SR-HDR) with a forehead bar to minimize head movement. Eye movement data were collected with Eyelink 1000 Plus system (SR Research, Ontario, Canada) using a desktop-mount at a sampling rate of 1000 Hz in the monocular mode. EEG data were collected using wireless, dry electrode DSI-24 EEG system (Wearable Sensing, California, USA) at a sampling rate of 300 Hz. Figure 3-4 illustrates the experimental setup.

Measures

The study employed multiple measures. First, pre-intervention measures were used to collect pre-screening data (using an online survey), and individual differences data using a test of working memory capacity (i.e., Automated Operation Span task), and a test of inhibitory control (i.e., NIH Flanker Inhibitory Control and Attention test). Second, process measures of a) visual attention distribution (interest area fixation and transition measures) and b) EEG-based cognitive dynamics (e.g., alpha and theta power) were used during the intervention. Finally, several product measures were used upon the completion of the intervention: a) a learning test of retention and transfer and b) a survey of learner perceptions (i.e., cognitive load, perceived learning, satisfaction, situational interest, social presence, and perceptions of the instructor). Details on each measure are provided below.

Pre-Intervention Measures

Pre-screening survey

Before participants watched the two instructional videos, they responded to a brief online pre-screening survey (Appendix C), providing information on their age, gender, ethnicity, first language, major (if declared), familiarity with research design terminology and ANOVA. The pre-screening survey also included items regarding participant vision, history of neurological disorders and medication use.

Inhibitory control

Inhibitory control was measured using the Flanker Inhibitory Control and Attention test in NIH Toolbox (Akshoomoff et al., 2013) iPad™ application. The test required the participant to focus on a given visual stimulus while inhibiting attention to stimuli (arrows) flanking it. Sometimes the middle stimulus was pointing in the same direction as the “flankers” (congruent) and sometimes in the opposite direction (incongruent). Participants were asked to press either the left key or the right key on the iPad^{TM} keyboard that corresponded to the direction in which the middle arrow was pointing. Scoring was based on a combination of accuracy and reaction time. Figure 3-5 shows an incongruent example of the Flanker Inhibitory Control and Attention test. This measure has been shown to have excellent reliability and validity and appears sensitive to participants’ variations in inhibitory control (Zelazo et al., 2013).

Working memory capacity

Working memory capacity was measured by the Automated Operation Span task (Unsworth et al., 2005). An alternative test is a reading span test but because participants in this study would learn statistical concepts that involve mathematics in the easy and difficult topic video, the Operation Span task was used. The Automated Operation Span task has been shown to be a reliable and valid indicator of WMC (Unsworth et al., 2005). The test was conducted online at http://www.millisecond.com/download/library/ospan/. In the Operation Span task, participants were asked to read and verify a simple math problem (such as “(3*4) + 9 = 21?”) and then read a letter right after each operation (e.g., F). After a series of math operations and letters had been presented, participants were asked to recall the letters that follow each math operation. The number of operation-letter strings in a sequence (i.e., set size) were increased and decreased to measure the participant's operation span. Figure 3-6 shows an example of the Automated Operation Span task.

Measures Used During Intervention

Visual attention distribution

In order to examine the influence of instructor presence on visual attention distribution in the instructional videos, this study defined the portion of the frame showing the instructor in each video as the instructor interest area and the rest of the frame including images and pencast as the content interest area. Visual attention distribution was inferred by examining participants' number of fixations, average fixation duration, and dwell time on the two interest areas. As visual attention is hypothesized to split between the instructor frame and the rest of the screen when the instructor is present, the number of transitions between fixating on the instructor interest area and the content interest area was calculated to examine the potential for and magnitude of split attention caused by the instructor presence in the video.

Cognitive dynamics

While participants watched the two videos, the DSI-24 EEG system recorded EEG data in the following four frequency bands: delta (0 - 4 Hz), theta (3 - 7 Hz), alpha (8 - 12 Hz), and beta (13 - 30 Hz) (Basar, 1999). EEG was recorded at a sampling rate of 300 Hz for each of the electrodes located at Fp1, Fp2, F3, Fz, F4, F7, F8, P3, Pz, P4, T3, T4, T5, T6, C3, Cz, C4, O1 and O2, of the 10-20 international system (Figure 3-7, Jasper, 1958) with respect to mastoid electrodes (A1 and A2) in common reference.

Post-Intervention Measures

Learning test

After participants finished watching the two videos, their learning from the videos was assessed by a learning test that included 12 retention questions and 5 transfer questions for the easy topic and 8 retention questions and 5 transfer questions for the difficult topic. Thus, each participant completed a total of 30 learning test items. The difference in the number of retention questions for the two videos was due to the fact that the difficult video was slightly longer. The easy topic video lasted approximately 3 minutes whereas the difficult topic video lasted 4 minutes. For the video on terminology associated with experiments and observational studies (easy topic), the retention and transfer questions assessed definition of experiment, observational study, explanatory variable, response variable, factor, levels, treatments, subjects and replication. For the video on rationale of the ANOVA (difficult topic), the retention and transfer questions assessed purpose of ANOVA, null hypothesis, alternative hypothesis, between group variance, within group variance, and *F* test statistics.

The retention questions were recognition-based questions, which assessed learner's ability to recognize the information covered in the videos. An example retention question for the difficult topic of rationale for ANOVA was "The purpose of running a one-factor ANOVA on three groups is to _________. A. Compare the means between three groups; B. Find the similarities between three groups; C. Characterize the overlapped portions between three groups; D. Find which two groups have different means; E. I don't know".

The transfer questions provided new scenarios that were not provided in the videos and examined learner's ability to apply the knowledge they acquired from the video into a novel context. An example transfer question for the easy topic of terminology associated with experiments and observational studies was "A researcher carried out an experimental study to examine the effectiveness of GRE prep programs (Powerscore or Kaplan) and the method of delivery (in person, online, or blended) on GRE verbal score. In the study, there are ____ factors. A. 1; B. 2; C. 3; D. 6; E. I don't know".

The retention and transfer questions were both multiple-choice questions. The learning test items were reviewed and optimized by three experts (e.g., faculty members and graduate students) in Statistics Education to ensure content validity. In order to reduce variance from guesswork, participants were allowed to select "I don't know" if they did not know the correct answer. No time limit was imposed on participants for completing the learning test. The learning test was delivered using Qualtrics™. The learning test questions for the two topics are provided in Appendix D.

Learner perceptions

Several questions were asked to elicit participants' perceptions of the videos with and without instructor presence, and these included questions on the perceived cognitive load, perceived learning, satisfaction, situational interest, social presence, and perceptions of the instructor. It is important to examine learning effects but it is also necessary to understand how the intervention influenced students' learning experience, which could be reflected in the constructs such as perceived learning, satisfaction, and social presence. The perceptions questions were delivered using Qualtrics™. The questions included in the learner perception survey are provided in Appendix E.

Cognitive load. Immediately after viewing each video with or without instructor presence, participants self-reported four well-recognized types of cognitive load (Leppink et al., 2013) they experienced while watching the video.

Overall load (Paas, 1992). Participants rated the perceived amount of mental effort they invested while watching the video, using a 9-point Likert scale that ranged from very, very low mental effort (1) to very, very high mental effort (9).

Intrinsic load (Ayres, 2006). Participants rated the how easy the topic covered in the video was, using a 9-point Likert scale that ranged from very, very easy (1) to very, very difficult (9).

Extraneous load (Cierniak, 2009). Participants rated how easy it was to learn from the video, using a 9-point Likert scale that ranged from very, very easy (1) to very, very difficult (9).

Germane load (Salomon, 1984). Participants rated how concentrated they were while they watched the video, using a 9-point Likert scale that ranged from very, very little (1) to very, very much (9).

Perceived learning. After reporting the four types of cognitive load, participants indicated how much they learned from each video, using a 9-point Likert scale that ranged from did not learn anything (1) and learned a great deal (9). This measure has been used in a related previous study (Wang & Antonenko, 2017) and it appears sensitive to differences in participants' perceptions of learning.

Satisfaction. After reporting perceived learning, participants rated their satisfaction regarding learning with each video, using a 9-point Likert scale that ranged from extremely dissatisfied (1) to extremely satisfied (9). This measure has been used in a related previous study (Wang & Antonenko, 2017) and it appears sensitive to differences in participants' perceptions of satisfaction.

Situational interest. Participants responded to a question (Lathrop, 2011) that examined the effects of each video on increasing situational interest with or without instructor presence on a five-point scale: I am willing to watch more videos like this because it is exciting and relevant. ('Strongly disagree'; 'Disagree'; 'Neither agree nor disagree'; 'Agree'; 'Strongly Agree'). This measure has been reported sensitive to differences in participants' perceptions of situational interest with regard to learning environment stimulation (Lathrop, 2011).

Social presence. Afterwards, for each video participants indicated the level of agreement with five statements that examine instructor's social presence (Kizilcec et al., 2015) on a five-point scale ('Strongly disagree'; 'Disagree'; 'Neither agree nor disagree'; 'Agree'; 'Strongly Agree'). The statements included: I felt like the instructor was in the same room as me; I felt that the instructor was very detached in his interactions with me; I felt that the instructor was aware of my presence; I felt that the instructor was present; I felt that the instructor remained focused on me throughout our interaction. This measure has been reported sensitive to differences in participants' perceptions of instructor's social presence (Kizilcec et al., 2015).

Perceptions of the instructor. Each participant watched one video with instructor presence and the other video without instructor presence. At the end of the instructor present video, participants responded to two additional questions to provide more information regarding their perceptions of the instructor. They first responded to an open-ended question: Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor. Then, participants were asked to provide feedback on their perceptions of instructor presence by selecting all adjectives that characterized their experience (e.g., 'helpful', 'entertaining'; 'useful'; 'engaging'; 'frustrating'; 'distracting'; 'annoying'). Participants were also allowed to write down other adjectives that were not provided on the list. This measure has been reported sensitive to variations in participants' perceptions of instructor presence.

Data Collection Procedures

Potential participants were approached and they completed the online pre-screening survey and the researcher decided if they would be invited to participate in the experiment. If the participants did not qualify after pre-screening, they were thanked and were not invited to participate in the study. The qualified participants were invited to participate in the study. All testing took place at the Neuroscience Applications for Learning (NeurAL) Laboratory located at Norman Hall G525 in the UF College of Education. After signing the informed consent (Appendix F), participants' working memory capacity was assessed by the Automated Operation Span task. After the working memory capacity test, participants' inhibitory control ability was assessed by the Flanker Inhibitory Control and Attention test. Afterwards, participants were fitted with the DSI-24 EEG headset (Wearable Sensing, California, USA). The DSI-24 EEG headset did not require any additional skin preparation or applying conductive gel to the scalp or electrodes. The EEG headset was non-invasive and had been used in multiple research studies in higher education. After the headset was donned appropriately, participants were asked to perform several simple tasks such as rapid eye blinks, coughing, and clenching jaw, to check if the EEG responses were accurate. After that, the gaze of each participant was calibrated and validated using Eyelink's 9-point calibration algorithm.

Then, participants watched the videos on the two topics given the experimental condition they were assigned to. Participants watched the videos without pauses and were not allowed to take notes while watching the videos. While participants watched the videos with or without instructor presence, simultaneous EEG data and eye movement data were collected to capture their cognitive dynamics and visual attention distribution respectively. Immediately after watching each instructional video, participants reported four types of cognitive load, perceived learning, satisfaction, situational interest, social presence for the video they just watched. For the video with instructor presence, participants also respond to two additional questions eliciting about their perceptions of the instructor. After watching both videos, participants completed a learning test that measured retention and transfer of knowledge from the two videos. The entire data collection session took approximately 60 minutes. The tasks for each phase of the study and the approximate length for each task were summarized in Table 3-2.

Data Cleaning and Scoring Procedures

Inhibitory Control Test Data

The NIH Toolbox calculated one 2-vector score (reaction time and accuracy) and a total normed score (fully corrected for age and other demographic variables) combining the two for participant's performance on the Flanker Inhibitory Control and Attention test. For data analysis, the fully-corrected score was used to represent each individual's ability of inhibitory control.

Working Memory Capacity Test Data

The OSPAN score was based on the traditional "absolute OSPAN" scoring method, which produced the sum of all perfectly recalled sets. For example, if a participant recalled correctly 2 letters in a set size of 2 (i.e., 2 math operations to process and 2 letters to recall), 3 letters in a set size of 3, and 3 letters in a set size of 4, then the participant's OSPAN score would be 5 (2 + 3 + 0). This OSPAN score was used to represent each individual's working memory capacity.

Cognitive Dynamics Data

Custom scripts in EEGLAB (Delorme & Makeig, 2004) were written to decontaminate EEG data and pre-process EEG data. The researcher adopted Independent Component Analysis (ICA) approach to decontaminate EEG artifacts due to body movement and eye blinks. Wavelet analysis was conducted in EEGLAB using custom scripts to infer the cognitive dynamics while participants watched the two videos and the resulting time-frequency representations were achieved for each participant. This method had been used in multiple cognitive neuroscience studies focusing on the mechanisms of attention (Keil et al., 2003) and cognition (Keil et al., 2001).

Visual Attention Distribution Data

The eye movement data (interest area fixations and transitions) were processed in Data Viewer (SR Research, Ontario, Canada). Data Viewer exported several variables in respect to the interest areas, including number of fixations, percentage of fixations, average fixation duration, dwell time, and percentage of dwell time regarding the instructor interest area and the content interest area, and transitions between the two interest areas.

Learning Test Data

Learning test scores for the easy and difficult topics were computed by awarding one point for each correct answer, and zero points for each incorrect response or “I don’t know” response. Each participant had four scores from the learning test: a) score for easy topic retention test; b) score for easy topic transfer test; c) score for difficult topic retention test; d) score for difficult topic transfer test.

Learner Perception Data

For measures of cognitive load, perceived learning, satisfaction, situational interest, and social presence, responses on the scales were directly used. For responses to the question on the perceptions of the instructor (i.e., response to the open-ended question), responses were treated as qualitative data. For the characterization of feelings toward the instructor, frequency of selecting each adjective was examined for the easy topic and the difficult topic respectively.

All the cleaned data were entered into SPSS. Table 3-3 shows an example of data format for two participants who watch the difficult topic with and without instructor presence respectively (shown in transposed manner due to page size limit).

Data Analysis

Analyses of variance (ANOVA) was used to address Research Question 1, that is, the effects of instructor presence on dependent variables including learning, cognitive dynamics, visual attention distribution, and learner perceptions. Multiple regression was used to answer Research Question 2, that is, to examine how influences of individual differences moderate the effects of instructor presence on these DVs.

Step 1: Checking Assumptions for Statistical Tests

First, assumptions for specific statistic models were checked. For ANOVA tests, assumptions of parametric tests (normality, independence, homogeneity of variance) were checked and if not met, non-parametric tests (e.g., Mann Whitney test) was adopted as an alternative. For multiple regression tests, assumptions including independence, homogeneity, linearity, normality, and collinearity were checked. A criterion of .05 was used for determining the level of significance in all statistical tests. The data analysis was conducted in several steps.

Step 2: Exploring Group Homogeneity

To determine whether the experimental groups are homogeneous relative to working memory capacity and inhibitory control, one-way MANOVA was performed across the experimental conditions. As the balancing of the groups was controlled to include both low WMC and low IC vs. high WMC and high IC in the sample for each condition, the results should indicate that there is no significant difference across the experimental conditions on either of the two individual difference variables and the two experimental conditions should be well matched on participants' WMC and IC scores.

Step 3: Examine the Effects of Instructor Presence

First, ANOVA was performed to test the effects of instructor presence (independent variable) for easy and difficult topics respectively on each of the following dependent variables:

- Learning (retention, transfer);
- Cognitive dynamics (average alpha and theta power);
- Visual attention distribution (number of fixations and dwell time in the two interest areas);
- Self-reported cognitive load (overall CL, intrinsic CL, extraneous CL, germane CL);
- Perceived learning;
- Satisfaction;
- Situational interest;
- Social presence

Step 4: Examine the Moderating Effects of Individual Differences

To examine how individual differences in WMC and IC moderated the effects of instructor presence on each dependent variable for the easy and difficult topics, I utilized a battery of multiple regression analyses with instructor presence variable (present or absent), WMC score, and IC score as predictors of each of the following outcome variables:

- Learning (retention, transfer);
- Cognitive dynamics (average alpha and theta power);
- Visual attention distribution (number of fixations and dwell time in each interest area; number of transitions between the two interest areas);
- Self-reported cognitive load (overall CL, intrinsic CL, extraneous CL, germane CL);
- Perceived learning;
- Satisfaction;
- Situational interest;
- Social presence

I ran regressions with WMC and IC variables separately with instructor presence variable (one regression involving instructor presence and WMC, and the other one regression involves instructor presence and IC for each dependent variable). The regression analyses were conducted for each topic respectively.

Hierarchical linear regression analysis was also conducted for the two IVs (instructor presence and WMC). This model aimed to identify the added variance of the DVs the interaction between main IV and moderator IVs (WMC, IC) could contribute in addition to the variance explained by the IVs alone.

I will enter instructor presence and WMC into block 1, interaction between instructor presence and WMC into block 2. Results from the first block could indicate whether instructor presence or WMC has a significant influence on DVs. Results from the second block could indicate whether the addition of the interaction term in the second block can account for a significant portion of additional variance.

To further evaluate the influence of WMC in instructor present/absent condition, separate linear regressions were conducted. If WMC is significantly related to any DVs, I could conclude a moderating effect of WMC in the instructor present/absent condition. Assuming in the instructor presence condition, there is a significant positive relationship between WMC and learning transfer, I could conclude that instructor presence has a positive effect on transfer of learning, and this effect is most pronounced in participants with higher WMC.

Step 5: Examine the Effect of Individual Differences on Attentional Dynamics

All the following analyses (steps 5 and 6) focused on the data from the instructor present videos. As only the instructor present videos would produce data on number of fixations and dwell time on instructor interest area, as well as number of transitions between the two interest areas (instructor interest area and content interest area), I ran regressions analyses for the data from the instructor present videos, to examine the moderating effect of WMC and IC on several dependent variables (i.e., number of fixations and dwell time on instructor interest area, as well as number of transitions between the two interest areas) in instructor present videos. Similar procedure (as in step 4) were used here except only WMC and IC scores were be entered as IVs in the hierarchical linear regression model.

Step 6: Examine the Relationship between Attentional Dynamics and Other Dependent Variables

Furthermore, I am interested in examining whether number of fixations, average fixation duration, and dwell time on instructor IA and number of transitions between two IAs can predict learning, learner perceptions, and cognitive dynamics in the instructor present condition. Multiple regression models with four IVs (i.e., number of fixations, average fixation duration, and dwell time on instructor IA and number of transitions between two IAs) on learning, learner perception variables and cognitive dynamics were tested.

Table 3-1. Variables in the current study

Variable	Definition
Main IV	Instructor present vs. instructor absent
Moderator IV	Working memory capacity Inhibitory control
DV	Learning (retention and transfer) Visual attention distribution (fixations and transitions) Cognitive dynamics (alpha and theta power) Perceptions (cognitive load, perceived learning, satisfaction, situational interest, social presence, and perceptions of the instructor)

Table 3-2. Phases of the study

Phases of Study	Tasks
Pre-intervention	Informed consent (2 min) Automated Operation Span task (10 min) Flanker Inhibitory Control and Attention test (5 min) EEG headset setup (3 min) Eye tracker setup (2 min)
Intervention	Cognitive dynamics (8 min) Visual attention distribution
Post-intervention	Learner perceptions survey (5 min) Learning test (20 min)

Table 3-3. Data format for difficult topic

Variable	Participant 1 (Condition: Instructor present)	Participant 2 (Condition: Instructor absent)
Instructor presence	1	0
OSPAN	40	70
Inhibitory control	20	30
Retention	6	8
Transfer	2	5
Overall load	5	7
Intrinsic load	5	7
Extraneous load	5	7
Germane load	5	7
Perceived learning	8	6
Satisfaction	7	6
Situational interest	4	3
Social presence statement 1	2	2
Social presence statement 2	2	2
Social presence statement 3	2	2
Social presence statement 4	2	2
Social presence statement 5	2	2
Average alpha power at parietal lobe	1.1	1.3
Average theta power at central lobe	1.3	1.5
Percentage of fixations on the instructor IA	20%	1%
Percentage of dwell time on the instructor IA	25%	2%
Percentage of fixations on the content IA	80%	99%
Percentage of dwell time on the content IA	75%	98%
Number of transitions between IAs	30	1

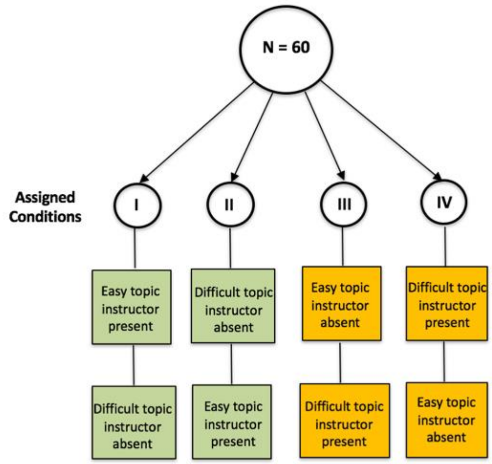


Figure 3-1. Group assignment for the study.

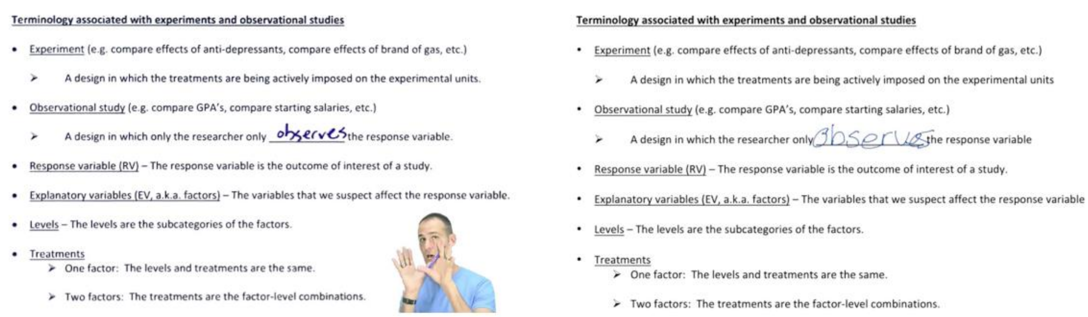


Figure 3-2. Screenshots of the videos on the easy topic: Terminology associated with Experiments and Observational Studies.

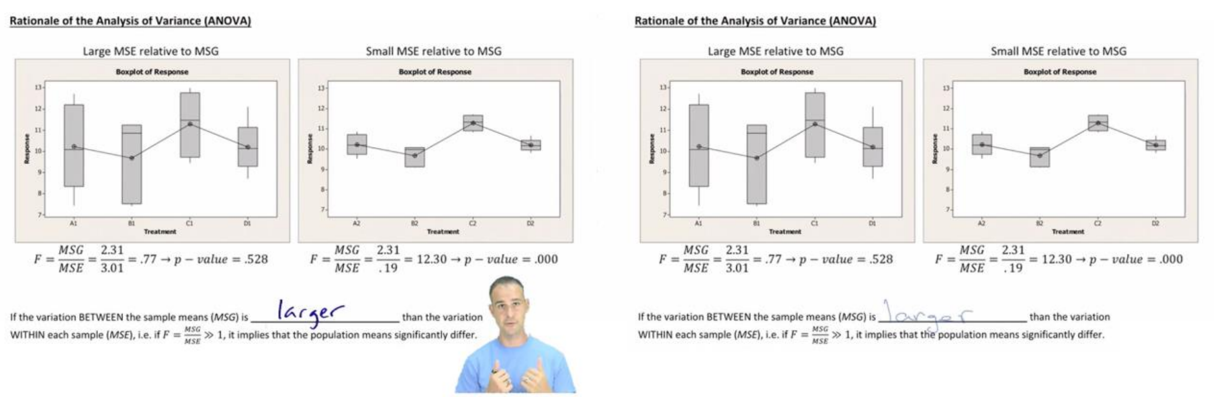


Figure 3-3. Screenshots of the videos on the difficult topic: Rationale for the Analysis of Variance (ANOVA).

Figure 3-4. Experimental setup. Photo courtesy of author.

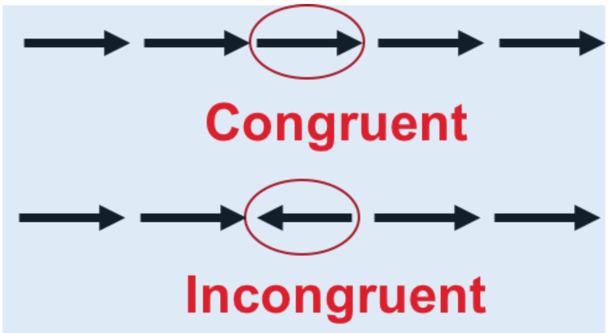


Figure 3-5. Examples of the Flanker Inhibitory Control and Attention test. In the upper example (congruent), the participant is expected to press the right-pointing key as the middle arrow in the array is pointing right. In the bottom example (incongruent), the participant is expected to press the left-pointing key as the middle arrow in the array is pointing left.

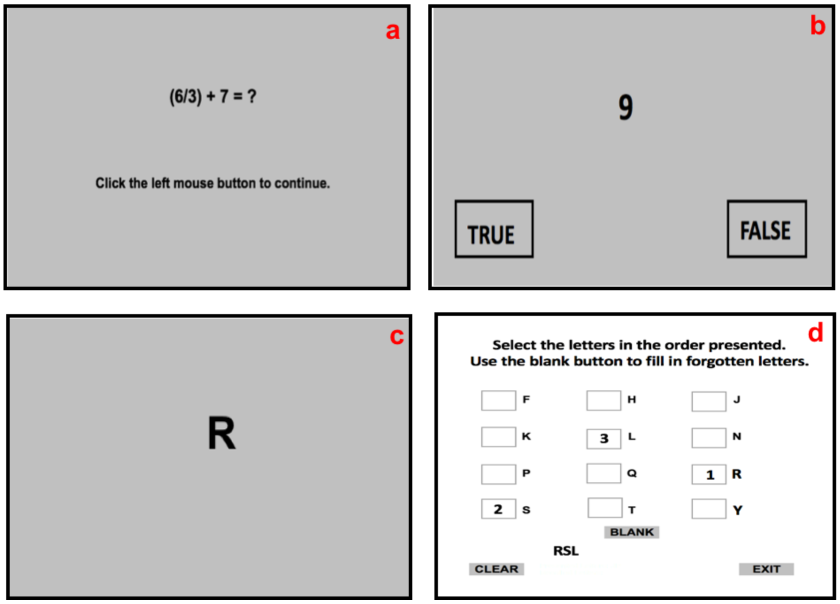


Figure 3-6. An example of the Automated Operation Span task. In this example, the participant is expected to check if the answer to the math problem is correct (Figure a; b), memorize letter R (Figure c), check if the answer to another math problem is correct (not shown here), memorize letter S (not shown here), then check if the answer to another math problem is correct (not shown here), memorize letter L (not shown here). At the end, the participant is expected to select letters R, S and L (Figure d).

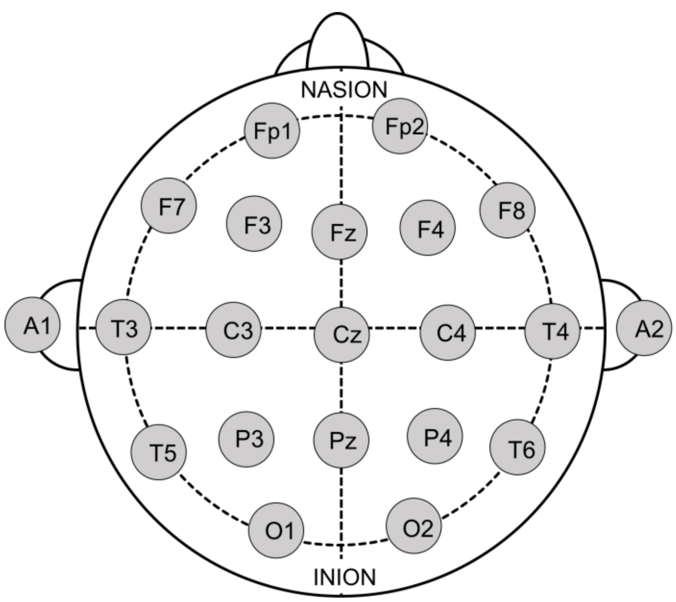


Figure 3-7. EEG 10-20 system.

CHAPTER 4
RESULTS

This chapter presents the findings of the current study. I first reported the participants' demographics information. Next, I presented the data analyses on the effects of instructor presence on learning, learner perceptions, visual attention distribution, and cognitive dynamics in the easy and difficult topic video conditions. Then, I provided the findings related to the predictors of learning and learner perceptions in the two experimental conditions. Finally, I reported the findings relative to the moderating effects of individual differences in working memory capacity and inhibitory control in each condition.

Participants Demographics

Demographics information for the participants is provided in Table 4-1. Out of the sixty participants, twenty-one participants were male, and 39 of the participants were female. The participants had an average age of 18.36 (SD = 0.66). Twenty-five participants identified themselves as White or Caucasian, and 20 were Hispanic or Latino, 7 were Black or African American, and 8 were Asian or Pacific Islander.

Influences of Instructor Presence on Learning, Learner Perceptions, Visual Attention Distribution, and Cognitive Dynamics

I explored the influence of instructor presence on learning, learner perceptions, visual attention distribution, and cognitive dynamics. In the following section, I will discuss the influence of instructor presence on each of these dependent variables.

Learning

In the current study, the influence of instructor presence on learning was examined using retention and transfer measures.

Retention

Participants' retention of information from the videos was measured for both topics, using a test of 12 questions for the easy topic and 8 questions for the difficult topic. Table 4-2 shows the descriptive statistics for the retention test scores when instructor was present or absent in the videos. ANOVA test indicated that instructor presence did not influence retention positively or negatively for either the easy topic video, $F(1, 58) = .849$, $p = .361$, or the difficult topic video, $F(1, 58) = .090$, $p = .766$ (see Figure 4-1).

Transfer

Participants' transfer of information from the two videos was measured using a test of 5 transfer questions for both the easy and difficult topic videos. Table 4-3 shows the descriptive statistics for the transfer test scores when instructor was present or absent in the videos. The finding indicated that instructor presence did not influence transfer score positively or negatively for the easy topic video, $F(1, 58) = .670$, $p = .416$. However, participants who watched the difficult topic video with the instructor present did significantly better on the transfer test, $F(1, 58) = 3.779$, $p < .05$ (see Figure 4-2).

Learner Perceptions

The influences of instructor presence on learner perceptions were examined using measures of cognitive load, satisfaction, perceived learning, situational interest, and social presence.

Cognitive load

Participants self-reported four types of cognitive load: overall load (Paas, 1992), intrinsic load (Ayres, 2006), extraneous load (Cierniak, 2009), and germane load (Salomon, 1984) at the end of each video on a 9-point Likert scale. The measures of cognitive load have been used and validated in previous studies (e.g., Antonenko & Niederhauser, 2010; Leppink et al., 2013).

Table 4-4 shows the descriptive statistics for the four types of cognitive load when the instructor was present or absent in the easy topic video. For the easy topic video, instructor presence did not increase or decrease participants' self-perceived overall load, $F(1, 58) = 1.048$, $p = .310$; intrinsic load, $F(1, 58) = 1.844$, $p = .180$; extraneous load, $F(1, 58) = 2.311$, $p = .134$, or germane load, $F(1, 58) = .471$, $p = .495$. Figure 4-3 shows the comparison of self-perceived cognitive load when instructor was present or absent in the easy topic video.

Table 4-5 shows the descriptive statistics for the four types of cognitive load when instructor was present or absent in the difficult topic video. For the difficult topic video, instructor presence did not affect participants' self-perceived overall load, $F(1, 58) = .731$, $p = .396$, or germane load, $F(1, 58) = 3.598$, $p = .063$. However, instructor presence was found to decrease intrinsic load, $F(1, 58) = 4.095$, $p < .05$, and extraneous load, $F(1, 58) = 23.960$, $p < .001$. Figure 4-4 shows the comparison of self-perceived cognitive load when the instructor was present or absent in the difficult topic video.

Satisfaction

Participants rated their satisfaction level with instructor presence using a 7-point Likert scale ranging from *extremely dissatisfied (1)* to *extremely satisfied (7)*. This measure has been used in a related previous study (Wang & Antonenko, 2017) and it appeared sensitive to the differences in participants' perceptions of satisfaction. Table 4-6 shows the descriptive statistics for participants' satisfaction ratings when the instructor was present or absent. The findings showed that participants reported significantly higher satisfaction when the instructor was present both in the easy topic video, $F(1, 58) = 7.562$, $p < .001$, and in the difficult topic video, $F(1, 58) = 99.076$, $p < .001$. The findings are summarized in Figure 4-5.

Perceived learning

Participants indicated how much they learned from each video using a 5-point Likert scale that ranged from *did not learn anything (1)* to *learned a great deal (5)*. This measure has been used in a related previous study (Wang & Antonenko, 2017) and it also appeared sensitive to the differences in participants' self-perceptions of learning. Table 4-7 shows the descriptive statistics for participants' self-reported perceived learning when the instructor was present or absent in the two videos. The analysis showed that participants reported a significantly higher level of perceived learning when the instructor was present for the difficult topic, $F(1, 58) = 20.354$, $p < .001$. However, the instructor presence did not increase participants' perceived learning for the easy topic video, $F(1, 58) = .104$, $p = .748$ (Figure 4-6).

Situational interest

Participants reported their situational interest by rating their agreement with the statement "I am willing to watch more videos like this because it is exciting and relevant" on a five-point Likert scale that ranged from *strongly disagree (1)* to *strongly agree (5)*. This measure has been reported sensitive to the differences in participants' perceptions of situational interest with regard to learning environment stimulation (Lathrop, 2011). Table 4-8 shows the descriptive statistics for participants' self-reported situational interest level when the instructor was present or absent in the two videos. The findings indicated participants had significantly higher situational interest when the instructor was present in both the easy topic video, $F(1, 58) = 6.795$, $p < .05$, and the difficult topic video, $F(1, 58) = 110.481$, $p < .001$ (Figure 4-7).

Social presence

For each video participants indicated their level of agreement with five statements that examined the social presence on a five-point scale that ranged from *strongly disagree (1)* to *strongly agree (5)*. The statements included: I felt like the instructor was in the same room as me; I felt that the instructor was very detached in his interactions with me; I felt that the instructor was aware of my presence; I felt that the instructor was present; I felt that the instructor remained focused on me throughout our interaction. This measure has been reported sensitive to the differences in participants' perceptions of social presence in a previous study (Kizilcec et al., 2015). For the current study, internal consistency reliability was calculated using Cronbach's alpha = .771 for the five social presence items.

For the easy topic video, Table 4-9 shows the descriptive statistics for participants' responses to social presence items when the instructor was present or absent in the easy topic video. When the instructor was present in the easy topic video, participants agreed more with the following statements, "I felt that the instructor was aware of my presence", $F(1, 58) = 5.266$, $p < .05$; "I felt that the instructor was present", $F(1, 58) = 17.263$, $p < .001$; "I felt that the instructor remained focused on me throughout our interaction", $F(1, 58) = 19.189$, $p < .001$. Also, when the instructor was present in the easy topic video, participants agreed less with the statement "I felt that the instructor was very detached in his interactions with me", $F(1, 58) = 16.143$, $p < .001$. However, instructor presence did not affect participants' level of agreement with the statement, "I felt like the instructor was in the same room as me", $F(1, 58) = 3.258$, p

= .076. Overall, participants perceived a higher level of social presence when the instructor was present in the easy topic (Figure 4-8).

For the difficult topic video, Table 4-10 shows the descriptive statistics for participants' social presence responses when the instructor was present or absent in the difficult topic video. When the instructor was present in the difficult topic video, participants agreed more with the following statements, "I felt like the instructor was in the same room as me", $F(1, 58) = 160.616$, $p < .001$; "I felt that the instructor was aware of my presence", $F(1, 58) = 65.006$, $p < .001$; "I felt that the instructor was present", $F(1, 58) = 119.885$, $p < .001$; "I felt that the instructor remained focused on me throughout our interaction", $F(1, 58) = 73.025$, $p < .001$. Also, when the instructor was present in the difficult topic video, participants agreed less with the statement "I felt that the instructor was very detached in his interactions with me", $F(1, 58) = 31.849$, $p < .001$; Overall, participants perceived a higher level of social presence when the instructor was present in the difficult topic video (Figure 4-9).

Participants' feelings toward the instructor

At the end of watching the easy and difficult topic videos with instructor presence, participants were asked to report their feelings towards the instructor by selecting any of the following adjectives that characterized their feelings toward the instructor (e.g., 'helpful', 'entertaining'; 'useful'; 'engaging'; 'frustrating'; 'distracting'; 'annoying') and they were also encouraged to write down any adjectives that were not provided on the list. The findings indicated that participants generally had a positive feeling toward the instructor. They thought the instructor was 'useful', 'helpful', 'engaging', and 'entertaining', for both the easy and difficult topic videos. Only a few participants thought the instructor was 'frustrating', 'distracting', and 'annoying'. Figure 4-10 represents the frequencies of participants' responses, for the easy and difficult topic videos respectively.

Participants' perceptions of instructor presence

In addition to selecting the adjectives that characterized their feelings toward the instructor, participants also responded to an open-ended question: Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor. The data analysis of participants' responses followed Creswell's (2013) guidelines for data analysis in qualitative research. Thematic analysis was used to search for repeated patterns or themes in participants' responses to this open-ended question. Based on analysis of 60 participants' responses, the following two themes were found.

Theme 1: Instructor provided non-verbal cues. First, participants appreciated the presence of non-verbal cues provided by the instructor. One participant commented, "Connecting audible voice with visual lip movements and hand gestures reinforces the content being taught". Another participant wrote,

> I am able to see his hand movements and gestures, making it easier for me to maintain my focus and attention on what he is saying and less distracted. It also helps me feel more connected and learn better than to try to follow along with a voice that I cannot see.

Participants also expressed satisfaction with the personal feeling the instructor presence provided, by commenting "It makes it seem more personal and like I am in a real, active classroom". Another participant noted,

> Having the instructor in the video made the learning experience seem more like a true interaction, however, it wasn't by much due to the special effects of the video. It was still obvious that the instructor wasn't aware of my presence. However, I felt that it was easier to focus on the video because I could watch the instructor's body language and movements; it's like watching a professor in a lecture hall. The learning experience is slightly more personalized than by not seeing the instructor in the video at all. When the instructor isn't in the video, it's hard to focus because seeing

> just words and material on the screen isn't that interesting to watch. Overall, seeing the instructor makes it easier to pay attention because it creates a more engaging learning experience.

Theme 2: Instructor helped focus on learning. Moreover, participants reported seeing the instructor on the screen helped them focus on processing the material better. One participant mentioned, “Seeing the instructor helped me keep my focus on what I was learning. I think that if I didn't see him, I would not have been as focused on the material”. This positive influence of instructor presence was also reflected in another participant’s response,

> I think that the instructor being visible in this study made it easier for me to focus, rather than just looking at a screen full of words and having to read it for myself. He gave many examples that would help better understand the concepts.

However, two participants thought including the instructor was unnecessary. One participant mentioned, “I don't think there will be too different either with or without the instructor in the video. As long as the voice is being played, I will be able to stay focus”. Another one commented, “It didn't make much of a difference whether he was on screen or not”. Moreover, one participant preferred not seeing the instructor, by saying “While not seeing him I concentrate more on the paper”. Overall, participants had a positive perception of the instructor on the screen for both the easy and the difficult topic videos. Ninety-five percent of the participants provided a positive response about their perception of instructor presence.

Visual Attention Distribution

Participants’ eye movement data were aggregated for each video (i.e., easy topic video with the instructor present; easy topic video with the instructor absent; difficult topic video with the instructor present; difficult topic video with the instructor absent). To investigate people's visual attention distribution, participants' fixation behavior was examined with regard to two areas of interest: the instructor interest area (IA) and the content interest area (IA). As the instructor absent condition did not actually have an instructor IA, I created a corresponding interest area that had the equivalent size and location of instructor's interest area from the instructor present videos. Based on the aggregated fixation maps (Figure 4-11 for easy topic videos and Figure 4-12 for difficult topic videos), the participants distributed a significant amount of attention to the instructor on the screen for both videos, particularly focusing on the face part of the instructor.

Specifically, I examined participants' percentage of fixations in each interest area. Also, as fixations are different in length, I also examined the percentage of dwell time (i.e., total length of fixations) in each interest area. Last, as visual attention was hypothesized to split between the instructor frame and the content frame when the instructor is present, I also examined the number of transitions between the two interest areas to understand the magnitude of split attention when instructor was present in the video.

For the easy topic video, the statistics on instructor IA_fixations (%), instructor IA_dwell time (%), content IA_fixations (%), content IA_dwell time (%), number of transitions between the two IAs are provided in Table 4-11. For the easy topic video, when instructor was present, learners devoted 22% of the fixations and 35% of the dwell time to the instructor. Compared to the instructor absent videos, the same area of interest around the instructor attracted significantly more fixations, $F(1, 58) = 251.570$, $p < .001$ and a longer dwell time, $F(1, 58) = 334.181$, $p < .001$. Also, when the instructor was present, less attention was distributed to the content interest area compared to the instructor absent condition. Moreover, participants made 22 transitions on average between the two interest areas.

For the difficult topic videos, the statistics on the instructor IA_fixations (%), instructor IA_dwell time (%), content IA_fixations (%), content IA_dwell time (%), number of transitions between the two IAs are provided in Table 4-12. For the difficult topic video, when the instructor was present, learners devoted 27% of the fixations and 37% of the dwell time to the instructor. Compared to the instructor absent videos, the same area of interest around the instructor attracted significantly more fixations, $F(1, 58) = 323.131$, $p < .001$ and a longer dwell time, $F(1, 58) = 242.273$, $p < .001$. Similar to the finding for the easy topic videos, when the instructor was present, less attention was distributed to the content interest area compared to the instructor absent condition. Also, participants made an average of 47 transitions between the two interest areas.

Cognitive Dynamics

Participants' cognitive dynamics was examined using their EEG data for the two videos when the instructor was present or absent. As it was an authentic learning task, there were artifacts in the EEG data such as eye blinks and body movements. Therefore, before the time frequency analysis of EEG data, EEG artifacts due to body movement and eye blinks were decontaminated using the Independent Component Analysis (ICA) approach (Delorme & Makeig, 2004). Using one participant's ICA output example (see Figure 4-13), components 1, 2, 15 are typical examples of vertical eye blink and the components got rejected before the time frequency analysis of the EEG data for this specific participant.

After decontaminating EEG data, similar to the approached used by Stevens and colleagues (2013), the data for the two videos were broken down into 2-second segments for each video and the noise-free segments were retained for further power spectrum analysis. The easy topic video was 170 seconds long and so each EEG file was divided into 85 segments. The difficult topic video was 240 seconds long and so each EEG file was divided into 120 segments. A high percentage of noise-free segments were retained for further analysis for easy topic video with instructor present (90%), easy topic video with instructor absent (97%), difficult topic video with instructor present (97%), difficult topic video with instructor absent (95%). Table 4-13 summarizes the number of interpretable EEG data and the number of noise-free segments for each video condition.

Power Spectral Analysis was then conducted on the EEG data using Fast Fourier Transform in EEGLAB (Delorme & Makeig, 2004). In this study, the analysis focused on examining alpha and theta wave activity as alpha and theta wave activity are most prevalent when a person is cognitively engaged, such as in a learning task (Klimesch, Schack, & Sauseng, 2005). As the alpha rhythm is most pronounced in the parietal lobe, I focused the analyses of the alpha wave data acquired from three parietal lobe sensors P3, P4, and Pz. As the theta rhythm is most pronounced in the central and frontal lobes, I focused the analyses of the theta wave data acquired from three central lobe sensors C3, C4, and Cz, as well as the three frontal lobe sensors F3, F4, and Fz. Absolute power in theta frequency band (4 - 8 Hz) and alpha frequency band (8 - 13 Hz) was computed and compared between the instructor present and instructor absent versions of the easy and difficult topic videos.

Table 4-14 shows participants' absolute EEG power in theta and alpha bands for the easy topic video. Before group comparison, EEG absolute power data was transformed using Log transformation to obtain normally distributed data (van Albada & Robinson, 2007). The findings indicated that for the easy topic video, higher theta absolute power values in C4 were found in the instructor present condition, $F(1, 37) = 5.283$, $p < .05$. Figure 4-14 shows participants' absolute power at C4 for the easy topic video when the instructor was present and absent.

Table 4-15 summarizes participants' absolute EEG power in theta and alpha bands for the difficult topic video. The findings indicated that for the difficult topic video, higher theta absolute power values at C4 were found in the instructor absent condition, $F(1, 42) = 8.918$, $p < .01$. Also, a higher average theta absolute power values at C3, C4, and Cz were found in the instructor absent condition, $F(1, 42) = 5.587$, $p < .05$. Figure 4-15 shows participants' absolute power at C4 for the difficult topic video when instructor was present or absent. Figure 4-16 shows participants' average absolute power at C3, C4, and Cz for the difficult topic video when the instructor was present or absent.

Predictors of Learning and Learner Perceptions

I also conducted a series of regression analyses to explore if visual attention distribution and cognitive dynamics, as process measures, predicted learning and learner perceptions. In the following section, I presented the findings on visual attention distribution as a predictor of learner perception, as well as cognitive dynamics as a predictor of learning and learner perception.

Visual Attention Distribution Predicted Learner Perception

To explore the effects of visual attention distribution on learner perception in the instructor-present easy and difficult topic videos, I conducted a series of linear regression analyses with learner perception variables (i.e., satisfaction, situational interest, perceived learning, cognitive load types, level of agreement with social presence statements) as outcome variables and the visual attention distribution variables (i.e., fixation count on the instructor IA, percentage of fixation count on the instructor IA, dwell time on the instructor IA, percentage of dwell time on the instructor IA, number of transitions between the instructor IA and the content IA) as predictor variables.

Easy topic video with instructor present

For the instructor-present easy topic video, the regression analysis indicated fixation count on the instructor IA significantly predicted participants' satisfaction rating, $F(1, 28) = 4.984$, $p < .05$, $R^2 = .156$. The more fixations were allocated to the instructor IA, the more satisfied the participants were with the instructor-present easy topic video, $b = .015$, $t(28) = 2.233$, $p < .05$.

Difficult topic video with instructor present

For the instructor-present difficult topic video, the regression analysis indicated percentage of fixation count on the instructor IA significantly positively predicted participants' satisfaction rating with the video, $F(1, 28) = 7.309$, $p < .05$, $R^2 = .207$. The higher percentage of fixation count were allocated to the instructor IA, the more satisfied the participants were with the instructor-present difficult topic video, $b = 5.660$, $t(28)= 2.704$, $p < .05$.

Also, percentage of dwell time significantly positively predicted participants' satisfaction rating with the video, $F(1,28) = 10.10$, $p < .05$, $R^2 = .265$. The higher percentage of dwell time were allocated to the instructor IA, the more satisfied the participants were with the instructor-present difficult topic video, $b = 4.645$, $t(28) = 3.178$, $p < .01$.

To summarize the findings, for both the instructor-present easy and difficult topic videos, the amount of attention allocated to the instructor IA positively predicted participants' satisfaction ratings. The more participants paid attention to the instructor on the screen, the more satisfied they were with the instructor-present videos. However, the amount of attention to the instructor was not found to predict other learner perception variables, which included situational interest, perceived learning, cognitive load types, or level of agreement with social presence statements. I found no effects of increased attention to the instructor on improving learning test scores (i.e., retention and transfer test scores), either.

Cognitive Dynamics Predicted Learning

To explore the effects of cognitive dynamics on learning, I conducted a series of multiple regression analyses with each one of the learning test scores (i.e., retention and transfer test scores) as outcome variable and each one of cognitive dynamics variables (i.e., Alpha power at P3; Alpha power at P4; Alpha power at Pz; Average Alpha power at P3 & P4 & Pz; Theta power at C3; Theta power at C4; Theta power at Cz; Average theta power at C3, C4, and Cz; Theta power at F3; Theta power at F4; Theta power at Fz; Average theta power at F3, F4, and Fz) and instructor presence as predictor variables. The analyses were conducted for easy and difficult topic videos, respectively.

Easy topic video

For the easy topic video, the multiple regression model including theta power at F4 and instructor presence as predictor variables, and retention test score as outcome variable was significant at $F(2, 35) = 3.439$, $p < .05$, $R^2 = .164$. Theta power at F4 was a significant negative predictor of participants' retention test scores, $b = -1.676$, $t(35) = -2.552$, $p < .05$, controlling for instructor presence.

Besides, the multiple regression model including average theta power at F3, F4, and Fz and instructor presence as predictor variables, and retention test score as outcome variable was significant at $F(2, 35) = 2.687$, $p < .05$, $R^2 = .133$. Average theta power at F3, F4, and Fz was a significant negative predictor of participants' retention test scores, $b = -1.498$, $t(35) = -2.241$, $p < .05$, controlling for instructor presence.

Difficult topic video

For the difficult topic video, the findings indicated none of the cognitive dynamics variables (i.e., Alpha power at P3; Alpha power at P4; Alpha power at Pz; Average Alpha power at P3, P4, and Pz; Theta power at C3; Theta power at C4; Theta power at Cz; Average theta power at C3, C4, and Cz; Theta power at F3; Theta power at F4; Theta power at Fz; Average theta power at F3, F4, and Fz) along with the instructor presence variable significantly predicted either the retention or transfer test scores.

Cognitive Dynamics Predicted Learner Perception

To explore the effects of cognitive dynamics on learner perception, I conducted a series of multiple regression analyses with each one of the learner perception variables (i.e., satisfaction, situational interest, perceived learning, cognitive loads, level of agreement with social presence statements) as outcome variable, and each one of cognitive dynamics variables (i.e., Alpha power at P3; Alpha power at P4; Alpha power at Pz; Average alpha power at P3, P4, and Pz; Theta power at C3; Theta power at C4; Theta power at Cz; Average theta power at C3, C4, and Cz; Theta power at F3; Theta power at F4; Theta power at Fz; Average theta power at F3, F4, and Fz) and instructor presence as predictor variables.

Easy topic video

For the easy topic video, the multiple regression model including theta power at Fz and instructor presence as predictor variables, and level of agreement with social presence statement #2 (i.e., I felt that the instructor was very detached in his interactions with me) as outcome variable was significant at $F(2, 35) = 7.368$, $p < .01$, $R^2 = .296$. Theta power at F4 was a significant negative predictor of participants' level of agreement with social presence statement #2 (i.e., "I felt that the instructor was very detached in his interactions with me"), $b = -.812$, $t(35) = -2.097$, $p < .05$, controlling for instructor presence.

Besides, the multiple regression model including average theta power at F3, F4, and Fz and instructor presence as predictor variables and level of agreement with social presence statement #2 (i.e., I felt that the instructor was very detached in his interactions with me) as outcome variable was significant at $F(2, 35) = 6.666$, $p < .01$, $R^2 = .276$. Average theta power at F3, F4, and Fz significantly negatively predicted participants' level of agreement with social presence statement #2 (i.e., I felt that the instructor was very detached in his interactions with me), $b = -.746$, $t(35) = -1.812$, $p < .05$, controlling for instructor presence.

Difficult topic video

None of the cognitive dynamics variables (i.e., Alpha power at P3; Alpha power at P4; Alpha power at Pz; Average Alpha power at P3, P4, and Pz; Theta power at C3; Theta power at C4; Theta power at Cz; Average theta power at C3, C4, and Cz; Theta power at F3; Theta power at F4; Theta power at Fz; Average theta power at F3, F4, and

Fz) along with the instructor presence variable significantly predicted the learner perception variables (i.e., satisfaction, situational interest, perceived learning, cognitive load types, level of agreement with social presence statements).

Moderating Effects of Individual Differences

The second goal of the study was to explore the moderating effects of individual differences in easy and difficult topic videos with and without the instructor. In the following section, for working memory capacity and inhibitory control respectively, I presented the information on participants' scores and the moderating effects of individual differences in easy and difficult topic videos.

Working Memory Capacity

Individual differences in working memory capacity

Working memory capacity affects the ability to control one's attention (Conway & Engle, 1994). In this study, working memory capacity was measured by the Automated Operation Span Task (Unsworth et al., 2005). Participants' absolute Operation Span (O-Span) scores ranged from 13 to 75 where the maximum score was 75. The mean score equals 49.21 (*SD* = 14.96). The distribution of participants' working memory capacity scores is presented in Figure 4-17.

Moderating effects of individual differences in working memory capacity

To explore the moderating effects of working memory capacity on learning in easy and difficult topic videos with and without the instructor, I conducted a series of multiple linear regression analyses with each one of the learning test scores (i.e., retention and transfer test scores) as outcome variable, and using instructor presence and working memory capacity as predictor variables. Same procedure was followed to examine the moderating effects of working memory capacity on learner perception in easy and difficult topic videos with and without the instructor, except using each one of the learner perception variables (i.e., satisfaction, situational interest, perceived learning, cognitive load types, level of agreement with social presence statements) as outcome variable. I also explored the moderating effects of working memory capacity on cognitive dynamics and visual attention distribution in easy and difficult topic videos with and without the instructor.

Easy topic video. The multiple regression model including working memory capacity score and instructor presence as predictor variables and retention test score for the easy topic video as outcome variable was significant at $F(2, 56) = 6.063$, $p < .01$, $R^2 = .181$. Working memory capacity score was a significant positive predictor of participants' retention test score for the easy topic video, $b = .051$, $t(56) = 3.358$, $p < .001$, controlling for instructor presence.

However, the multiple regression model including working memory capacity score and instructor presence as predictor variables, and transfer test score, or learner perception variables, or cognitive dynamics variables, or visual attention distribution variables for the easy topic video as outcome variable was not significant at $p < .05$.

Difficult topic video. The multiple regression model including working memory capacity score and instructor presence as predictor variables, and retention test score, or transfer test score, or learner perception variables, or cognitive dynamics variables, or visual attention distribution variables for the difficult topic video as outcome variable was not significant at $p < .05$.

Inhibitory Control

Individual differences in inhibitory control

Inhibitory control influences participants' ability to inhibit attention to irrelevant stimuli while focusing on the task goal (Rothbart & Posner, 1985). In the current study, inhibitory control was measured by the Flanker Test (Eriksen & Eriksen, 1974). Participants' raw inhibitory control scores were fully corrected for age and other demographic variables using NIH Toolbox's national representative sample. Participants' fully-corrected inhibitory control scores ranged from 21 to 70, where a higher score indicated a stronger ability to inhibit attention to irrelevant stimuli while focusing on the task goal. The mean fully-corrected inhibitory control score was 40.83 (*SD* = 10.03). The distribution of participants' inhibitory control scores is presented in Figure 4-18.

Moderating effects of individual differences in inhibitory control

To explore the moderating effects of inhibitory control in easy and difficult topic videos with and without the instructor, I conducted a series of multiple linear regression analyses with each of the learning test scores (i.e., retention and transfer test scores) as outcome variable, and using instructor presence and inhibitory control as predictor variables. Same procedure was followed to examine the moderating effects of inhibitory control on learner perception in easy and difficult topic videos with and without the instructor, except using each one of the learner perception variables (i.e., satisfaction, situational interest, perceived learning, cognitive load types, level of agreement with social presence statements) as outcome variable. I also explored the moderating effects of inhibitory control on cognitive dynamics and visual attention distribution in easy and difficult topic videos with and without the instructor.

Easy topic video. The multiple regression model including inhibitory control score and instructor presence as predictor variables, and retention test score, or transfer test score, or learner perception variables, or cognitive dynamics variables, or visual attention distribution variables for the easy topic video as outcome variable was not significant at $p < .05$.

Difficult topic video. The multiple regression model including inhibitory control score and instructor presence as predictor variables and transfer test score for the difficult topic video as outcome variable was significant at $F(2, 56) = 4.986$, $p < .01$, $R^2 = .151$. Inhibitory control score was a significant positive predictor of participants' transfer test score for the difficult topic video, $b = .045$, $t(55) = 2.423$, $p < .05$, controlling for instructor presence.

However, the multiple regression model including inhibitory control score and instructor presence as predictor variables, and retention test score, or learner perception variables, or cognitive dynamics variables, or visual attention distribution variables for the difficult topic video as outcome variable was not significant at $p < .05$.

Summary of Findings

The study has two main purposes. The first purpose was to study the influences of instructor presence on the products of learning (i.e., learning and learner perceptions) and processes of learning (i.e., visual attention distribution and cognitive dynamics) in easy and difficult topic videos respectively. The second purpose was to examine the moderating effects of individual differences in working memory capacity and inhibitory control in instructional videos with and without instructor presence.

Regarding the first purpose of the current study, the data suggested that the instructor on the screen did not affect retention positively or negatively in either topic, but improved learners' ability to transfer information from the difficult topic. Regarding the influences on learner perceptions, instructor presence in the video produced a positive effect on learners' satisfaction and situational interest for both topics, and led to higher level of perceived learning for the difficult topic. Instructor presence also helped lower the intrinsic load and the extraneous load for the difficult topic video while not influencing any type of cognitive load for the easy topic video. The instructor on the screen was largely perceived as helpful, entertaining, useful, engaging for both topics and a high percentage of participants preferred to see the instructor compared to not seeing it for both easy and difficult topic videos.

Also, process measures (i.e., visual attention distribution and cognitive dynamics) indicated that the instructor on the screen attracted significant amount of visual attention for both topics and when the instructor was present, less attention was distributed to the content interest area. Regarding cognitive dynamics, instructor presence led to higher theta power at C4 sensor for the easy topic video and lower theta power at C4 sensor for the difficult topic video, where a lower theta power indicated a lower level of working memory load.

Also, the current study suggested the process measures (i.e., visual attention distribution and cognitive dynamics) were able to predict product measures (i.e., learning and learner perception). First, the more participants paid attention to the instructor on the screen, the more satisfied they were with the instructor-present videos. For instructor-present easy topic video, the fixation count on the instructor IA positively predicted participants' satisfaction rating. And for the instructor-present difficult topic video, the percentage of fixation count and the percentage of dwell time on the instructor IA significantly positively predicted participants' satisfaction rating with the video. Second, cognitive dynamics was found to predict learning. Specifically, for the easy topic video, theta power at F4 sensor and the average theta power at F3, F4, and Fz (i.e., three frontal lobe sensors) were both significant negative predictors of participants' retention test scores.

Regarding the second purpose of the study, we did not identify any moderating effects of individual differences in working memory capacity and inhibitory control. In fact, participants who had higher WMC scores performed significantly better on the retention test for the easy topic, controlling for instructor presence. Also, those participants who had higher inhibitory control scores excelled on the transfer test for the difficult topic.

Table 4-1. Participant characteristics

Variables	Statistics
Gender	21 Male, 39 Female
Age	*M* = 18.36 (*SD* = 0.66)
Race	25 White/Caucasian 20 Hispanic/Latino 7 Black/African American 8 Asian/Pacific Islander

Table 4-2. Mean accuracy (%) and standard deviations on retention test

Topic	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Easy	0.82	0.16	0.85	0.15
Difficult	0.53	0.21	0.51	0.21

Table 4-3. Mean accuracy (%) and standard deviations on transfer test

Topic	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Easy	0.84	0.20	0.79	0.19
Difficult	0.71	0.26	0.55	0.32

Table 4-4. Means and standard deviations on four types of cognitive load for the easy topic video

Cognitive Load	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Overall load: In the video I just finished watching, I invested *(1: very, very low mental effort; 9: very, very high mental effort)*	4.72	1.46	4.33	1.47
Intrinsic load: The video I just finished watching was *(1: very, very easy; 9: very, very difficult)*	3.17	1.26	3.60	1.16
Extraneous load: Learning from this video was *(1: very, very easy; 9: very, very difficult)*	3.00	1.13	3.53	1.53
Germane load: When watching this video, I concentrated *(1: very, very little; 9: very, very much)*	5.45	1.38	5.20	1.40

Table 4-5. Means and standard deviations on four types of cognitive load for the difficult topic video

Cognitive Load	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Overall load: In the video I just finished watching, I invested *(1: very, very low mental effort; 9: very, very high mental effort)*	6.07	1.23	5.76	1.53
Intrinsic load: The video I just finished watching was *(1: very, very easy; 9: very, very difficult)*	5.97	1.27	6.62	1.21
Extraneous load: Learning from this video was *(1: very, very easy; 9: very, very difficult)*	4.90	1.77	6.97	1.45
Germane load: When watching this video, I concentrated *(1: very, very little; 9: very, very much)*	6.30	1.29	5.45	2.08

Table 4-6. Mean and standard deviations on satisfaction ratings with the easy and difficult topic videos. 1: Extremely dissatisfied; 7: Extremely satisfied

Topic	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Easy	5.10	1.40	4.10	1.37
Difficult	5.63	1.00	2.48	1.40

Table 4-7. Mean and standard deviations on perceived learning for the easy and difficult topic videos

Topic	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Easy	2.72	0.96	2.80	0.85
Difficult	3.13	0.73	2.14	0.95

Table 4-8. Mean and standard deviations on self-reported situational interest level for the easy and difficult topic videos

Topic	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Easy	3.10	0.94	2.47	0.94
Difficult	3.77	0.77	1.66	0.77

Table 4-9. Mean and standard deviations on level of agreement with the social presence statements for the easy topic video

Social Presence Statements *1: Strongly disagree; 5: Strongly agree*	Instructor Present	Instructor Absent
Q1. I felt like the instructor was in the same room as me.	2.86 (0.92)	2.33 (1.30)
Q2. I felt that the instructor was very detached in his interactions with me.	2.10 (1.01)	3.17 (1.02)
Q3. I felt that the instructor was aware of my presence.	3.14 (0.88)	2.50 (1.22)
Q4. I felt that the instructor was present.	3.86 (0.83)	2.70 (1.26)
Q5. I felt that the instructor remained focused on me throughout our interaction.	3.72 (0.92)	2.47 (1.25)

Table 4-10. Mean and standard deviations on level of agreement with the social presence statements for the difficult topic video

Social Presence Statements 1: Strongly disagree; 5: Strongly agree	Instructor Present	Instructor Absent
Q1. I felt like the instructor was in the same room as me.	3.77 (0.90)	1.31 (0.54)
Q2. I felt that the instructor was very detached in his interactions with me.	2.20 (0.92)	3.76 (1.18)
Q3. I felt that the instructor was aware of my presence.	3.47 (0.78)	1.72 (0.88)
Q4. I felt that the instructor was present.	4.03 (0.72)	1.76 (0.87)
Q5. I felt that the instructor remained focused on me throughout our interaction.	3.83 (0.75)	1.83 (1.04)

Table 4-11. Visual attention distribution statistics for the easy topic video

Parameters	Instructor Present	Instructor Absent
Instructor IA_Fixations (%) (average percentage of all fixations on instructor IA)	22%	1%
Instructor IA_Dwell time (%) (average percentage of trial time spent on instructor IA)	35%	2%
Content IA_Fixations (%) (average percentage of all fixations on content IA)	78%	99%
Content IA_Dwell time (%) (average percentage of trial time spent on content IA)	65%	98%
Number of transitions between IAs (average number of times the attention was switched from the instructor IA to the content IA, or from the content IA to the instructor IA)	22	1

Table 4-12. Visual attention distribution statistics for the difficult topic video

Parameters	Instructor Present	Instructor Absent
Instructor IA_Fixations (%) (average percentage of all fixations on instructor IA)	27%	1%
Instructor IA_Dwell time (%) (average percentage of trial time spent on instructor IA)	37%	2%
Content IA_Fixations (%) (average percentage of all fixations on content IA)	73%	99%
Content IA_Dwell time (%) (average percentage of trial time spent on content IA)	63%	98%
Number of transitions between IAs (average number of times the attention was switched from the instructor IA to the content IA, or from the content IA to the instructor IA)	47	3

Table 4-13. Number of interpretable EEG data and number of noise-free segments for each video condition. Number of total segments for easy topic video EEG data - 85; number of total segments for difficult topic video EEG data - 120

Video	# of interpretable EEG data	*Mean (SD)* of noise-free segments
Easy Topic - Instructor Present	22	76.73 (9.69)
Easy Topic - Instructor Absent	17	82.65 (2.57)
Difficult Topic - Instructor Present	23	115.83 (3.76)
Difficult Topic - Instructor Present	21	113.57 (5.95)

Table 4-14. Participants' absolute power in theta and alpha bands for the easy topic video

	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Alpha power at P3	1.33	0.76	1.00	0.40
Alpha power at P4	1.37	0.78	1.06	0.33
Alpha power at Pz	1.26	0.75	1.03	0.32
Average Alpha power at P3, P4, and Pz	1.32	0.72	1.03	0.34
Theta power at C3	1.26	0.54	1.07	0.30
Theta power at C4 *	1.39	0.68	0.99	0.27
Theta power at Cz	1.90	2.18	1.39	0.70
Average theta power at C3, C4, and Cz	1.51	0.94	1.15	0.33
Theta power at F3	1.31	0.55	1.25	0.92
Theta power at F4	1.27	0.47	1.17	0.32
Theta power at Fz	1.34	0.54	1.14	0.23
Average theta power at F3, F4, and Fz	1.31	0.42	1.19	0.41

* indicates significant difference in absolute power between instructor present and instructor absent conditions at $p < .05$.

Table 4-15. Participants’ absolute power in theta and alpha bands for the difficult topic video

	Instructor Present		Instructor Absent	
	Mean	*SD*	*Mean*	*SD*
Alpha power at P3	0.95	0.33	1.27	0.84
Alpha power at P4	0.97	0.30	1.33	1.10
Alpha power at Pz	1.10	0.38	1.23	0.68
Average Alpha power at P3, P4, and Pz	1.01	0.32	1.28	0.85
Theta power at C3	0.94	0.23	1.05	0.32
Theta power at C4 *	0.90	0.30	1.29	0.68
Theta power at Cz	1.04	0.25	1.42	1.41
Average theta power at C3, C4, and Cz *	0.96	0.21	1.25	0.66
Theta power at F3	1.41	1.72	1.20	0.42
Theta power at F4	1.09	0.33	1.18	0.29
Theta power at Fz	1.03	0.20	1.17	0.23
Average theta power at F3, F4, and Fz	1.18	0.64	1.18	0.27

* indicates significant difference in absolute power between instructor present and instructor absent conditions.

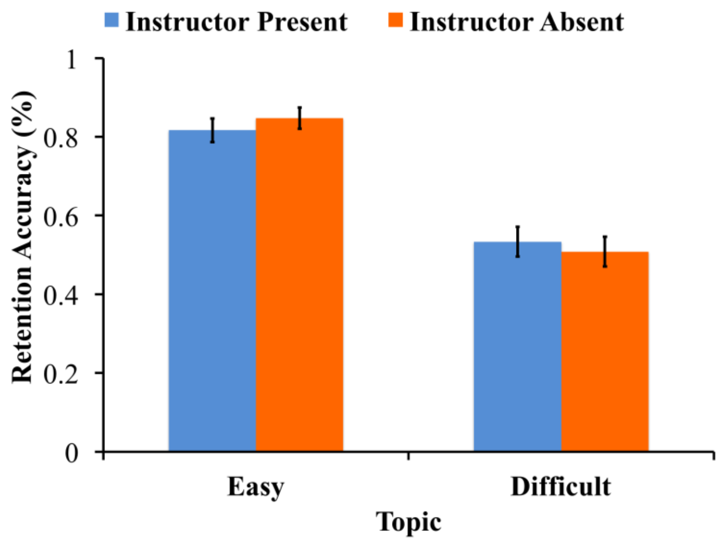


Figure 4-1. Participants' retention accuracy percentage for the easy and difficult topic videos in the instructor present and instructor absent conditions.

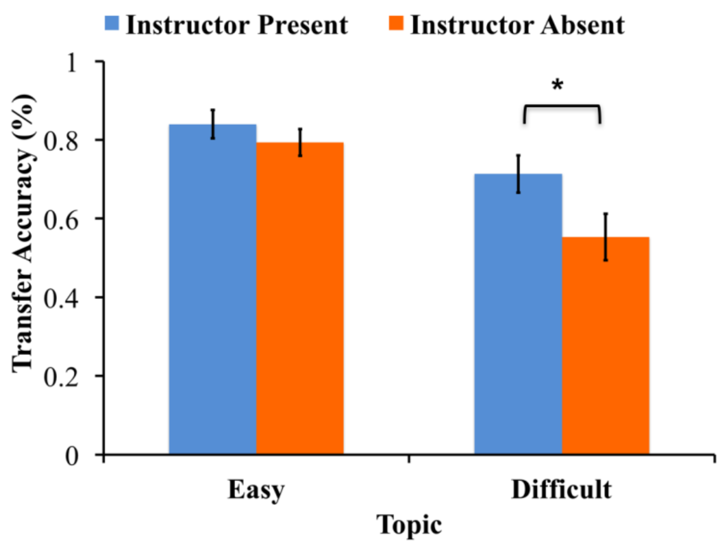


Figure 4-2. Participants' transfer accuracy percentage for the easy and difficult topic videos in the instructor present and instructor absent conditions.

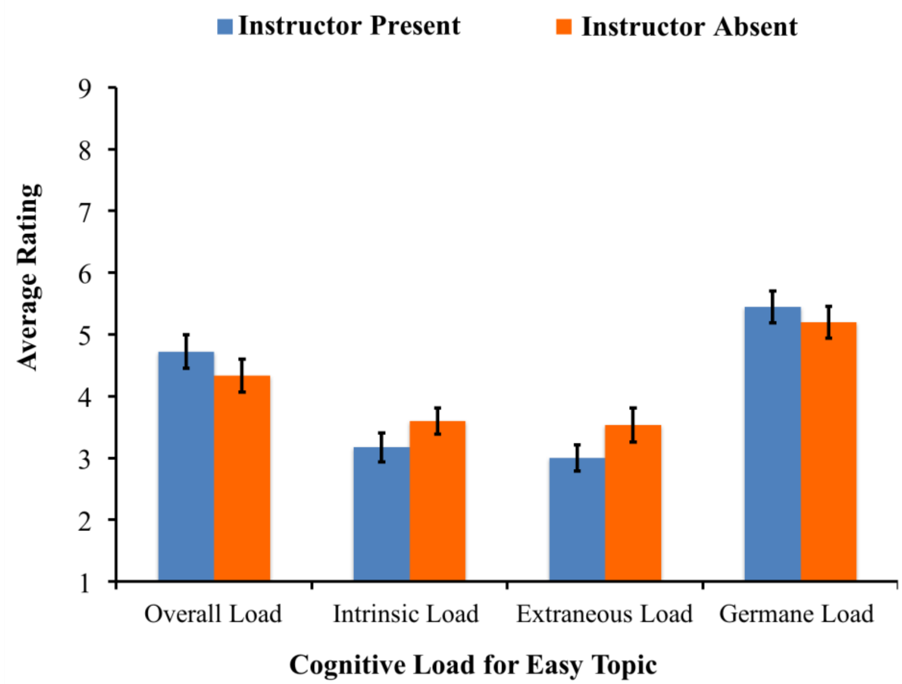


Figure 4-3. Participants’ self-reported cognitive load for the easy topic video.

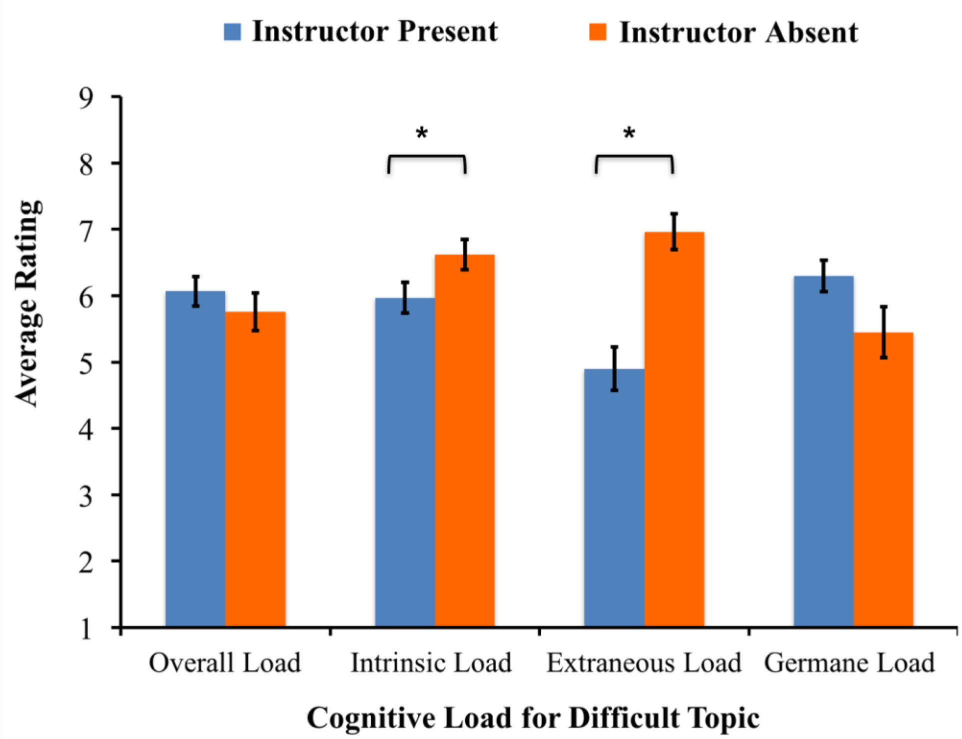


Figure 4-4. Participants’ self-reported cognitive load for the difficult topic video.

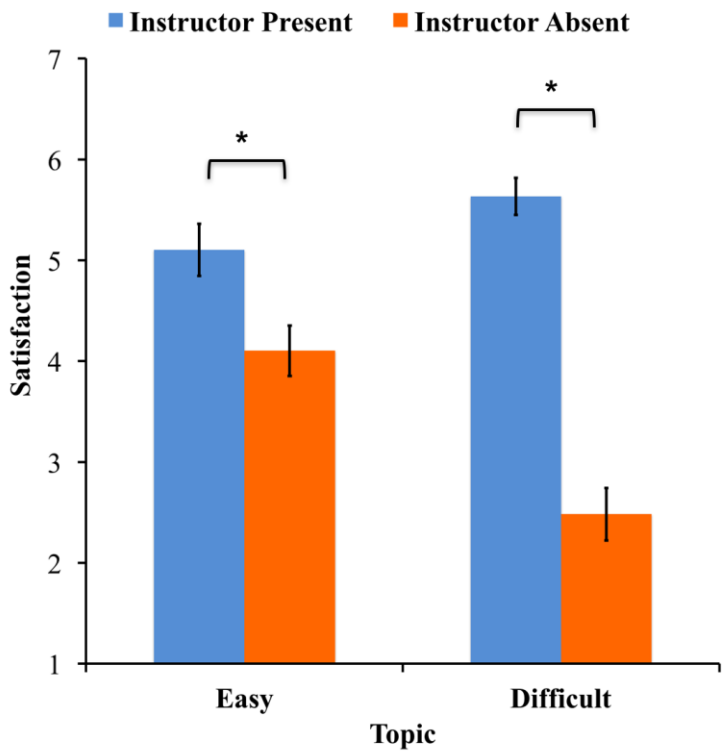


Figure 4-5. Participants' satisfaction ratings for the easy and difficult topic videos.

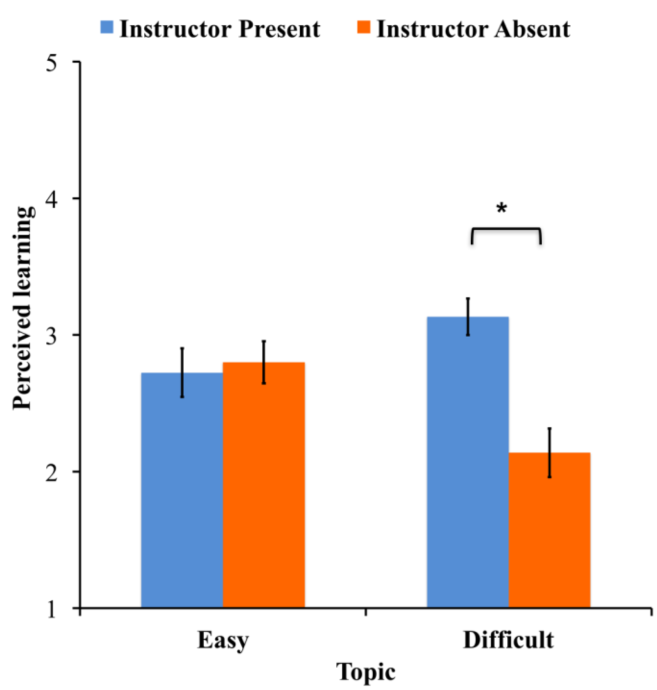


Figure 4-6. Participants' self-reported perceived learning. 1. Not at all; 2. A little; 3. A moderate amount; 4. A lot; 5. A great deal.

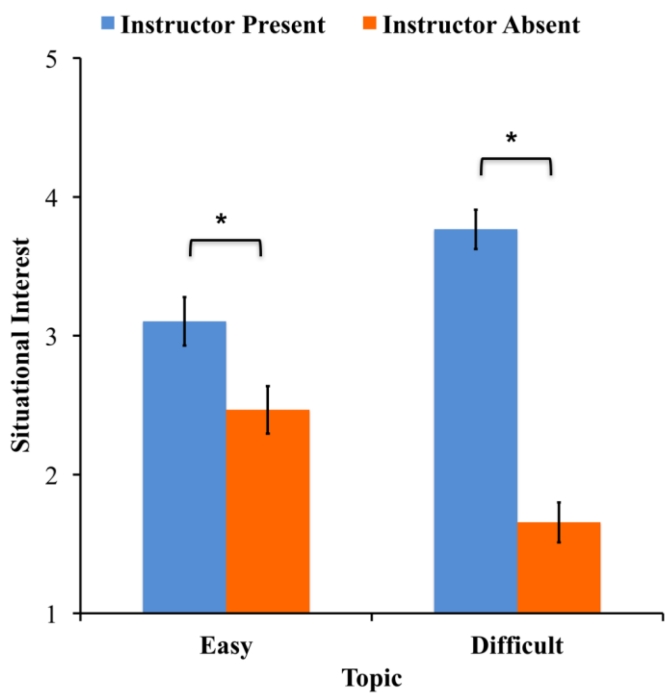


Figure 4-7. Participants' self-reported situational interest level.

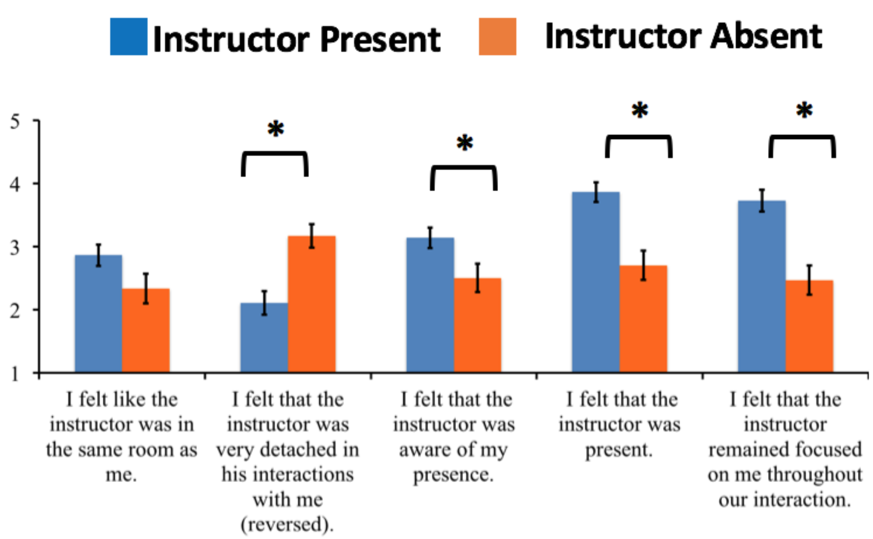


Figure 4-8. Participants' social presence responses for the easy topic video.

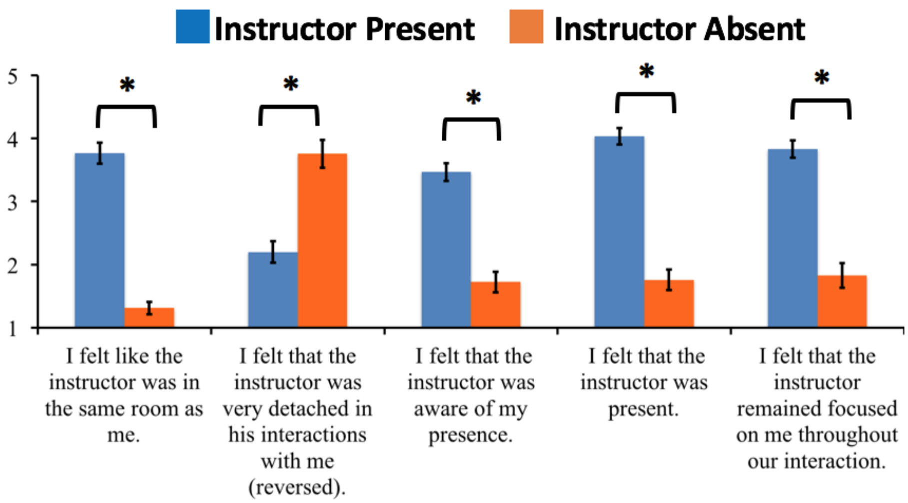


Figure 4-9. Participants' social presence responses for the difficult topic video.

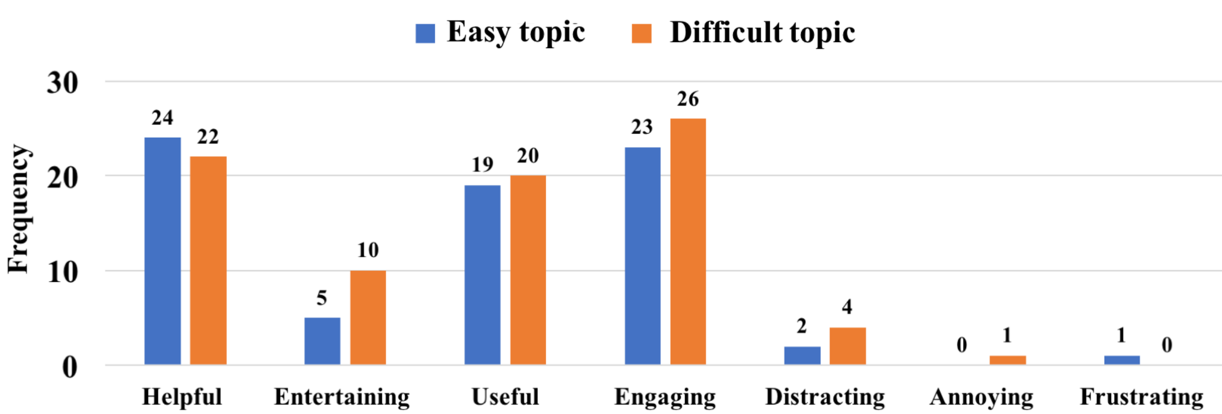


Figure 4-10. Participants' feelings toward the instructor for easy and difficult topic videos.

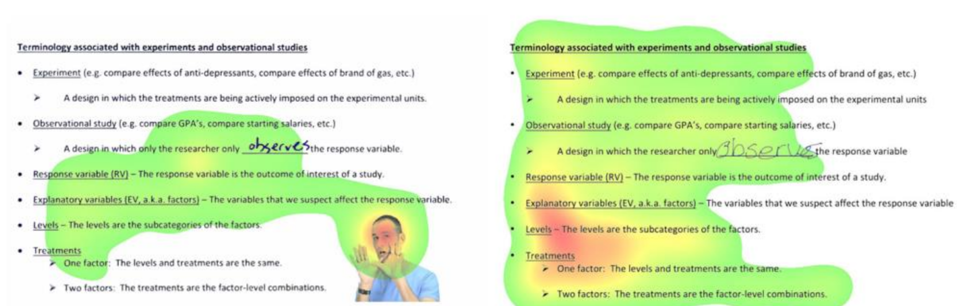


Figure 4-11. Participants' visual attention distribution for the easy topic videos. Red color represents a higher amount of visual attention; Yellow color - medium amount of visual attention; Green color - lower amount of visual attention.

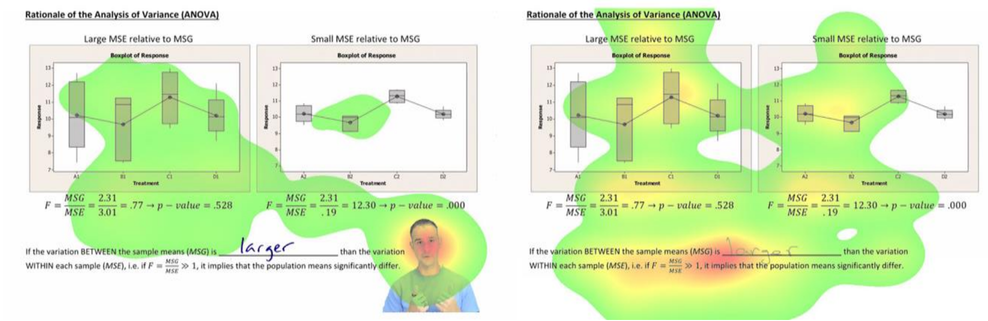


Figure 4-12. Participants’ visual attention distribution for the difficult topic videos. Red color represents a higher amount of visual attention; Yellow color - medium amount of visual attention; Green color - lower amount of visual attention.

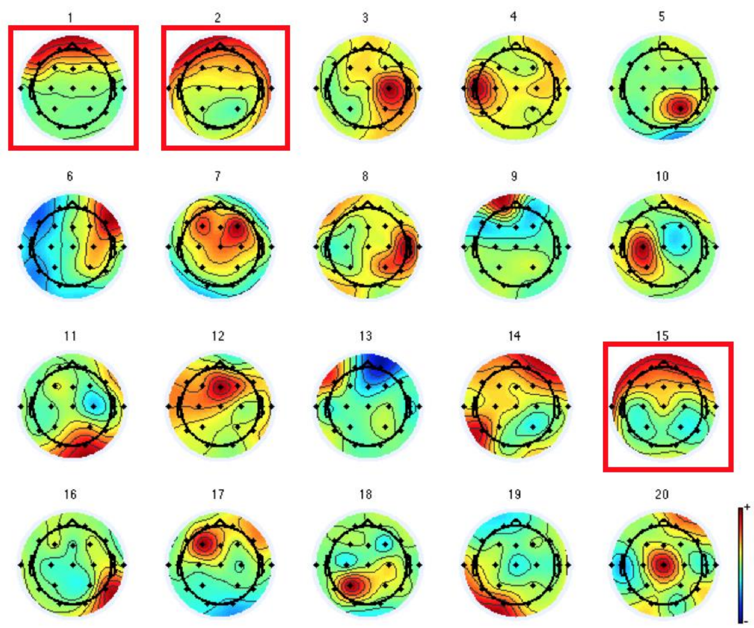


Figure 4-13. Example Independent Component Analysis output from one participant. Components 1, 2, 15 (in red boxes) are typical examples of vertical eye blink and these components were rejected before the time frequency analysis of the EEG data for this participant.

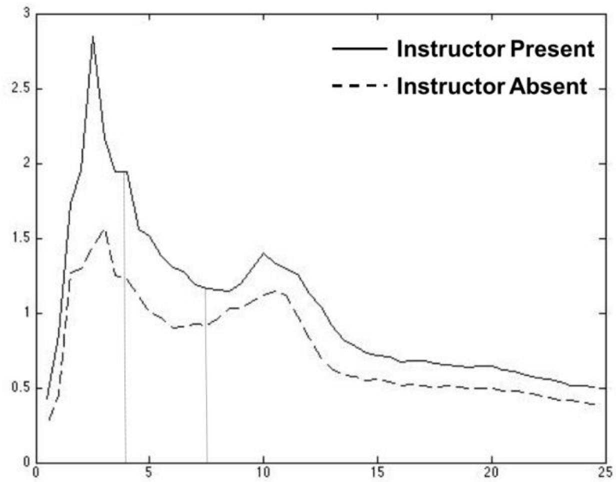


Figure 4-14. Participants' absolute power at C4 when instructor was present (solid line) and absent (perforated line) in the easy topic video. Theta wave is in the 4 - 8 Hz range indicated by the dotted vertical lines.

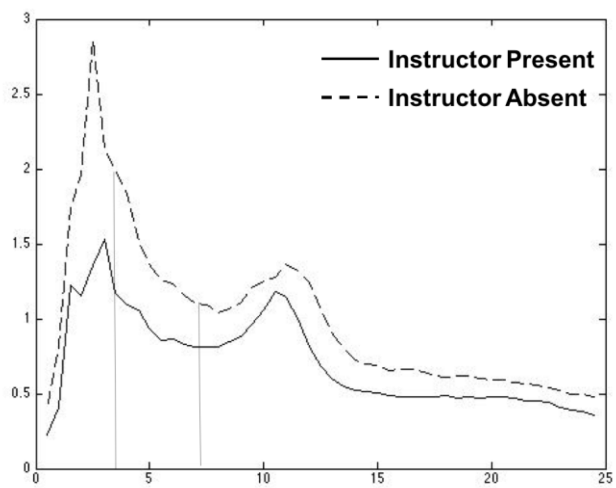


Figure 4-15. Participants' absolute power at C4 when instructor was present (solid line) and absent (perforated line) in the difficult topic video. Theta frequency band is in the 4 - 8 Hz indicated by the dotted vertical lines.

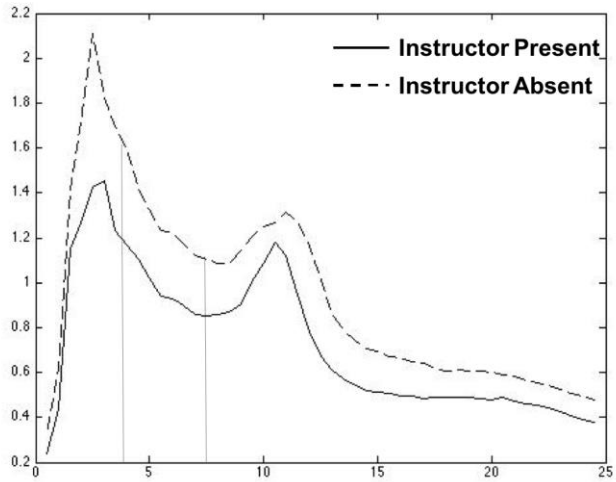


Figure 4-16. Participants' average absolute power at C3, C4, and Cz for the difficult topic video when instructor was present (solid line) and absent (perforated line). Theta frequency band is in the 4 - 8 Hz indicated by the dotted vertical lines.

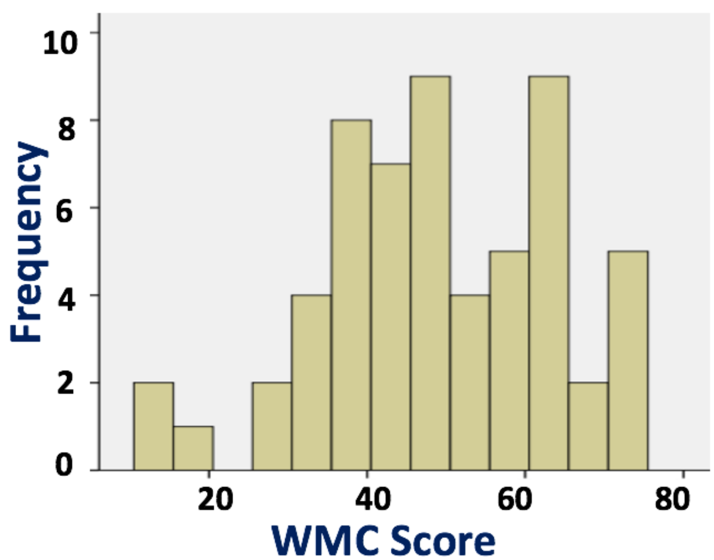


Figure 4-17. Distribution of participants' working memory capacity scores.

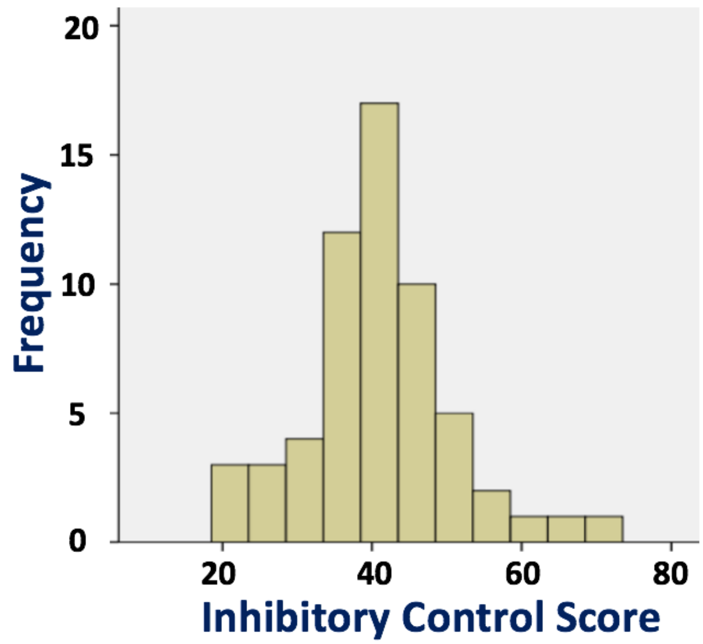


Figure 4-18. Distribution of participants’ inhibitory control scores.

CHAPTER 5
DISCUSSION

This chapter discusses the findings of the current study. I first discussed the findings with regard to the influences of instructor presence on learning, learner perceptions, visual attention distribution, and cognitive dynamics in easy and difficult topic videos. I also discussed the predictors of learning and learner perceptions (i.e., process measures such as visual attention distribution and cognitive dynamics) in easy and difficult topic videos with or without instructor presence. Next, I discussed the moderating effects of individual differences in working memory capacity and inhibitory control in easy and difficult topic videos when the instructor was present or absent.

Influences of Instructor Presence on Learning, Learner Perception, Visual Attention Distribution, and Cognitive Dynamics

The first goal of this study was to examine the influences of instructor presence on the products of learning (i.e., learning and learner perceptions) and processes of learning (i.e., visual attention distribution and cognitive dynamics) in easy and difficult topic videos respectively. The data generated from the product measures (i.e., learning and learner perception) showed that the instructor on the screen did not affect retention positively or negatively in either topic, but improved learners' ability to transfer information from the difficult topic. Regarding the influences on learner perceptions, instructor presence in the video produced a positive effect on learners' satisfaction and situational interest for both topics, and led to higher level of perceived learning for the difficult topic. Instructor presence helped lower the intrinsic load and the extraneous load for the difficult topic video while not influencing any type of cognitive load for the easy topic video. The instructor on the screen was largely perceived as helpful, entertaining, useful, engaging for both topics and a high percentage of participants preferred to see the instructor compared to not seeing it for both easy and difficult topic videos. Next, the findings based on the process measures (e.g., visual attention distribution) indicated that the instructor on the screen attracted significant amount of visual attention for both topics and when the instructor was present, less attention was distributed to the content interest area. Regarding cognitive dynamics, instructor presence led to higher theta power at C4 sensor for the easy topic video and lower theta power at C4 sensor for the difficult topic video.

Learning

In the current study, participants who viewed difficult topic video with the instructor present performed significantly better on the transfer test compared to those who viewed the instructor absent version video. A possible explanation for this result is that the instructor in this study used a variety of nonverbal communication means including mutual gaze, facial expressions, and gestures, which attracted a significant amount of participants' visual attention (i.e., 37% of total dwell time for the difficult topic video). As discussed in the introduction to this study, nonverbal cues are very important in everyday social interactions (Argyle, 2013) and in mathematics learning and instruction specifically (e.g., Alibali & Nathan, 2012). The nonverbal cues provided by the instructor in our study likely served an important signaling function (Mayer, 2014; Van Gog, 2014) and directed learners' attention to the most important and relevant aspects of the instructional content, thus resulting in improved comprehension of the difficult material and enhanced transfer performance. The finding regarding the positive influence on the transfer of information is aligned with the results of a previous study conducted by Chen and colleagues (2015). The researchers used an experimental design and compared the influence of three types of videos on learning document writing: voice over (instructor's video in the upper left corner of the screen), lecture capture (i.e., a video recording of the lecture) and picture-in-picture video that included an instructor frame in the bottom right-hand corner. The researchers found the transfer performance was improved by instructor presence, that is, participants who watched the video with instructor presence in either the picture-in-picture or the lecture capture format outperformed those who received the instruction in the voice-over format.

The finding from the current study provides empirical evidence for the assumption that the instructor in the video could help direct and possibly maintain learners' attention and keep them engaged in the cognitive processing of learning materials when the topic is difficult. However, the positive effect of instructor presence on transfer was not replicated in the case of the easy topic video. The nonverbal cues did not produce quite the same magnitude of effect for the easy topic video likely because learners had more cognitive resources at their disposal as they were learning easier content. So, it is reasonable to assume that in this situation, when the instructor was absent in the easy topic video, the transfer performance was already high considering the information was less difficult for learners. Therefore, it is possible that the ceiling effect prevented us from observing the additional benefits of instructor presence on transfer performance for the easy topic video.

In addition to transfer performance, the present study examined if instructor presence could help improve retention of information for the easy and difficult topic videos. However, the study did not identify any evidence that instructor presence enhanced retention of information for either topic. The finding is consistent with the study conducted by Kizilcec and colleagues (2014), who investigated how adding the instructor to instructional video influenced undergraduate and graduate students' learning on a topic in Organizational Sociology. Their findings indicated that learners who received the video instruction with instructor presence did not perform significantly better or worse on knowledge recall tests compared to the control condition without instructor presence. However, in another study that examined the influence of instructor presence on retention in easy and difficult topic videos (i.e., Similar Triangles and Trigonometry), Wang & Antonenko (2017) found that instructor presence helped improve participants' retention of information from the easy topic video. These mixed findings regarding the influence of instructor presence on retention of information can possibly be explained by the differences in the nature of materials and topics used in the videos.

Learner Perceptions

Unlike many studies that focus solely on learning outcomes (e.g., retention and transfer of information), the current study included measures of participants' perceptions of the efficacy of the educational intervention – that is, instructor presence – in instructional video. Participants' ratings on four types of cognitive load (i.e., overall load, intrinsic load, extraneous load, and germane load) suggested that in the difficult topic video, instructor presence helped lower participants' self-reported intrinsic load and extraneous load, although not affecting any type of cognitive load participants self-perceived for the easy topic video. Perceived learning, situational interest, and satisfaction scales, as well as participant responses to the open-ended questions indicated a strong preference for the videos with instructor presence for both easy and difficult topics. This is important because student perceptions moderate their experience with learning tools and materials and so it is important to understand where learners stand with regard to their preferences.

Cognitive load

In the present study, instructor presence was found to decrease self-reported intrinsic load and extraneous load for the difficult topic video, while not influencing any type of self-reported cognitive load for the easy topic video.

For the easy topic video, instructor presence did not increase or decrease any type of self-reported cognitive load, which included overall load (Paas, 1992), intrinsic load (Ayres, 2006), extraneous load (Cierniak, 2009), or germane load (Salomon, 1984). The result on overall load is consistent with the finding from Wang & Antonenko (2017), where participants who watched an easy topic video (i.e., Similar Triangle) with or without instructor presence reported the same level of overall load. Similar to the findings on retention and transfer of information for the easy topic video, instructor presence did not influence overall load, intrinsic load, extraneous load, or germane load. Based on the statistics regarding cognitive load for the easy topic video, it is reasonable to speculate the four types of cognitive load are relatively low for the easy topic video when the instructor was absent resulting in a floor effect (i.e., around 3 on 9-point Likert scales). So, this study failed to show that instructor presence decreased the already low cognitive load for the easy topic video.

For the difficult topic video, the findings showed that instructor presence did not affect participants' overall load or germane load. However, instructor presence was found to decrease self-reported intrinsic load and extraneous load. The finding is important as it points out the usefulness of instructor presence in lowering the intrinsic load of the content, especially when the content itself is difficult. The instructor on the screen helped the participants with little knowledge about the difficult topic in this study (i.e., Analysis of Variance) perceive a lower level of intrinsic load. A possible explanation for this outcome is that the instructor's non-verbal cues such as body language and facial expression were instrumental in making the content more understandable, and thus helping decrease the intrinsic load of the content. This explanation can also be corroborated by participants' responses to the open-ended question, **"**Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor**".** For example, one participant commented, "I liked being able to see him so that I could 'maintain' eye contact with him and watch his hand motions. These two factors aided in my comprehension of the material". Another two participants expressed the same feeling in their responses, "The instructor allowed me to fully understand the concept because he was present and his gestured helped remember the concept"; "Seeing the instructor definitely added a visual that helped me understand the lecture better than the video when he was not present."

Moreover, the extraneous load was lower when the instructor was present in the difficult topic video. This finding is quite interesting, as the instructor present video actually included additional information on the screen (i.e., the instructor) as compared to instructor absent version. This additional information, in turn, helped decrease the extraneous load participants perceived for the difficult topic video. Relevant information regarding this interesting finding was provided by participants' responses to the open-ended question, "Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor". For example, one participant pointed out that the instructor on the screen helped him/her focus on the material better, "Seeing the instructor helped me keep my focus on what I was learning. I think that if I didn't see him, I would not have been as focused on the material". So, it appears seeing the instructor on the screen helped at least some learners give their attention to the most important information on the screen, and avoid attending to extraneous components on the screen, thus lowering extraneous load.

Unlike most previous studies on instructor presence that just examined the overall load (e.g., Wang & Antonenko, 2017; Homer & Plass, 2008), the present study explored the influence of instructor presence on cognitive load in a more detailed manner. By examining three individual types of cognitive load (i.e., intrinsic load, extraneous load, and germane load), we were able to identify the positive influence of instructor presence on lowering extraneous load and intrinsic load for the difficult topic video. It is important that future research on instructor presence examines effects on different types of cognitive load, instead of merely gauging the overall load. Caution has to be exercised, however, because the extent to which the existing measures tap these different types of cognitive load still needs to be explored.

Satisfaction

The findings from the current study showed that participants reported significantly higher level of satisfaction when the instructor was present in both easy and difficult topic videos. The results of this study align with the findings of Wang & Antonenko (2017). In that study, undergraduate participants were assigned to watch two videos on an easy mathematics topic (Similar Triangles) and a difficult topic (Trigonometry), each with the instructor present or absent in a counter-balanced design. Their findings indicated the positive influence of instructor presence on participants' satisfaction with the two instructor present videos on an easy and a difficult topic.

The satisfaction results of this study echo the findings of Fredericksen and colleagues (2000), who reported that student-instructor interaction is the most significant factor that contributes to a higher level of satisfaction with the course. Similarly, empirical data on the affective aspects of animated pedagogical agents in multimedia learning suggests that learners tend to appreciate the “humanness” of agents, especially when the level of embodiment is high (e.g., Baylor & Kim, 2005; Kim & Baylor, 2016).

Perceived learning

Participants reported a significantly higher level of perceived learning when the instructor was present in the difficult topic. Interestingly, participants’ perceptions of learning were not correlated with their actual learning performance on either the retention or the transfer test. This result confirms findings from other relevant studies that tried to compare subjective, self-reported learning performance or judgments of learning with the results of objective learning tests. For example, in a study published in the journal *Science*, Karpicke & Blunt (2011) found that students could not accurately predict what learning strategy was the most effective for restudy for test. The strategy they identified in their metacognitive predictions (repeated study) was significantly less effective than retrieval practice, which resulted in the highest learning outcomes on recall and inference tests. Other relevant studies have reported the following problems with self-reports of learning: students typically overestimate how well they understand, fail to recognize their own states of impasse in problem solving, and persist with unproductive strategies (Anderson & Beal, 1995; Gobert, Sao Pedro, Baker, Toto & Montalvo, 2012; Markman, 1977; Stevens & Thadani, 2007). Thus, an unintended contribution of the present study is empirical evidence that individuals may not be able to provide reliable data regarding their own learning and that studies should not be designed to rely only on self-reported measures when it comes to assessing learning.

Situational interest

The findings from the present study indicated participants had significantly higher situational interest when the instructor was present in both the easy topic video and the difficult topic video. Generally, participants who watched the easy and difficult topic videos with instructor presence were willing to watch more videos like the ones they saw in the study. No previous studies on instructor presence measured participants' situational interest intent to watch more videos. This finding is important, as including the instructor in instructional video could help maintain participants' situational interest and potentially even result in longer-term changes to their situational interest in the autonomous and self-regulated online learning as a result of watching videos that they find engaging.

Social presence

The findings from the current study also indicated having an instructor on the screen contributed to participants' enhanced perception of the instructor's social presence, and this finding applied to both the easy and difficult topic videos. When the instructor was present in the videos, participants agreed more with the social presence statements such as "I felt like the instructor was in the same room as me", "I felt that the instructor was aware of my presence", "I felt that the instructor was present", and "I felt that the instructor remained focused on me throughout our interaction". Also, when the instructor was present, participants agreed less with the statement "I felt that the instructor was very detached in his interactions with me". The high level of perceived social presence when instructor was present could also help explain the enhanced perceived learning and satisfaction (Kizilcec et al., 2015).

In this study, videos with instructor presence elicited positive responses to the social presence statements from the participants, possibly due to the social cues in the instructor-present videos. The non-verbal social cues provided by the instructor such as gestures, mutual gaze, facial expressions, as well as the instructor's seamless interaction with the content likely contributed to an improved socio-emotional reaction in the learners (Bhat et al., 2015; Cui et al., 2013; Krämer & Bente, 2010) and thus elevated participants' perception of the instructor's social presence in the video. This explanation can also be corroborated by participants' response to the open-ended question that elicited their perception toward instructor presence. For example, one participant reported the usefulness of non-verbal cues, by saying, "I am able to see his hand movements and gestures, making it easier for me to maintain my focus and attention on what he is saying and I feel less distracted. It also helps me feel more connected and learn better than to try to follow along with a voice that I cannot see". Other participants positively commented on the social connection established by the instructor presence. One learner said, "Seeing the instructor gave a better connection between myself and the instructor, and therefore promoted more concentration on the topic and a better learning experience." The instructor presence was also found to make the learning experience resemble one that occurs in a classroom, based on two participants' responses: "The instructor on the screen made it feel more personal, and like I was sitting in a classroom learning from a teacher"; "When I saw the instructor, I felt like I was in a regular classroom. It helped me stay focused on the material as I saw the teacher and what he was pointing at."

Perceptions of instructor presence

Instructor presence was found in this study to have a significant positive effect on lowering two of the four cognitive load types, and increasing participants' perceived learning, satisfaction, and situational interest, all of which are essential factors that influence learning, engagement and interest (e.g., Bandura & Cervone, 1986; Kim, Kim, & Wachter, 2013). According to the responses to the two qualitative questions, participants thought the instructor was 'useful', 'helpful', 'engaging', and 'entertaining', for both the easy and difficult topic videos. Participants' positive perception of the instructor was also strengthened by participants' responses to the open-ended question, "Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor". Having said this, seeing the instructor was not unanimously preferred by all learners in our study. Although a high percentage of positive feelings toward the instructor was identified, a few participants thought the instructor was frustrating and distracting in both the easy and difficult topic videos and commented the instructor was unnecessary or they preferred not to see the instructor. Based on this finding, instructional video designers could consider providing the option of hiding the instructor in the video for whom instructor presence is not favorable, instead of offering a video of instructor in instructional videos to all learners.

Visual Attention Distribution Predicted Learner Perception

The current study is perhaps one of the first studies that used eye-tracking technology to explore the effect of instructor presence on visual attention distribution in instructional videos. Eye-tracking measures such as dwell time, fixation count, and number of transitions between areas of interest in the visual field were able to illustrate the attentional dynamics as the learners distributed attention between the content portion of the video and the picture-in-picture video of the instructor. In the current study, the instructor presence influenced participants' visual attention distribution in important ways, as evidenced by a relatively high percentage of fixation counts and dwell time on the instructor interest area, as compared to the instructor-absent version of the videos. Also, the content area received less attention when instructor was present. The findings on the considerable amount of attention to the instructor is consistent with the visual attention distribution data reported in previous studies, such as Wang & Antonenko (2017) and Kizilcec and colleagues (2015), both of which demonstrated that participants allocated significant amount of attention to the instructor on the screen. The high amount of visual attention given to the instructor can possibly be explained by the well-known finding that face relevant stimuli can assist people in seeking social cues such as gaze, facial expression, and so on, and so people are attracted to face as a source for important information that facilitates social interaction and communication (Farroni et al., 2005).

The current study also indicated that the more participants paid attention to the instructor on the screen, the more satisfied they were with the instructor-present videos. For instructor-present easy topic video, the fixation count on the instructor interest area positively predicted participants' satisfaction rating. And for the instructor-present difficult topic video, the percentage of fixation count and the percentage of dwell time on the instructor interest area significantly positively predicted participants' satisfaction rating with the video. The response to the open-ended question "Please explain what you think about seeing the instructor in the video, compared to not seeing the instructor" also indicated the relationship between visual attention allocation to the instructor and enhanced satisfaction. For example, one participant commented, "Seeing the instructor on the screen made it feel like he could actually see me. It made me pay attention more because it was as if he was watching me. Also, it made the video more entertaining and satisfying to watch".

This finding implies the visual attention instructor on the screen received from the learners played a significant role in enhancing participants' satisfaction with the video, and it suggests including instructor presence based on the fact that paying attention to the instructor on the screen predicts participants' satisfaction with the videos. The current study is the first study that identifies this relationship between visual attention given to the instructor and enhanced satisfaction with the video.

Cognitive Dynamics Predicted Learning

To our knowledge, the current study is the first study that examined the influence of instructor presence on EEG-based cognitive dynamics in instructional videos with and without instructor presence. Participants' brain wave activity was recorded while they viewed instructional videos on easy and difficult content. EEG findings from this study indicated that instructor presence led to significantly different cognitive dynamics (mainly manifested in the theta frequency band) in easy and difficult topic videos. The EEG data indicated that instructor present video resulted in higher theta power at C4 sensor compared to the instructor absent video for the easy topic; and for the difficult topic video, having the instructor on the screen decreased the theta power at C4 sensor among the participants, as compared to the instructor absent version of the video.

Theta activity is most prevalent when a person is cognitively engaged (Klimesch et al., 2005). It has been demonstrated that brain oscillations in the theta frequency band are involved in active maintenance and recall of working memory representations (Jensen & Tesche, 2002). Using different experimental paradigms in previous studies, theta activity has been found to be associated with cognitive load, that is, theta frequency band power increases as cognitive load increases (Gevins et al., 1998; Jensen & Tesche, 2002; Antonenko & Niederhauser, 2010; Kumar & Kumar, 2016). For example, Gevins and colleagues (1998) had eight participants perform high-, moderate-, and low-load working memory tasks, and found theta activity increased with increasing working memory load. In a subsequent study, Jensen and colleagues (2002) recorded neuromagnetic responses from 10 subjects performing the Sternberg task. Subjects were required to retain a list of 1, 3, 5 or 7 visually presented digits during a 3-s retention period. Similar finding was obtained, that is, activity in the theta frequency band increased parametrically with the number of items retained in working memory.

The findings from the current study showed theta frequency band power increased in the easy topic video when instructor was present, which could indicate an increase in working memory load when the instructor was present in the easy topic video. This study also showed that a process measure such as EEG-based cognitive dynamics can predict learning. For the easy topic video, theta power at F4 sensor and the average theta power at F3, F4, and Fz (i.e., three frontal lobe sensors) were both significant negative predictors of participants' retention test scores. In other words, participants who experienced higher increase in theta power in the frontal lobe exhibited lower scores on the retention test. It is possible the participants who watched the instructor-present easy topic video experienced higher extraneous cognitive load and thus poorer retention performance. Also, it needs to be pointed out the self-report cognitive load measure did not identify any difference in cognitive load when the instructor was present or absent in the easy topic video. Thus, cognitive dynamics measure based on theta EEG activity can be a more reliable measure of extraneous load, that is the type of cognitive load that hinders rather than facilitates learning.

On the other hand, theta frequency band power decreased in the difficult topic video when instructor was present, which could indicate a decrease in cognitive load when the instructor was present in the difficult topic video as compared to the version with instructor absent. It has also been found when the instructor was present in the difficult topic video, participants self-perceived a lower intrinsic load and extraneous load. The learning measure also indicated participants who watched the difficult topic video with instructor present performed better on the transfer test. It is possible that learners who watched the instructor-present difficult topic video experienced lower level of intrinsic load and extraneous load, which resulted in better transfer performance.

Taken together, for the easy topic video, instructor presence led to higher level of theta activity, which could be associated with higher cognitive load. Higher theta power in the frontal lobe was associated with poorer performance on the retention test for the easy topic. For the difficult topic, instructor presence resulted in lower theta power, which could be an indicator of lower cognitive load. Actually, participants reported lower intrinsic and extraneous cognitive load and they performed better on the transfer test when instructor was present in the difficult topic video. Based on these findings, cognitive dynamics based on EEG theta activity is a more reliable measure of cognitive load compared to self-report measure of cognitive load, and it is useful in helping us understand why learners end up with a higher or lower scores on the tests of learning (i.e., retention and transfer).

Moderating Effects of Individual Differences

The second goal of this study was to investigate the moderating effects of individual differences in working memory capacity and inhibitory control in easy and difficult topic videos when instructor was present or absent. Despite the hypotheses, the current study did not identify any moderating effects of individual differences in working memory capacity and inhibitory control on learner perceptions, visual attention distribution, or cognitive dynamics, in easy and difficult topic videos with or without instructor presence.

However, the working memory capacity score was found in this study to predict the retention test score for the easy topic. Participants with higher working memory capacity scores performed better on the retention test for the easy topic. Besides, the inhibitory control score was found to predict the transfer test scores for the difficult topic. People with higher inhibitory control scores outperformed those with lower inhibitory control scores on the transfer test for the difficult topic.

Working Memory Capacity Score Predicted Retention Performance

Working memory capacity influences one's ability to control attention (Conway & Engle, 1994). Despite the hypothesis, in this study, we did not identify any mediating effect of working memory capacity on learning and learner perception in instructional videos with and without instructor presence. Based on the eye-tracking data generated from the current study, we did not see that working memory capacity influenced participants' patterns of visuals attention distribution to the instructor interest area and content interest area, either by more attention to the instructor interest area or more transitions between the two interest areas (i.e., a proxy for split attention).

The findings from the current study indicated that working memory capacity score was a significant positive predictor of participants' retention test score for the easy topic video, controlling for instructor presence. From a Cognitive Theory of Multimedia Learning (CTML) perspective, successful multimedia learning requires three processes: selecting, organizing and integrating relevant information (Mayer, 2014). This study's results suggested that one or more of these processes may be more easily disrupted in learners with lower working memory capacity. In the current study, the participants were expected to maintain many conceptual information from the instructional videos, in order to do well on the retention tests. For example, the easy topic video focused on the terminology associated with experiments and observational studies, and conceptual information such as the definition of factor, level of treatment needed to be organized by the working memory and integrated with the long-term memory while participants watched the easy topic video. As a result, presenting lower working memory capacity learners with multiple sources of visual information in the instructional video may impair one or more of these essential processes, and therefore leading to a lower retention performance for the easy topic video.

This finding on the positive influence of working memory capacity on retention from instructional video is consistent with findings from at least two previous studies. Lusk and colleagues (2009) explored the influence of individual differences in working memory capacity on learning from a multimedia historical inquiry unit, in segmented or unsegmented condition. Data generated from the recall measure showed working memory capacity had a significant, positive effect on participants' recall scores in the unsegmented condition. Moreover, in the same study, the researchers found that segmentation of the unit specifically improved recall performance for participants with low working memory capacity score. Similarly, Sanchez & Wiley (2009) examined the influences of working memory capacity in learning from paginated text and non-paginated scrolling text. In their study, participants who varied in WMC read a complex illustrated text about ice age. Learning was measured by response to one free-recall question, "What causes ice age?". Results showed learners with higher working memory capacity outperformed lower-WMC individuals in the scrolling format and higher-WMC individuals learned equivalently across scrolling or paginated presentations, suggesting a resiliency to competing demands in the scrolling condition. So, it is reasonable to speculate that in the current study, participants with higher working memory capacity were better at processing information and organizing it into existing mental models, and thus excelled at recalling and recognizing more information from the easy topic video. To further explore this hypothesis, future studies can test if breaking down the video into smaller segments can improve retention of information among learners with lower working memory capacity, as compared to the unsegmented version of the video.

Inhibitory Control Score Predicted Transfer Performance

Inhibitory control represents the ability to selectively attend to relevant information and suppress attention to irrelevant stimuli while focusing on the task goal (Rothbart & Posner, 1985; Diamond, 2013). Despite the original hypothesis in the literature review, in the current study, we did not identify any mediating effect of inhibitory control on learning and learner perception in instructional videos with and without instructor presence. Based on the eye-tracking data generated from the current study, we did not see that inhibitory control influenced participants' patterns of visuals attention distribution to the instructor interest area and content interest area, either by more attention to the instructor interest area or more transitions between the two interest areas (i.e., a proxy for increased split attention).

Instead, data from the present study showed that inhibitory control ability significantly positively predicted participants' ability to transfer information for the difficult topic video, controlling for instructor presence. This finding is not very surprising, considering working memory capacity positively predicted retention performance for the easy topic video. It is likely that participants with higher inhibitory control used their cognitive resources more efficiently, thus resulting in enhanced comprehension of the difficult material, whereas learners with lower inhibitory control may have found it more challenging to process a high amount of complex information from the difficult topic video. Similar findings were obtained from a previous study conducted by Homer and Plass (2014), who investigated the interaction between instructional format and learner's ability in inhibitory control of attention among high school students. Participants were assigned to learn with a web-based simulation of an intrinsically complex topic (i.e., ideal gas law) that varied in instructional format (exploratory simulation or worked examples). In the simulation with worked examples, learners navigated the simulation by following step-by-step instructions provided by an expert. Results indicated that the exploratory simulation facilitated transfer for students with higher levels of inhibitory control whereas students with lower levels of inhibitory control benefited more from the guided simulation with worked examples in learning transfer.

The current study implies that learners with higher inhibitory control benefit more from the instructional video on difficult content. Thus, it is reasonable to hypothesize that inhibitory control is an important individual difference variable mediating college students' processing of information in an instructional video. Thus, additional instructional support can be provided to learners with lower inhibitory control to better facilitate the processing of complex information. For example, learners can be provided with some pre-training (Mayer et al., 2002) at the beginning of the video to assist the learners in the knowledge construction process. It is also suggested the videos can include visual cues to important concepts in the instructional video, which can serve as a cognitive guide in facilitating the learners in understanding the information (Mautone & Mayer, 2001).

Taken together, in the current study, learning from the instructional videos is significantly predicted by individual differences in working memory capacity and inhibitory control. Working memory capacity score was found to be a positive predictor of retention performance for the easy topic video while inhibitory control score positively predicted transfer performance for the difficult topic video. This study emphasized the importance of considering individual differences in working memory capacity and inhibitory control when designing instructional videos. The instructional videos are largely used by college students who vary in working memory capacity and inhibitory control. Thus, additional instructional support can be provided for learners who have low working memory capacity and inhibitory control, for example, segmenting the video into smaller units, in order to allow those learners to process the information in the instructional video more efficiently.

Implications

First, the study provided evidence that supports including the instructor in online instructional video. Instructor presence has been found to improve participants' transfer of information from the difficult topic video. Also, instructor presence enhanced participants' satisfaction, situational interest, perceived learning, and their perceptions toward instructor's social presence. Instructor presence was also found to lower self-reported intrinsic and extraneous load for the difficult topic video. The practical implication of the current study is that instructional video designers could consider including the instructor in instructional videos, especially for the videos that deal with difficult content. The practitioners also need to realize that merely including an instructor in the video will not necessarily produce the positive effects on learning and learner perception. Instructors in online videos should consider replicating the practices of the instructor in the current study, for example, delivering a sufficient amount of non-verbal cues such as facial expression, body gesture, and eye contact which help engage the learners. Future research could also test the efficacy of instructor presence in other subjects besides Statistics. It would also be useful to examine the effect of adaptive instructor presence, specifically when the instructor frame is presented not all of the time but only during the times when the instructor provided nonverbal cues and signaling can enhance the processing of learning content.

Second, individual differences in working memory capacity and inhibitory control have been found to affect learning from video. The practical implication is instructional videos can be designed to accommodate individual differences in working memory capacity and inhibitory control. To be specific, as processing information from the instructional video is more difficult for students who have low inhibitory control and working memory capacity, additional instructional support such as signaling and pre-training can be provided to these learners. Besides, in addition to working memory capacity, there are other cognitive differences that vary among learners that could have influenced participants' learning from instructional videos with instructor presence. As millions of learners representing a variety of individual differences use instructional videos today, it is also imperative to understand how learners with individual differences respond to instructor presence in instructional videos and learn with such videos and how the design of videos can be improved to accommodate the needs of a wider range of learners. Future research should consider examining the influence of other individual differences and examine how these individual difference variables impact learning from instructional videos. The findings will offer important information on how individual differences affect learning and provide implications for future personalized instructional videos based on learners' individual differences, not just their current knowledge of the content, which is a common practice with adaptive systems today.

Last but not least, neurocognitive and psychophysiological tools such as EEG and eye-tracking are useful in understanding the process of learning during watching an instructional video with or without instructor presence. An implication of the current study is that educational researchers can apply these neurocognitive and psychophysiological tools to multiple contexts of learning, including but not limited to instructional videos, to understand the underlying process of learning and better explain the outcome measures such as learning and learner perception. For future studies, it could also be helpful to investigate the cognitive dynamics on the temporal scale from the start of the video to the end, in order to explore the influence of instructor presence as time goes.

Limitations

There were certain limitations to the study design that may have influenced the reliability and generalizability of the findings. First, the study was conducted in a highly controlled lab setting with the use of an eye tracker, which could have influenced participants' viewing behavior. Second, the participants were told they would be tested on the materials after watching the videos, and this possibly increased their engagement with the video content. Moreover, the participants in the current study were not allowed to take notes or pause videos during the viewing session, which is not representative of authentic video viewing contexts. Lastly, the majority of the participants were female and the instructor in the video was a male. It is possible we will identify different findings on the influence of instructor presence if recruiting a higher percentage of male participants, or including a female instructor in the video among a group of female participants. Therefore, future studies could consider having a more balanced participant sample with males and females or designing video conditions that include both male and female instructors.

Conclusion

This study explored the influence of instructor presence on learning, learner perception, visual attention distribution, and cognitive dynamics, when viewing instructional videos at easy and difficult levels of content complexity. Findings suggest that while the picture-in-picture video of the instructor attracted significant levels of visual attention across the entire viewing session, instructor presence did not result in increased retention for easy or difficult learning content but increased transfer for difficult content. Moreover, instructor presence produced a significant positive effect on increasing participants' perceived learning, satisfaction, and situational interest, as well as lowering intrinsic load and extraneous load for the difficult topic video, all of which are essential factors that contribute to learner engagement in the autonomous and self-regulated online learning environment.

APPENDIX A
EASY TOPIC VIDEO DETAILS

Terminology associated with experiments and observational studies

- Experiment (e.g. compare effects of anti-depressants, compare effects of brand of gas, etc.)

  - ➢ A design in which the treatments are being actively imposed on the experimental units.

- Observational study (e.g. compare GPA's, compare starting salaries, etc.)

  - ➢ A design in which only the researcher only _____________ the response variable.

- Response variable (RV) – The response variable is the outcome of interest of a study.

- Explanatory variables (EV, a.k.a. factors) – The variables that we suspect affect the response variable.

- Levels – The levels are the subcategories of the factors.

- Treatments

- One factor: The levels and treatments are the same.

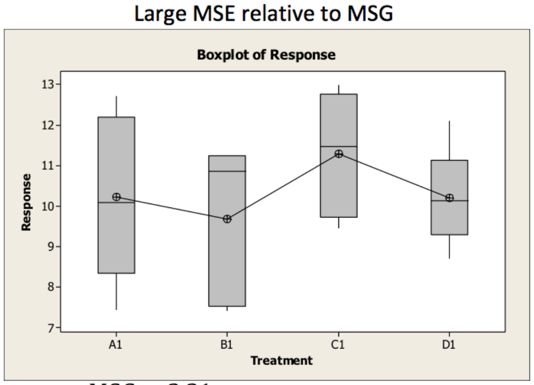
- Two factors: The treatments are the factor-level combinations.

- Subjects – The experimental units are the people or things in the study.

- Replications – The number of replications equals the number of times each treatment is being applied.

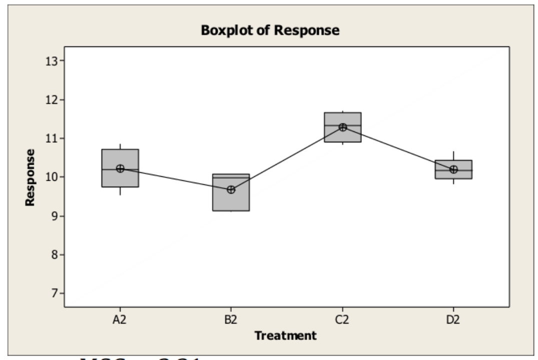
Rationale of the Analysis of Variance (ANOVA)

Large MSE relative to MSG



$$F = \frac{MSG}{MSE} = \frac{2.31}{3.01} = .77 \rightarrow p - value = .528$$

Small MSE relative to MSG



$$F = \frac{MSG}{MSE} = \frac{2.31}{.19} = 12.30 \rightarrow p - value = .000$$

If the variation BETWEEN the sample means (*MSG*) is

_____________________________ than the variation WITHIN each sample

(*MSE*), i.e. if $F = \frac{MSG}{MSE} \gg 1$, it implies that the population means significantly differ.

APPENDIX C
PRE-SCREENING SURVEY

What is your age?

_________ years old

I identify my gender as ________________

What is your undergraduate major (if declared)?

____

How do you identify your race/ethnicity?

- White/Caucasian
- Black/African-American
- Asian/Pacific Islander
- Native American
- Hispanic/Latino
- Other

Is English your first language?

- Yes
- No

Do you have normal or corrected to normal vision?

- Yes
- No

Do you have a history of brain trauma or neurological disorders?

- Yes
- No

Do you have autism?

- Yes
- No

Are you taking depression and anxiety medications or have you taken these medications in recent 3 months?

- Yes
- No

How familiar are you with terminology associated with experiments and observational studies on a scale of 1-5?

- 1: Not familiar at all
- 5: Very familiar

How familiar are you with Analysis of Variance (ANOVA) on a scale of 1-5?

- 1: Not familiar at all

- 5: Very familiar

APPENDIX D
LEARNING TESTS

<u>Easy topic - Terminology associated with experiments and observational studies</u>

<u>Retention questions:</u>

1. Which statement is true about an experiment?

A. In an experiment, the researcher observes a group of subjects without actually doing anything to the subjects

B. In an experiment, treatments are being actively imposed on the experimental units

C. In an experiment, no data is collected from the subjects

D. All of the above

E. I don’t know

2. Which statement is true about an observational study?

A. In an observational study, treatments are actively imposed on the experimental units

B. In an observational study, the researcher manipulates the subjects’ environment

C. In an observational study, the researcher only observes the experimental units and records the response variable

D. All of the above

E. I don’t know

3. What is the relationship between explanatory variable and response variable?

A. Response variable may affect explanatory variable

B. Explanatory variable may affect response variable

C. Explanatory variable and response variable are independent of each other

D. I don’t know

4. In an experiment with two explanatory variables, each explanatory variable is known as a ________.

A. Level

B. Factor

C. I don’t know

5. A researcher examined the influence of exercise (low, moderate, or high) on health score. How many treatment(s) does this study have?

A. 1

B. 2

C. 3

D. I don’t know

6. In an experiment, there are two explanatory variables and each explanatory variable has two subcategories. Each subcategory is known as a ________ of an explanatory variable.

A. Level

B. Factor

C. I don't know

The following set of questions (7-12) will focus on the following scenario:

A researcher examined the influence of diet (healthy or unhealthy) and exercise (low, moderate, or high) on health score. Ninety UF students were randomly assigned to each cell.

		Diet	
		Healthy	Unhealthy
Exercise	Low		
	Medium		
	High		

7. Specify the subjects of this study. UF students or 90 UF students

8. Specify the explanatory variable(s). Diet and exercise

9. Specify the response variable(s). Health score

10. Specify the number of levels for the factor(s). Diet has two levels and exercise has three levels.

11. Specify the number of treatments. 6

12. Specify the number of replications. 15

<u>Transfer questions:</u>

1. Students are randomly assigned to one of two statistics classes. One class was exposed to an applied hands-on approach, whereas the other one used a traditional lecture approach. The outcome consisted of scores on the final exam. This is an example of an ______ study.

A. Experimental

B. Observational

C. I don’t know

2. A study in California showed that students who learn a musical instrument have higher GPAs than students who do not, 3.59 to 2.91. Of the music students, 16% had all As, compared with only 5% among the students who did not learn a musical instrument. This is an example of an______ study.

A. Experimental

B. Observational

C. I don’t know

3. A researcher is curious if the number of hours spent doing homework has an effect on the grade students earn on an exam. In this case, the number of hours spent doing homework is the ______ variable, and the grade on the exam is the ______ variable.

A. explanatory; response

B. explanatory; explanatory

C. response; explanatory

D. response; response

E. I don't know

4. A researcher carried out an experimental study to examine the effectiveness of GRE prep programs (Powerscore or Kaplan) and the method of delivery (in person, online, or blended) on GRE verbal score. In the study, there are ____ factors.

A. 1

B. 2

C. 3

D. 6

E. I don't know

5. A researcher carried out an experimental study to examine the effectiveness of GRE prep programs (Powerscore or Kaplan) and the method of delivery (in person, online, or blended) on GRE verbal score. In the study, there are ____ treatments.

A. 1

B. 2

C. 3

D. 6

E. I don't know

<u>Difficult topic - Rationale of the ANOVA</u>

<u>Retention questions:</u>

1. What does ANOVA stand for?

A. Analysis of Variance

B. Analysis of Variation

C. Analyzing Ordinal Variation

D. At Northern Virginia

E. I don't know

2. The purpose of running a one-factor ANOVA on three groups is to _________.

A. Compare the means between three groups

B. Find the similarities between three groups

C. Characterize the overlapped portions between three groups

D. Find which two groups have different means

E. I don’t know

3. In a one-factor ANOVA of four samples, the null hypothesis asserts that

_________.

A. All the means are equal among the four groups

B. The means of two specific groups are equal

C. All the means are different among the four groups

D. At least one group mean is different from another group mean

E. I don’t know

4. In a one-factor ANOVA of four samples, the alternative hypothesis asserts that

_________.

A. All the means are equal among the four groups

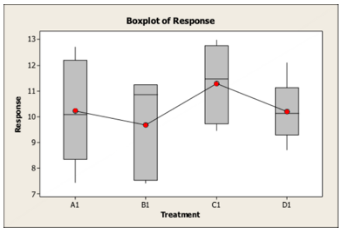
B. The means of two specific groups are equal

C. All the means are different among the four groups

D. At least one sample mean is different from another sample mean

E. I don’t know

5. The following plot shows the average weight loss of four different exercise programs. The way to decide the variation between the sample means is to _________.



A. Compare the means of each sample which are shown by the red dots on the bars

B. Examine the overlapping area of the bars

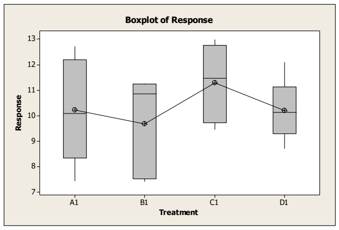
C. Compare the height of bars

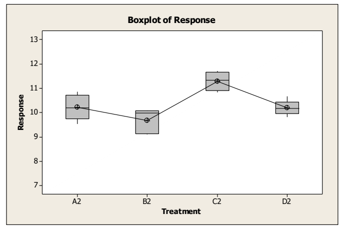
D. Compute the length of the connected line

E. I don’t know

6. The following two plots show the average weight loss of four different exercise programs. Which one of the following statements is true?

Plot A　　　　　　　　　　　　Plot B





A. The data in plot A have a higher variation within each sample

B. The data in plot B have a higher variation within each sample

C. The data in plot A and B have the same variation within each sample

D. Insufficient information to determine

E. I don't know

7. The *F* test statistic is defined as _________.

A. The variation between the sample means divided by the variation within each sample

B. The variation within each sample divided by the variation between the sample means

C. The variation between the sample means plus by the variation within each sample

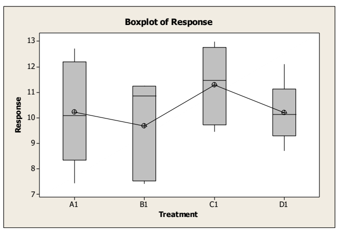
D. The variation between the sample means minus by the variation within each sample

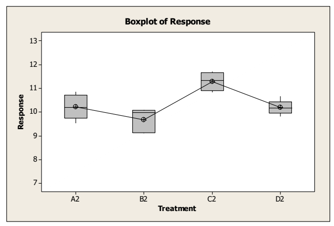
E. I don't know

8. The following two plots show the average weight loss of four different exercise programs. Assuming the variation between the sample means is the same for these two plots, which one of the following statements is true?

Plot A

Plot B





A. The data in plot A have a higher *F* test statistic than the data in plot B

B. The data in plot A have a lower *F* test statistic than the data in plot B

C. The data in plot A have the same *F* test statistic as the data in plot B

D. Insufficient information to determine

E. I don't know

Transfer questions:

1. When will a one-factor ANOVA be appropriate?

A. When assessing if three instructional methods are associated with different mean test scores

B. When assessing if students in grade levels 6, 7, and 8 have significantly different average reading comprehension levels

C. When assessing if different ethnicity groups display significant mean differences on the GRE quantitative section

D. All of the above

E. I don't know

2. Data for three samples (training program A, training program B, training program C) were analyzed using a one-factor ANOVA and the null hypothesis was rejected. Which one of the following statements is true?

A. The group mean of training program A is different from that of training program B

B. The group mean of training program B is different from that of training program C

C. The group means of training program A, B, and C are different from each other

D. At least one group mean is different from another group mean

E. I don't know

3. Data for three samples are analyzed using a one-factor ANOVA. If means of the three samples are equal, what is the value of the variation between the sample means?

A. 0

B. 1

C. 2

D. 3

E. I don't know

4. Which one of the following statements is true for the dataset below?

Student	Group	Grade (0-100)
1	A	25
2	A	76
3	A	42
4	A	95
	MEAN	59.5
5	B	92
6	B	25
7	B	46
8	B	75
	MEAN	59.5

A. There is a high variation within each sample, and no variation between the sample means

B. There is a high variation between the sample means, and no variation within each sample

C. There is a high variation between the sample means, and a high variation within each sample

D. There is a no variation between the sample means, and no variation within each sample

E. I don't know

5. Which one of the following statements is true for the dataset below?

Student	Group	Grade (0-100)
1	A	68
2	A	68
3	A	68
4	A	68
	MEAN	68
5	B	95
6	B	95
7	B	95
8	B	95
	MEAN	95

A. There is a high variation within each sample, and no variation between the sample means

B. There is a high variation between the sample means, and no variation within each sample

C. There is a high variation between the sample means, and a high variation within each sample

D. There is a no variation between the sample means, and no variation within each sample

E. I don’t know

APPENDIX E
LEARNER PERCEPTIONS SURVEY

1. In the video I just finished watching, I invested

1. very, very low mental effort / 2. very low mental effort / 3. low mental effort / 4. rather low mental effort / 5. neither low nor high mental effort / 6. rather high mental effort / 7. high mental effort/ 8. very high mental effort / 9. very, very high mental effort

2. The topics covered in the video I just finished watching was

1. very, very easy / 2. very easy / 3. easy / 4. Rather easy / 5. neither easy nor difficult / 6. rather difficult / 7. difficult / 8. very difficult / 9. very, very difficult

3. Learning from the video that I just finished watching was

1. very, very easy / 2. very easy / 3. easy / 4. Rather easy / 5. neither easy nor difficult / 6. rather difficult / 7. difficult / 8. very difficult / 9. very, very difficult

4. When watching this video, I concentrated

1. very, very little / 2. very little / 3. little / 4. Rather little / 5. neither little nor much / 6. rather much / 7. much / 8. very much / 9. very, very much

5. On a scale from 1 to 5, please indicate how much you have learned from the video

1. Did not learn anything; 5. Learned a great deal.

6. On a scale from 1 to 7, rate your satisfaction regarding the instructor presence in the video

1. Extremely dissatisfied; 7. Extremely satisfied.

For questions 7-12, please indicate how much you agree or disagree with each statement:

7. I am willing to watch more videos like this because it is exciting and relevant.

Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

8. I felt like the instructor was in the same room as me. Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

9. I felt that the instructor was very detached in his interactions with me. Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

10. I felt that the instructor was aware of my presence. Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

11. I felt that the instructor was present. Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

12. I felt that the instructor remained focused on me throughout our interaction.

Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

Question 13-14 apply to the video with instructor presence.

13. Please explain what you think about seeing the instructor in the video, compared to not seeing him.

____

____

____

14. Do you think the instructor in the video is _______ (Select all adjectives that apply)?

- Helpful
- Entertaining
- Useful
- Engaging
- Frustrating
- Distracting
- Annoying
- Other: ____________

APPENDIX F
INFORMED CONSENT

Protocol Title: Examining Influence of Instructor Presence in Instructional Videos: An Individual Difference Perspective

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study: The purpose of the study is to evaluate the influence of instructor presence in Study Edge™ instructional videos on learning, cognitive dynamics, visual attention distribution, and learner perceptions and also how these effects are moderated by individual differences such as working memory capacity and inhibitory control.

What you will be asked to do in the study: You will be first asked to complete two tasks that assess cognitive process such as WMC (via the Automated Operation Span task) and inhibitory control (Flanker Inhibitory Control and Attention test). You will be then asked to watch two Study Edge™ videos (Terminology associated with experiments and observational studies, and rationale of the ANOVA) with or without instructor present on the screen. The two videos last 8 minutes in total. After each video, you will respond to a few questions on your perceptions of the video and the instructor. While you watch the two videos, you will be asked to wear an electroencephalography (EEG) headset that records your brain activity. It doesn't require any additional skin preparation or applying conductive gel to the scalp or electrodes. The EEG equipment is non-invasive and has been used in multiple research studies in higher education and K-12 education settings. During the study, you will also rest your chin on a chin rest, and the researcher will collect eye movement data which will reveal where you focus on the screen. As you finish watching the two videos, you will respond to a learning test to assess your retention and transfer of knowledge.

Time required: Approximately 60 minutes.

Risks and Benefits: No risks are anticipated. While there are no direct benefits for you, the data collected may have significance for the design of Study Edge™ videos, which are used by thousands of students at the University of Florida.

Compensation: You will receive $15 for participating in this study.

Confidentiality: Your identity will be kept confidential to the extent provided by law. Your name will not be used in any report.

Voluntary participation: Your participation in this study is completely voluntary. There is no penalty for not participating.

Right to withdraw from the study: You have the right to withdraw from the study at any time without consequence. You do not have to answer any questions you do not want to answer.

Whom to contact if you have questions about the study:

Principal Investigator: Jiahui Wang, G518F Norman Hall, School of Teaching and Learning, University of Florida. Phone: 352-222-0636. Email: jwang01@ufl.edu

Whom to contact about your rights as a research participant in the study:

UFIRB Office, Box 112250, University of Florida, Gainesville, FL 32611-2250; ph 392-0433.

I have read the procedure outlined above. I voluntarily agree to participate in this study and have received a copy of this description.

Participant	Date	Researcher	Date

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BIOGRAPHICAL SKETCH

Jiahui Wang is a doctoral student and research fellow in curriculum and Instruction with emphasis on educational technology. She completed her bachelor's degree in elementary education with an emphasis on mathematics education at Ningbo University during 2008-2012 and Jiahui participated in an exchange program at the University of Wisconsin-Oshkosh during 2010-2011. She graduated from the University of Virginia in 2013 with a Master of Education degree in curriculum and instruction and she taught Chinese at elementary and secondary schools in Fairfax County, VA after graduation. During her Ph.D. study, Jiahui's research focused on learning technologies and cognition including multimedia and online learning, individual differences, and educational neuroscience.