Fall 2017

The Influence of Cognitive Load on Infotec Students Participating in Online Learning

Joe Price
Old Dominion University

THE INFLUENCE OF COGNITIVE LOAD ON INFOTEC STUDENTS PARTICIPATING IN ONLINE LEARNING

by

Joe Price

B.A. August 2014, Old Dominion University

A Research Paper Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

OCCUPATIONAL AND TECHNICAL STUDIES

OLD DOMINION UNIVERSITY
Fall 2017

Approved by:

SEPS 636 Instructor

ABSTRACT

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The theory of cognitive load has been developed to help educators, instructional designers, and developers of e-learning curriculum and materials, anticipate learning outcomes by fully understanding the cognitive capabilities and limitations of the learner. The theory is broad enough to be used in many educational environments because the focus is on making learning as effective and efficient as possible in regards to the human brain's ability to process information. By reducing the complexity of the information to be learned and the manipulatives used to produce understanding, the curriculum developer can focus their energies on producing lessons that are streamlined and geared to the way the human mind works best. Infotec, a computer training facility in Virginia Beach, Virginia has historically offered classes in a traditional face-to-face format. More recently, they have converted many of their classes into web only curriculum. After conducting these web-based courses they found that student's success rates and certification test scores had dropped.

The purpose of this study was to determine whether this format change had increased the cognitive load on the learner and to develop techniques which can be used to reduce cognitive load. The study divided students into three classroom environments; (Group I) traditional face-to-face, (Group II) web-based with e-book, and (Group III) web-based with e-book and dual computer monitors. The identical curriculum was delivered to all three groups. Traditional

methods of reducing cognitive load such as using “worked examples” and reducing the redundancy of materials seemed to have a similar ameliorative effect on all groups. Methods for reducing split attention cognitive load were conducted using Group III. Cognitive load seems to have increased slightly for male participants in Group II, using a single monitor and e-book with online instruction. The data demonstrates that there was a tangible increase in cognitive load in female participants in Group II. Reducing the split-attention effect using multiple computer monitors produced a minor positive effect on males within Group III, but seemed to have a significant positive effect on female participants of the same group. As part of the study, instructors also recorded communication frequency to determine if students in e-learning environments have similar communication regularity as traditional face-to-face instruction. Results showed a slight reduction in communication for individuals participating in online learning environments.

In conclusion, results showed that the format change to a web-based learning environment at the Infotec Information Technology (IT) training school increased the cognitive load on the students. According to the results of the survey used in the study, as well as the certification exam scores, the increase in cognitive load seems to be more profound in female participants than their male counterparts. Furthermore, results showed that using a dual computer monitor in the e-learning environment helps to reduce cognitive load, and the use of dual monitors seems to have had a greater ameliorative effect on female participants.

Keywords: Cognitive Load Theory, e-Learning, Use of Dual Computer Monitors

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CHAPTER I:
INTRODUCTION

The world of education has changed dramatically with the advancement of online instructional technology. In the past, students who needed formal education were forced to find a school that was in close driving proximity, often limiting the field of study that they could pursue. As Thomas and Cunningham have explained, "Many non-traditional students work full-time in addition to having to juggle the demands of family, find time to attend class, and prepare assignments. Distance learning is education that is accessible at a time, place, location, and pace that is convenient to the user. The most commonly used distance education tool would be e-learning (online) courses" (Thomas & Cunningham, 2002).

As improvements in technology occurred, educational institutions began to explore various ways to use the technology to promote learning. Electronic books were developed as well as learning management systems (LMS) such as Blackboard, Moodle, and Instructure. These systems were often used for asymmetric communication between the student and teacher. The instructor could load PowerPoint lectures, syllabi, as well as assignments into the LMS for the students to find. The students could submit their assignments by loading attachments into the LMS. As technology and bandwidth capabilities expanded the opportunities for real-time, synchronous communication, educational institutions began to adopt new methods of delivering information and training. Web training tools such as Instructure, GoToMeeting, and WebEx were employed to teach students a variety of fields of study regardless of the student location. Students encountered a portal that allowed them to interact with their teacher by voice, video, and chat communication methods (Codone, 2001). They could also research topics online with search engines and by perusing their e-book. Students were confronted with a myriad of media to manipulate in order to learn and interact with their instructor and fellow students.

Statement of the Problem

Infotec, an information training school in Virginia Beach recently made a large portion of their classes available completely online with the use of tools such as WebEx, Instructure, and other online resources such as e-books and online simulations. After months of conducting these courses, instructors and administrators identified a noticeable decline in test scores and certifications achieved. Administrators were concerned that the new technology was adding to the cognitive load of the students. The concern was that the many varied online tools were more of a distraction and not organized in a way that was actually conducive to learning. The administration's desire was to find if cognitive load increased with the use of the new media, as well as to identify strategies that may reduce the cognitive load on the students leading to better test scores and higher frequency of certification success.

Purpose of the Study

The purpose of this study was to evaluate the impact of cognitive load on students involved in newly introduced e-learning courses at the Infotec Information Technology (IT) training school. Students in these courses have produced lower test scores than individuals participating in the same course in a more traditional setting.

Research Questions

To guide this study, the following objectives were developed, targeted to e-learning courses at the Infotec IT training school:

1. Does the medium of e-learning introduce unique cognitive load problems?
2. What portion of the educational experience is most impacted by increases in cognitive load?

3. What strategies can be employed in e-learning programs to reduce cognitive load on the student?
4. Does e-learning increase cognitive load by decreasing formal and informal communication?

Hypothesis Statements:

Null: Cognitive load is no different between students in a traditional curriculum and an e-learning based curriculum.

Alternate (Research): Cognitive load is greater in students enrolled in an e-learning based curriculum compared to students enrolled in a traditional curriculum.

Background and Significance

Understanding the effects of cognitive load on students using e-learning is important in order to understand the challenges that students face. Infotec is an instructional organization that provides technical certifications to thousands of civilian and military students. The initial outcome of incorporating online technology in course delivery at Infotec resulted in a significant reduction in student test scores and passing certifications.

The Computer Technology Industry Association (CompTIA) is an organization that provides certification in the IT field. CompTIA is highly respected as one of the top IT associations in the industry. In order to achieve a CompTIA A+ certification, a student must score a 675 on the first certification exam and a 700 on the second certification exam. In the traditional (brick and mortar) classes conducted at the training facility nearly 85% of participants achieved certification by passing both exams. After conducting the same courses using WebEx,

Instructure, and with the use of e-books the certification scores dropped by nearly 35 points for the first exam and 25 points for second exam, and there was a 15% reduction in students achieving certification success. This study will focus on the first week certification exam which is often regarded as the "hardware" section of the certification. It should be noted that about 35%- 50% of the second week curriculum is redundant information covered during the first certification exam.

It is imperative to evaluate the different online platforms that are available in order to identify the technology that allows for both efficient use, and student success (Plass, 2010). As more technology emerges for students to incorporate into the learning, functions regarding cognitive load should be analyzed to ensure that the new technology will not become a hindrance to acquiring necessary information (Sweller, 2006).

Limitations

This research was confined to traditional students, as well as online students that are using WebEx, Instructure, and other online media in the completion of their course activities at Infotec learning centers. Further, CompTIA A+ certifications scores were used to test the significance of cognitive load on the students. All of the research was conducted at the training facility at Virginia Beach, VA.

Assumptions

The students who seek certification in CompTIA A+ are individuals who have generally spent more than two years in the IT field. The ages of such participants are generally between 20 and 50 years of age. These individuals have used troubleshooting methods to solve complex IT

problems and are skilled in using multi-tasking strategies to solve computer related issues. These individuals have superior experience using computers, peripherals, and other input/output technologies.

Procedures

Three groups of students went through the course. Group I used traditional face-to face instructional resources. Group II used synchronous WebEx technology, an online learning management system, and an e-book. Group III used the same technology as Group II, but were also given the use of multiple computer monitors to determine if the use of an additional computer monitor reduced the cognitive load of the students. By adding a second computer monitor the student were able to view the e-book on one screen and follow the instructor lecture on the second screen. This reduced split-attention effect which can increase cognitive load on the students. Certification success were evaluated to determine if having multiple computer monitors on the students' desks reduce cognitive load and have a positive impact of achieving certification.

Another important factor addressed was to determine the most beneficial communication method to incorporate into the training environment. Good communication is seminal in developing collaboration and effective teacher to student feedback. Currently WebEx class communication is limited to WebEx chat and email. Face-to-face communication between the student and teacher is significantly less than in traditional classrooms. Group I used traditional face-to-face communication consistent with normal classroom procedures, email and chat were also available. Group II used traditional WebEx communication (chat and email) while Group III had their courses augmented by weekly discussion groups. Table 1 summarizes the specific

characteristics of each group in the study. The study was conducted to determine if augmenting the communication method resulted in a reduction of cognitive load and better student success.

Table 1:Experimental Conditions

Condition	**Group I**	**Group II**	**Group III**
Learning Environment	Traditional	Online (1 computer monitor)	Online (2 computer monitors)
Instruction Materials	Hardcopy manual	e-book	e-book
Communication Method	Traditional	WebEx	WebEx

Definition of Terms

Cognitive load theory (CLT) - The Instructional theory based on our knowledge of human cognitive abilities and the understanding that our ability to process information is limited. Educational tools that are complex add to the cognitive load of the student. Students spend mental resources understanding how to use poorly developed tools which interfere with their ability to understand the primary concepts.

Extraneous cognitive load - The load generated by the manner in which information is presented to learners.

Germane cognitive load - The load devoted to the processing, construction, and development of learning strategies.

Intrinsic cognitive load - The inherent level of difficulty associated with a specific instructional topic.

CompTIA A+ - The computer industry certification which validates the ability to evaluate, troubleshoot and correct computer and network problems.

Summary and Overview

The purpose of the present study was to investigate the effects of cognitive load on students using an online learning format over those that had their course of study augmented with the use of multiple computer monitors and formal planned discussion sessions. Student success is of the utmost importance to the educators and staff at Infotec. The study was important to determine what level and method of online technologies is most conducive to CompTIA A+ certification success. The research will be used as a guide for Infotec to follow when instructing individuals who are involved in CompTIA A+ certification classes performed in the e-learning environment.

Chapter II will review literature about various topics related to human cognition, the three recognized forms of cognitive load, educational strategies for limiting cognitive load, using "worked examples" in the classroom, the impact of split-attention effect, e-learning curriculum and human-computer interaction. Chapter III details the methods and procedures used to collect the data required to complete the study. It describes the population, instrument and research design, survey instrument, as well as educational environments involved in the study. The relevant findings of the study are presented in Chapter IV. Chapter V summarizes the research, explores important conclusions, and provides recommendations for further research regarding e-learning and cognitive load.

CHAPTER II:
REVIEW OF LITERATURE

The purpose of this chapter is to review the literature related to cognitive load in an e-learning environment. The sections of this chapter include early works in cognitive ability, cognitive load theory, extraneous cognitive load, intrinsic cognitive load, germane cognitive load, split-attention effect, redundancy effect, cognitive load in e-learning, and human-computer interaction.

Early Works in Human Cognitive Ability

Understanding the human mind has been a focus for researchers in the fields of psychology and education for many decades. One element of examination has focused on the human cognitive ability to create memory. Research into the method of assimilating information by the human mind is critical in developing working models on which to base effective curriculum and instruction. William James was a one of America's preeminent philosophers and psychologists of the 19th century. He published a voluminous work of nearly twelve hundred pages regarding elements of the human mind. His focus on the minds "stream of consciousness" noted that unlike the nearly unlimited storage potential of the "secondary memory", the "primary memory" of the human mind was extremely volatile and temporal (James, 1890). Arguably, the seminal work regarding temporary memory was published by the cognitive psychologist George Miller. In a series of tests, Miller found that the average participant could maintain a limited capacity of seven chunks of information at a given time. This held true regardless of whether the individuals were asked to remember numbers, letters, or words. In his writings, he described the ability for individuals to remember seven plus or minus two as the channel capacity of the

participants. Miller stated, “The channel capacity is the upper limit on the extent to which the observer can match his responses to the stimuli we give him” (Miller, 1956, p. 126).

Richard Atkinson and Richard Shiffrin further developed the traditional view of short term memory in an article that proposed a theoretical concept known as the “Modal Model”. They initially described a two-step process where incoming stimuli is converted into long term memory. The authors later adjusted their model to include a third, initial stage to the memory process. The research described a process whereby information passes through several structurally unique storage devices (Atkinson & Shiffrin, 1968). In further research, the authors noted that without artificial memory practices, including rehearsal and acoustic encoding the average individual had a short-term memory capacity of fifteen to thirty seconds (Atkinson & Shiffrin, 1971).

Cognitive Load Theory

Cognitive Load Theory (Sweller, 1988) was a concept that was developed to understand how memory and its limited capacity could be understood in regards to effective educational procedures and practices. The term short-term memory was found to be insufficient in that its focus was related to the time that information could be temporarily understood; however, the term did not connote the methods or structures used to process this temporary information into long term memory. The term “working memory” was adopted to help focus the study on developing further research and methods to promote long term memory.

Extraneous Cognitive Load

Initial research regarding cognitive load was primarily focused on the instructional methods that were being used to transfer knowledge (Sweller, 1988). Many lessons were observed using problem solving techniques. Students were asked to look at a particular scenario and with the use of manipulatives, solve the particular concern. Sweller found that the students were very often so focused on using the manipulatives to fix the particular problem that they did not develop higher level thinking skills. Often the students focus was so dedicated to the means of instruction that the larger purpose of the activity was lost. They were able to come up with a solution, which was the goal of the immediate task, but they were not able to produce schema acquisition, which was the goal of the instruction. The concern of extraneous cognitive load is to prevent the method of instruction from getting in the way of producing learning. A modern example of creating extraneous cognitive load would be the use of overly complex e-learning tools where the learner spends more mental effort understanding the tool rather than learning the concepts from the tool itself (Asraj, Freeman & Chandler, 2011). Developers who are concerned with producing efficient instruction will design instructional materials to reduce the working memory of the students. Research in this area has shown that "learning is enhanced when learners attend to schema acquisition" (Sweller, 1990, p. 47). Additional research has found that instead of using problem solving scenarios, or means-ends analysis, using problems that have been previously "worked out" helps reduce extraneous cognitive load (Renkl & Atkinson, 2010).

Intrinsic Cognitive Load

As additional research was developed in regards to cognitive load and instruction, an added feature to the theory was included. Researchers found that many tasks require integrating

and synthesizing multiple concepts at once. The complexity of the material itself added to the cognitive load of the student. This intrinsic load is, "imposed by the basic characteristics of the information" (Sweller, 1994, p.86.). Young students learning to read experience high intrinsic cognitive load because they have not created an automated reading practice. Each syllable and letter needs to be recognized. After recognizing the letter the student needs to recall the phonemic sound that the letter makes. The student then needs to blend this sound with other existing letters and sounds in the target word, while maintaining memory of what the previous words meant to produce a logical thought. Clark et al. (2006) have defined intrinsic cognitive load (ICL) as "the mental work imposed by the complexity of the content" (p. 9). Designers who are transmitting complex concepts to their students should count the layers of complexities involved in understanding the information. Intrinsic load is not only the number of complex ideas that must be processed by working memory, but it also involves the prior knowledge of the student. If prior knowledge is low and complexity of materials is high than the student may experience an enormous intrinsic cognitive load. "E-learning tools cannot be identified by only analyzing the complexity of the material itself. Element interactivity can be determined by the number of interacting elements that a learner is required to understand" (Sweller & Chandler 1994, p 164).

Germane Cognitive Load

The main focus of cognitive load theory has historically been on reducing the extraneous and intrinsic load that the students are confronted with, in order to reduce the tasks in working memory. An article in the late nineties began to focus the attention of producing instructional design strategies that promoted schema building (Sweller, Van Merriënboer & Paas, 1998).

Unlike other previous cognitive load elements, germane load is seen as having a positive effect on learning acquisition because it is devoted to manipulating cognitive resources in order to create schema acquisition. It involves the process of constructing and storing schemas in long-term memory. Germane Cognitive Load (GCL) is concerned with the building and automation of schema development.

Educational Strategies for Reducing Cognitive Load

Understanding the theory of cognitive load is an important precursor to developing strategies that can be incorporated in the classroom to reduce cognitive load theory and promote schema development. Much research has been developed to formulate techniques which help students learn efficiently as possible. A discussion of those techniques follows.

Split Attention Effect

Chandler and Sweller (1994) provided evidence that cognitive load increases as students are required to use multiple sources or pages to understand or solve a given problem. This scenario is often common in science and mathematics education. Students are required to read a problem statement and also look at graphical representation of the problem. Only after reading and interpreting both items can the student begin to form a hypothesis as to the reason behind the problem and possible resolutions. This creates a split attention effect in solving for the formula or scenario. This split-attention promotes cognition that is geared to remembering page numbers, labels, and terms, but does not help to form a solution. Cerpa, Chandler and Sweller (1996) have found that reducing the complexity of the materials produces less cognitive load. Materials that display both the word problem and the graph on the same page produce less split attention effect on the learner. By redesigning instructional methods and materials learners can

focus their attention on the problem they are trying to resolve, and less on handling the media and manipulatives. Students who are inexperienced in an e-learning atmosphere learn about the educational content at the same time they are learning about delivery technologies. This may put much pressure on students (Clarke et al., 2005).

Worked Example Effect

Traditional methods of teaching science, technology, and mathematics have incorporated a simple linear technique. An instructor often begins the lesson by introducing principles and concepts. The instructor will subsequently demonstrate examples and scenarios where these principles are in play. Lastly, the instructor will provide opportunities for the students to work on practice activities that follow closely with the worked examples. Sweller and Cooper (1985; Cooper & Sweller, 1987) conducted pivotal research which found that learners could inculcate more knowledge by working out multiple examples than they were by trying to perform practice examples on their own. This "worked-out example effect" was much more efficient because it required less examples and explanations and led to better problem-solving skills. By analyzing multiple worked-out examples the students were able to see patterns that they could use in other scenarios. The student spent less time trying to build strategies to solve the problem and learned solid troubleshooting skills that could be used on future endeavors.

Redundancy Effect

Much research has been conducted to develop strategies for reducing extraneous load with the goal of increasing germane load for schema development. Research studies performed by Seufert and Brunkin (2006) found that in many occasions more resources were provided to the learners than was necessary. The research found that the recent focus on student learning

styles has created a superfluous amount of varying resources for the students to access. By providing instruction that caters to visual, kinesthetic, social, verbal, auditory and solitary learning styles, the learner is often inundated with multiple sources of information. This "redundancy effect" creates a flood of information and increases cognitive load. Well-formulated graphical images have little need for large textual explanations. Similarly, well-crafted textual instructions may have no need for graphical representations. The research tends to imply that designers of instruction should focus more attention on the effectiveness of the instructional media and less on the learning styles of the students. Redundancy is often critical with e-learning instructional formats. Integrated formats should be effective at reducing cognitive load due to split-attention when dealing with multiple sources of information that cannot be understood in isolation. However, if multiple sources of information can be understood in isolation, it decreases the cognitive load (Yeung et al., 1998).

Multimedia Instruction

Multimedia instruction which is often computer-based has a unique potential to challenge and inform the learner in new and exciting formats. Multimedia instruction may incorporate any combination of animation, text, video, photos, audio, or illustrations. Research has found that learners use separate channels to process visual materials and auditory materials (Baddeley, 1999) and they have a limited capacity of information that they can process in a given time (Chandler & Sweller, 1991). In order for learning to take place an individual needs to actively process the incoming information in a way that separates essential information from non-essential (Mayer, 2001). The most common extraneous force of cognitive load in multimedia is using materials which are poorly designed or do not use iterative or logical progression. This

forces the learner to expend cognitive resources on information that is not conducive to schema development. Managing essential cognitive processing focuses the cognitive resources of the learner on processing important information. Presenting multimedia instruction which is complex, or fast paced creates, a processing overload to the student.

E-Learning Curriculum

E-learning instruction provides for the availability of using text, video, and audio in a way that is unique to other forms of instructional media. Morrison and Anglin (2005) found that the fundamental concern with e-learning and cognitive load is creating an environment for the learner that is efficient and readily accessible. Designers of e-learning create curriculum often months before a learner begins to experience the instruction. In traditional classrooms, a student who is overwhelmed or confused can meet with the instructor for clarification after the class session. In an e-learning environment, learners may not be able to reach the instructor via any synchronous manner. The halting effect on learning in this scenario can lead to frustration and confusion as to the objectives and goals of the curriculum. Strategies have been developed by Mayer (2003) to identify the best use of this technology in regards to reducing the cognitive load effect in students. Some of the concepts to reduce cognitive load include breaking the content down into smaller segments which can allow the learner to control the pace of instruction, eliminating any non-essential content that could increase extraneous load, and using media that can easily be used together. Designers who force a student to follow multiple links over a given time should instead place the information in a format that can be seen and explored from one location.

Researchers have found that using total e-learning solutions in the field of human anatomy courses have led to poor understanding of primary task cognitive load requirements. Students tended to spend greater effort and time trying to understand how to use the commercial anatomy e-learning tools than focusing on the proper methodologies involved in manipulating and treating the needs of the *patient* (Van Nuland & Rogers, 2016). The use of multiple online manipulatives produced confounding variables which forced the educators to repeat instructions on the use of the technology which compromised their ability to focus on the educational topic.

Interactivity between a student and an educator is an important aspect of delivering information, probing for knowledge, providing productive feedback, and producing positive intrinsic motivations. Research by Slava Kalyuga (2006) found that extraneous load can be placed upon the online student based on the manner in which online communication takes place. On many e-learning formats there are both audio and video being displayed from the instructor, in addition there are areas when you can view the webcams of other students, as well as a chat feature that can be used to ask questions of fellow students or of the instructor. This format, if not well designed can add to the split-attention effect on the student. The poor design of the e-learning platform may force students to observe concurrent changes that are taking place in different locations on the screen. This may force the students to process overwhelming amounts of information from different sources, identify and prioritize the most important sources of information, while maintaining focus on the appropriate educational topic being addressed. Through exhaustive research, Kalyuga (2006) was able to produce recommendations that would be beneficial to explore in creating efficient online learning that “better match the nature of human cognition” (p. 212).

Cognitive Load Theory and Human Computer Interaction

Cognitive load theory and human-computer interaction (HCI) are factors in determining the efficacy of teaching individuals using a computer-based system. All learning tools should factor in the ease at which they can be used by a student during learning, but Mogamat Davis' (2013) research has found a limited amount of exploration involving the fields of human-computer interaction and cognitive load. HCI tries to reduce extraneous load by instituting computer-based designs in the form of usability strategies. The research conducted was in response to computer-based technologies that were created to help teach online medical students using Adobe Flash. Multiple usability measures were employed to collect both objective and subjective responses. User satisfaction questionnaires, Likert scale questions were used to determine the overall functionality of the e-learning curriculum. The researcher further evaluated the learning product using information regarding the average "time on task" as well as mouse activity, and tests of recall and transfer of knowledge. The results of the study allowed the developers to provide recommendations for creating effective e-learning. They recommend evaluating and optimizing the usability of the technology at beginning of the design process. Creating user friendly e-learning is an iterative process that should be assessed and re-assessed at every stage of development using both subjective and objective methods. The researchers "design-test-redesign model" can be used to make the e-learning experience more intuitive and user friendly (Dick & Carey, 2015).

Summary

The human mind has a limiting processing power in regard to working memory. Cognitive Load Theory identifies this constraint and practitioners of the theory have tried to identify design and instructional strategies that resolve this human condition. E-learning environments may delay learning if the instructional design does not manage or account for increased cognitive demands. To be effective, e-learning designs should balance an interactive and interesting environment with manageable mental effort levels. This is may be more difficult to achieve in distance learning because often the instruction is preformatted, and the designers may have very little control over the learner insight and learning processes. Often, there is a gap between how the course materials are being used, what designers expect to happen in a course, the usefulness of the material and the actual opinion of learners (Martens et al., 2007). Designers of instruction need to ensure that topics are chunked and delivered in a way that promotes schema acquisition. E-learning curriculum designers need to develop training methods that are intuitive for students and designed with awareness of the limits of human cognition. Effective training techniques would more easily be produced if instructional developers were cognizant of the different types of cognitive load that can be created through poor instructional tools and methodologies.

CHAPTER III:
METHODOLOGY

The purpose of this study was to examine the impact of cognitive load on students involved in newly introduced e-learning courses at the Infotec training school. The investigation was formed to evaluate whether cognitive loads are introduced into the classroom experience by delivering content in a solely electronic format. The study evaluates e-learning as a means of knowledge acquisition by going beyond traditional extraneous and intrinsic load examination to explore the ability to use efficient learning techniques to increase germane cognitive load. Specifically, it investigated the application of cognitive load theory (CLT) to the design of instruction, particularly by restructuring aspects of the introduced online courses in the school in order as to reduce split-attention effects.

This methodology chapter discusses the research design, target population, sample type to be used, instructional materials to be used in delivering the online courses, instrumentation method chosen for the research, data collection methods and procedures, and analysis procedures for the data to be collected during the study.

Population

The target population for this research were students involved in newly introduced e-learning courses at the Infotec Information Technology (IT) training school. The typical student in these courses have produced lower test scores than individuals participating in the same course in a more traditional setting. The target students were enrolled in online courses offered by the school's department of technology as they use Web training tools such as Instructure, and WebEx.

Students have different motivations for signing up for Information Technology (IT) classes at Infotec. Many of the students that take the CompTIA A+ course are individuals in the military that either need the certification to continue in their current position or to enhance their career. These individuals have both extrinsic motivations from their supervisor as well as intrinsic motivation to enhance and continue their IT career. Other individuals that often participate in the CompTIA A+ course are people who are funded by Opportunity Inc. Opportunity Inc. is an organization that helps individuals with a history of chronic unemployment. Often times these individuals have had past experience working with computers and in the IT area, but their skills have become outdated due to changing technology and their lack of continuous work experience. In order to ensure that the results of the study were valid it was important that all participants in the study have similar levels of IT skills. A Likert scale survey was produced to ensure that none of the individuals involved in the study had more than 5 years of IT experience or rated themselves "proficient" or higher on questions regarding network installation, network troubleshooting, or computer repair on the Likert scale.

Additionally, random selection and random assignment were both considered in this research in order to make sure that the design fulfills the following requirements: First, random selection was taken into consideration with the application of a cluster sampling procedure as it helped ensure that each class in the defined student population had an equal possibility of being picked to participate in the study. Secondly, the random assignment of classes was achieved through computer-generated random numbers. Random sampling was produced via Microsoft Excel "What-if" sampling add in. The results helped the education staff to determine the class roster for each session.

Instrument Design

The first segment of the study was conducted with the control group (Group I) using traditional training methods. All of the students were located in the Virginia Beach training center. Each student was given access to the Instructure learning management system (LMS). The LMS is a portal that allows the students to see computer schematics, pictures, graphs, and review questions. The LMS also has unit exams that test the students' knowledge of the topics that have been covered in class. In addition to the LMS, the students were given a hard copy training manual. The students in the traditional classroom had face-to-face access to the instructor during the entire week for communication purposes. The students were encouraged to ask questions during the day as well as after-hours via email or chat.

The second segment of the study was conducted in an online, synchronous format using WebEx. The instructor was located in Virginia Beach and the students (Group II) viewed the course in a training facility in Richmond, VA. Each student was given access to the Instructure LMS. In addition to the LMS the students were given an e-book of the training manual. This e-book was identical to the hard copy version of the training manual. The students were encouraged to use the chat feature in WebEx in order to ask questions of the instructor.

The third segment of the study was conducted over the web using WebEx. The instructor was located in Virginia Beach and the students were viewing the course in a training facility in Richmond, VA. Each student was given access to the Instructure LMS. In addition to the LMS the students were given an e-book of the training manual. These students (Group III) were also given a dual monitor setup and were instructed on how they could have the e-book open in one

monitor while viewing the WebEx course on a separate monitor. The students were encouraged to use the chat feature in WebEx in order to ask questions of the instructor.

Research Design

The study applied a quasi-experimental design that is commonly known as the post-test-only control group design. According to Burkes (2007, p. 19), "this design controls for history, maturation, testing, instrumentation, statistical regression, differential selection, and interaction of selection and maturation as sources for internal validity." By exploring findings related to Sweller's (1988) cognitive load theory, this study was designed to give understanding into cognitive load as a way of designing suitable instructional means for online students.

Traditional classes, WebEx with e-book, and WebEx with dual computer monitors for e-book were split into three groups of instruction. The post-test-only control group design involved the act of contrasting of experimental groups versus a control group. The experimental groups in this study were required to participate in a modified instructional lesson, whereas the control groups engaged in a non-modified instructional lesson. In each case, the groups were subjected to a survey and post-test in order to evaluate knowledge gained from incorporating cognitive load theory (CLT) strategies. A Likert survey with a scale of 1-7 was provided after the class sessions had culminated. Lower results on the Likert scale (1-3) indicated difficulty in using the resources provided, while higher scores (5-7) reflected the ease with which the students could manipulate and manage their educational resources.

Similarly, the study design was based on the qualitative post-test control group format. A pool of participants with similar skills were used for sampling to ensure that the students participating in each group of instruction consisted of similar demographics and skills set. A

random assignment of participants for both experimental and control group were developed. The quantitative post-test control group format combines the benefit of random assignment of the participants within the control group composition, demonstrates a formal method of investigation of CLT treatments and learning achievement, and offers a process by which important analysis can occur. A pre-test was not utilized. Yen, Chen, Lai, Su and Chuang (2015) investigated a work connected to pre-test sensitization and response-shift bias, which indicated that a pre-test can reduce internal validity through the introduction of a carryover effect when participants recall their answers given during the pre-test experimentation.

By using three methods of instruction: traditional, e-learning with e-book, and e-learning with e-book and multiple monitors, the study's goal was to determine which method of instruction wass more conducive to learning and how CLT can be utilized successfully. Infotec has years of data regarding examination success with a traditional format. Each classroom method involved participation in a survey, post-tests provided by the instructor, as well as the certification tests administered by CompTIA proctors.

Statistical Analysis

To guide this study, the following research questions were developed: Does the medium of e-learning introduce unique cognitive load problems? What portion of the educational experience is most impacted by increases in cognitive load? What strategies can be employed in e-learning programs to reduce cognitive load on the student? Does e-learning increase cognitive load by decreasing formal and informal communication?

The students were selected from the school population through a cluster sampling method. Groups of students were assembled rather than to pick students individually from the school population. The population of Group I consisted of fourteen students, nine males and five female students. Group II included twelve students, eight males and four female participants and Group III consisted of eleven students, seven males and four females. This research explored the use of independent sample *t* tests with low levels of alpha values. The research analysis was set the alpha level at .05.

Instructional Methods and Materials for the Study

The importance of having a controlled environment when conducting research methods cannot be overstated. In order to eliminate variances regarding teaching methods and strategies, one instructor was utilized for the entire experiment. The educational psychology theory of encoding specificity states that individuals that learn in a particular environment are more successful if they are tested in the same environment in which they learned the material. Goldstein states that humans, "encode information along with its environmental context" (Goldstein, 2011, p.184). In order to eliminate any variables regarding encoding specificity the final certification exam was conducted in the classroom in which the students learned the material. A PearsonVue mobile testing server was utilized in order to turn the students' classrooms into a temporary testing center.

The CompTIA A+ certification consists of two certification exams. The first course deals with computer hardware, troubleshooting, and introduction to networking. The second course covers more advanced topics on hardware, software, and advanced networking technologies. The instructor's teaching location was at the Infotec training office at Virginia Beach, VA.

LMS module test scores were recorded for the traditional, WebEx with e-book, and WebEx with e-book and dual monitor sessions of instruction. The scores were analyzed using measures of central tendency to determine any statistical difference between the different groups.

The training consists of four days of curriculum, and on day five all of the students take the CompTIA A+ certification exam. A passing score on the certification exam is a 675. These certification scores were analyzed according to the educational resources and strategies that were deployed during the course to determine if any trends or recommendations can be determined.

Split-Attention Effect

Under split-attention circumstances, students may experience higher levels of cognitive load as they are asked to manipulate the WebEx online media for lecture, the LMS website for quizzes and articles, and the e-book in order to view the graphs and tables used during the lecture. Instead of physically incorporating different amounts and types of sources of information, learning may be expedited by the use of multiple monitors. Multiple monitors were used by certain groups of students to eliminate the use of a traditional book, or toggling from the WebEx lecture portal to the e-book.

Data Collection Tools

The method of data collection used in this study were surveys distributed to members of Groups I, II and III, See Appendix A for survey document. This study used online and hardcopy surveys administered to all the students participating in the different segments of the study.

Surveys helped to identify the best approach for planning future courses of instruction. They also helped in creating a basis for decision making activities and finding the most effective

way to implement educational programs in the future. A Likert scale was developed to determine how participants prefer to communicate with their instructor, as well as what format of instruction best meets their educational training needs.

Data Collection Procedure

During the study, a post-test-only design was used to evaluate student cognitive performance. The participants enrolled in each section were asked to fill out a survey of the course. Partaking of the study was voluntary, and there was no extra benefit given participants. Taking the questionnaires and surveys required every participant's informed consent (see Appendix B).

Data Analysis

According to Spriestersbach et al. (2009), descriptive statistics are a vital part of biometric analysis. They are necessary for the understanding of further statistical analysis, as well as the drawing of conclusions. Descriptive statistics were computed to digest and describe the data sampled from the participants. A computerized survey form was established so as to assess groups representing differing demographic data, content knowledge, and mental effort in terms of correct and incorrect answers. The data was used to determine if altering course design with effective technology would promote more efficient knowledge acquisition.

An ANOVA was used to assess whether the mean scores of the three groups were statistically different from one another. A *t* test was used to assess whether mean scores were significantly different between males and females.

Summary

Cognitive load is an important aspect of designing online education. In order to develop standards for future classes, Infotec will focus much energy in analyzing current practices and developing new techniques to allow their students to learn in the most efficient educational environment possible. This chapter discussed the research design, target population sample, instructional materials for the study, instrumentation method, data collection procedure, and data analysis procedures used for the study.

The methods and procedures to conduct the study were assessed by the Old Dominion University College of Education Human Subjects Review Committee (see Appendix C for the letter of Determination of Exempt Status). Chapter IV presents the findings of the study.

CHAPTER IV:
FINDINGS

After course completion, Groups I-III participated in a voluntary survey. A Likert survey with a scale of 1-7 was provided after the class sessions had culminated. Lower results on the Likert scale (1-3) indicated difficulty in using the resources provided, while higher scores (5-7) reflected the ease with which the students could manipulate and manage their educational resources. The survey questions were calculated according to three categories: ease of use, the ability to maintain focus, and the ability to manage the educational resources. For example, question 4, “The use of multiple monitors is likely to create more errors in my work” was calculated in the Ease of Use category. Whereas question 5, “Focusing on two monitors as well as the instructor strained my eyes" was calculated using the Ability to Maintain Focus category. Group I survey information was used to provide a baseline as to the normal amount of cognitive load associated with traditional class settings. Group II, consisting of students using traditional online resources (1 monitor and e-book), survey results were compared to Group III which were given an additional monitor, e-book, as well as additional mediation strategies. Table 2 provides a description of the participants of each group. Table 2 shows the gender demographics for each experimental group (data collected is included in Appendix D).

Table 2: Description of Groups I-III

Group I Traditional face-to-face environment		**Group II Online environment with e-book and a single computer monitor**		**Group III Online environment with e-book and dual computer monitors**	
Male - 9	**Female - 5**	**Male - 8**	**Female - 4**	**Male - 7**	**Female – 4**

Data Analysis and Results

Research question 1 asked, “Does the medium of e-learning introduce unique cognitive load problems?” Likewise, research question 2 asked, “What portion of the educational experience is most impacted by increases in cognitive load?” Participants were asked to judge their ability to understand, maintain focus, and stay on pace with the instructor using their specific educational resources.

Table 3 presents descriptive statistics, mean and standard deviation (SD), of each response item used in the survey for the three groups. For the response on ease of use, the respondents in Group I (traditional) had a mean M = 4.57 (SD = 0.51), Group II had mean M = 3.45 (SD = 0.68) and respondents in Group III reported a mean M = 5.82 (SD = 0.75). Because the data had three groups, an ANOVA test was used for analysis. The ANOVA test was conducted to test the significance of differences in mean scores across the three groups. In order for an ANOVA test to be considered valid, the variance between the groups evaluated need to be similar, or nearly homogenous. To test the similarity of the variances a Levene’s test is necessary. A Levene’s test assesses the equivalence of variances for a given variable for calculations of two or more groups. Results of Levene’s test indicated that the variance of the respondents scores were indeed similar across the three groups ($p = .771$) therefore, the question of similarity of variance was satisfied. Results of the ANOVA test indicated that the null hypothesis of no significant difference in mean score across groups must be rejected at .05 level of significance. This would indicate that there was a significant difference between some, or all the groups. This shows a significant effect on group responses regarding the “ease of use” question. To find out which groups were different, Tukey’s post hoc test was carried out. Tukey’s post hoc comparisons test was performed to test the significance of difference of

different pairs of groups. Figure 1 displays the results of Tukey's test which indicated that Group III (online with e-book and 2 monitors) had significantly higher mean (M= 5.82) score in "ease of use" compared with both Group II and Group I. Group I (traditional) had a significantly higher mean (M = 4.57) compared to Group II. Therefore, it is concluded that with respect to "ease of use" questions Group III (online with e-book and 2 monitors) has the highest ease of use followed by Group I (traditional) with Group II (online with e-book) having the least ease of use.

Table 3:Responses to survey questions, values presented are mean ± standard deviation

	Group 1		**Group 2**		**Group 3**	
	Mean	SD	Mean	SD	Mean	SD
Ease of use	4.57	0.51	3.45	0.68	5.82	0.75
Ability of maintain focus on instructional content	5.79	0.43	4.73	0.47	5.64	0.67
Ability to manage educational resources	4.50	0.52	4.09	0.83	5.53	1.04

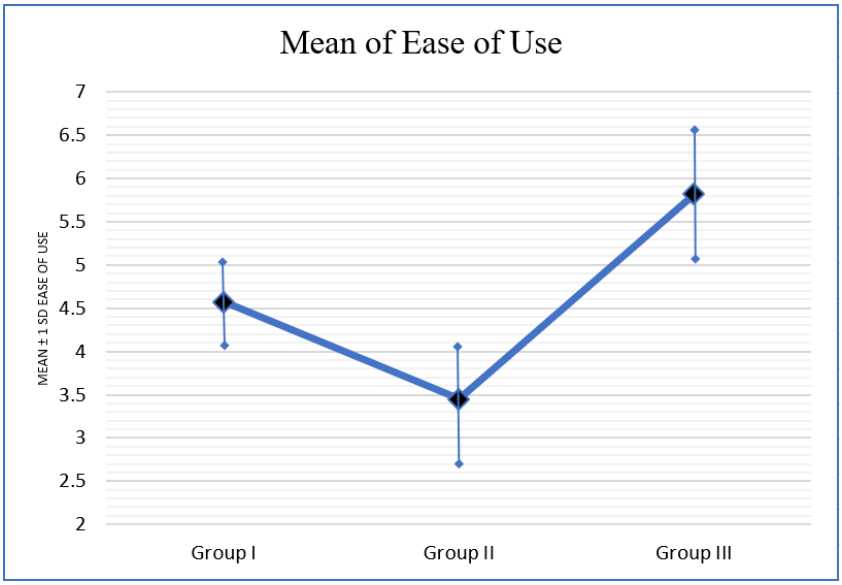

Figure 1: Means plot of Ease of use across Groups I-III, error bars indicate standard deviation.

For the questions regarding the ability to "focus on instructional content", the respondents in Group I (traditional) had a mean M = 5.79 (SD = 0.43), Group II had mean M = 4.73 (SD = 0.47) and individuals in Group III had a mean M = 5.64 (SD = 0.67). To test the significance of differences in mean scores across three groups, an ANOVA test was used. Results of Levene's test indicated that the variance of the response scores was the same across the three groups (p =.061). This indicated that the results variance between the groups is comparable. The ANOVA test indicated that the null hypothesis of no significant difference in mean score across the groups is to be rejected at .05 level of significance (p = <.001). This indicates that there is a significant effect of groups on responses regarding focus on instructional content. In order to test the significance of the difference group's responses, a Tukey's post hoc comparisons test was performed. Figure 2 displays the results of the Tukey's test, which indicated that Group II had significantly lower mean score (M = 4.73) on the questions of instructional material compared to both Group I and Group III. Group I and Group III did not show a significant difference in mean values. Therefore, it was concluded that with respect to focus on instructional material Group II has the least focus on instructional materials, while the traditional method (Group I) and online learning with two monitors and e-book (Group III) have a higher focus on instructional material.

For the response on ability to manage educational resources, the participants in Group I (traditional) had a mean of, M = 4.50 (SD = 052), Group II had a mean of, M = 4.09 (SD = 0.83) and respondents in Group 3 had a mean M = 5.53 (SD = 1.04). An ANOVA test was used to test the significance of difference in mean scores across three groups. Results of Levene's test indicated that the variance of the response scores is the same across three groups. Results of the

ANOVA test indicated that the null hypothesis of no significant difference in mean score across the groups must be rejected at .05 level of significance (p = <.001). This indicates that there is a significant effect on the responses concerning the ability to manage educational resources. Tukey's post hoc comparisons test was performed to test the degree of the difference of the groups. Figure 3 displays the results of Tukey's test which indicated that Group III had significantly higher mean score (M = 5.53) with respect to ability to manage educational resources compared to both Group I and Group II. Group I and Group II did not report any significant difference in means. It can safely be concluded that with respect to the ability to manage educational resources, Group III reports the highest ability to manage educational resources compared to other two methods.

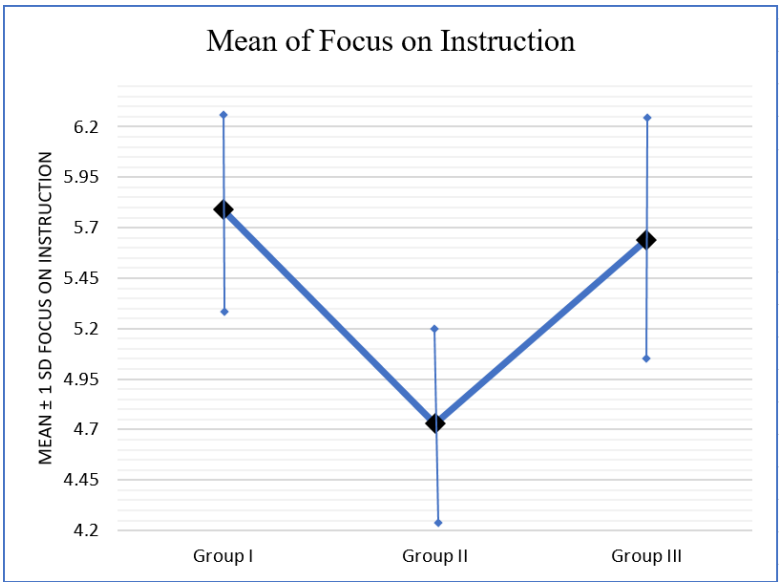

Figure 2: Means plot of Focus on Instructional Content across Groups I-III, error bars indicate standard deviation

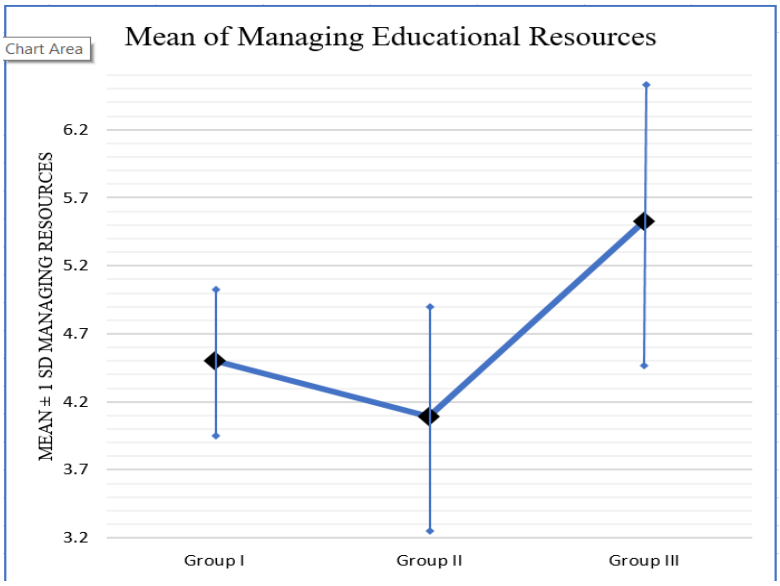

Figure 3: Means plot of Managing Educational Resource across Groups I-III, error bars indicate standard deviation.

Table 4 shows descriptive statistics of the responses to each survey item for males and females for each group along with summary of associated results of significance. Since the data is now split into two groups (males and females), a *t*-test was used to determine the significance of any variables. Levene's test was also used to test the assumption of equal variance of response between males and females.

Group I, for all three survey items (ease of use, focus on instructional content, and ability to manage educational resources), displayed no significant difference in variance of response between males and females. That is, the assumption of equal variance of response across males and female groups is satisfied. Results of independent samples *t*-test were not significant for all three survey items ($p = >.05$). This indicates that in Group I no significant effect of gender can be found with respect the participants responses to the survey.

Likewise, for Group II for all three survey items (ease of use, focus on instructional content, and ability to manage educational resources), no significant difference in variance of response between males and females was found (p = >.05). The results of independent samples *t*- test show no significant difference for all three survey items (p = >.05) between males and females. This indicates that in Group II no significant effect regarding gender can be found in the three survey items (ease of use, focus on instructional content, and ability to manage educational resources)

In Group III, for all three survey items (ease of use, focus on instructional content, and ability to manage educational resources), no significant difference in variance of response between males and females was reported (p = >.05). This proves the assumption of the similarity of variances of male and female respondents in Group III. Results of independent samples *t*-test report significant difference for responses regarding focus on instructional content and ability to manage educational resources. With respect to the ability to focus on instructional content, males reported mean M = 5.29 (SD = 0.488) and females reported mean M = 6.25 (SD = 0.50). Independent sample *t*-test results indicate that the null hypothesis of no significant difference in mean scores must be rejected at .05 level of significance. Findings show that females had a significantly higher perceived ability to focus on instructional content compared to males. With respect to the ability to manage educational resources, males reported mean M = 5.00 (SD = .816) and females reported mean M = 6.50 (SD = 0.577). Independent samples *t*-test results indicated that the null hypothesis of no significant difference in mean scores must be rejected at .05 level of significance. Accordingly, females had significantly higher perceived ability to manage educational resources compared to males.

Table 4:Comparison between Male and Female Groups for each Category of Question Across Groups I-III

		Gender	#of Participants	Mean ± SD	*t-values*
Group I	Ease of use	Male	9	4.56 ± 0.527	-.149
		Female	5	4.60 ± 0.548	
	Ability of focus on instructional content	Male	9	5.78 ± 0.441	-.090
		Female	5	5.80 ± 0.447	
	Ability to manage educational resources	Male	9	4.67 ± 0.500	1.732
		Female	5	4.20 ± 0.447	
Group 2	Ease of use	Male	8	3.29 ± 0.488	-1.087
		Female	4	3.75 ± 0.957	
	Ability of focus on instructional content	Male	8	4.71 ± 0.488	-.116
		Female	4	4.75 ± 0.500	
	Ability to manage educational resources	Male	8	4.14 ± 0.900	.261
		Female	4	4.00 ± 0.816	
Group 3	Ease of use	Male	7	5.57 ± 0.787	-1.537
		Female	4	6.25 ± 0.500	
	Ability of focus on instructional content	Male	7	5.29 ± 0.488	-3.127*
		Female	4	6.25 ± 0.500	
	Ability to manage educational resources	Male	7	5.00 ± 0.816	-3.211*
		Female	4	6.50 ± 0.577	

*Note: SD = standard deviation, *significant at .05 level*

Research question 3 asked, “What strategies can be employed in e-learning programs to reduce cognitive load on the student?” As mentioned previously the use of multiple monitors was incorporated into Group III curriculum. The goal of the research was to evaluate whether using multiple monitors and an e-book would reduce the split-attention effect within the students resulting in a reduction of cognitive load in comparison with Group II. Group II used a single monitor and an e-book. The survey results reflect a significant difference in the mean of Group II and Group III in relation to staying on task and maintaining a comfortable pace with the instructor.

An additional strategy employed was the use of “worked-out” examples to reduce the cognitive load in students performing after lesson activities and assessments. Previous research

has shown that students perform better at assessments and after lesson activities if an instructor first demonstrates how to perform a similar activity in front of the class. On the first day of the four-day training period, several activities were assigned to the students without any instructor interference. On day two, the instructor demonstrated "worked-out" examples for the students before they performed their activities. The after-course survey seemed to show that all groups believed that the "worked-out" examples allowed them to focus on their specific assignment without having to remember or memorize the steps necessary to complete them. As seen in Table 5, there was no significant difference in Group I or II, and only a slight increase in satisfaction in Group III.

Table 5: Worked-out examples (Likert scale 1-7, No effect to very effective)

Using Examples	Group I (Traditional)	Group II (Online, 1 Monitor, e-book)	Group III (Online, 2 Monitors, e-book)
	M ± SD	**M ± SD**	**M ± SD**
The instructor's use of "worked-out" examples reduced my anxiety in performing the assignment.	6 ± 0.352	5.5 ± 0.256	6.3 ± 0.325
The instructor's use of "worked-out" examples allowed me to focus on the steps to solve my problem.	7.1 ± 0.421	6 ± 0.227	6.7 ± 0.382

Note: SD = standard deviation

Research question 4 asked, "Does e-learning increase cognitive load by decreasing formal and informal communication?" One of the concerns of online education is the perceived reduction in communication between the student and instructor. As students focus on the medium of learning, informal communication may wane. This reduced communication can lead

to assignments not being fully understood of submitted at the appropriate time. During the study, the instructor was asked to track communication with the students of the three groups.

Instructure allows students to chat and send e-mail to the instructor at any time during or after a training session. According to the instructor's notes there was appreciable difference between the levels of communication between groups I-III. Group III were given an additional 10 minutes for discussion at the end of each day. As seen in Table 6, this strategy had no noteworthy effect on the quantity of communication between student and instructor.

Table 6: Communication log

Communication	Group I (Traditional)	Group II (Online, 1 Monitor, e-book)	Group III (Online, 2 Monitors, e-book)
Number of chat communications	8	4	5
Number of E-mail communication	10	7	8

The final review of Groups I-III was based on the successful completion of the CompTIA A+ certification exam. Table 7 denotes an 11% decrease in successfully passing the exam between Group I and Group II. Conversely, Group III shows a 10.2% increase in successfully passing the exam over Group II. The difference between Group I and Group III exam scores are negligible, see Appendix F for data on certification exam.

Table 7: CompTIA A+ Pass rates

General Population	Group I (Traditional)	Group II (Online, 1 Monitor)	Group III (Online, 2 Monitors)
CompTIA certification pass rate	77%	68%	75%

Summary

The findings of the study were obtained through student performance records on certification exams, communication logs, and survey instruments. Communication was found to be slightly less prevalent in online course environments. The use of CLT strategies involving worked-examples were beneficial to all groups of students. Reducing split-attention effect by adding an additional computer monitor had a significant effect on individuals in Group III, that is participants with e-book and dual monitors.

A noteworthy finding was the conclusion that females using multiple monitors had a higher level of satisfaction and ability to stay focused on training than those using a single monitor. Results of comparisons between male and female responses indicate that there was no significant difference in any of the three parameters in Groups I and II. However, in Group III significant differences between males and females were found regarding ability to focus on instructional content and ability to manage educational resources. The study shows that females had a significantly higher ability to focus on instructional content and manage educational resources compared to males in online environments with e-book and two computer monitors.

CHAPTER V:
CONCLUSIONS AND RECOMMENDATIONS

The importance in developing curriculum that reduces cognitive load in online education cannot be overstated. Many schools are now changing from an educational profile that was based primarily on traditional face-to-face courses, to curriculum that is predominantly web-based. University of Maryland-University College recently converted all of their curriculum to a web-based format. St. Leo University has recently abandoned the use of paper manuscripts and replaced them with 100% e-book offerings.

Results

Curriculum developers and education leaders need to be aware of the additional resources that online students need to master, as well as the effect online education has on communication between students and the professors. The results of the study tend to suggest that students using synchronous web-based educational tools experience a moderate increase of cognitive load over students who are involved in traditional classes. The increase does not appear to be severe, but any increase in cognitive load should be evaluated and addressed to determine if educational modifications should be implemented. According to the results of the survey, as well as the certification exam scores, the increase in cognitive load seems to be more profound in female participants than their male counterparts. Likewise, the use of dual monitors seems to have had a greater ameliorative effect on female participants.

A reduction in the quality and quantity of communication between student and professor can have a significant effect on the effectiveness of a course. The results of the study suggest

that informal communication is reduced in web-based curriculum. Communication method and frequency was recorded by the instructor for Groups I-III (see Appendix G for data). The records indicate that communication via email as well as chat communication decreased somewhat in Groups II and Group III. Communication before and after class and casual discussion about course topics were significantly reduced in the courses using online resources. Group III incorporated a formal discussion time at the end of each session. The results of this modification did not seem to have a significant effect on informal communication. The instructor noted that students seemed to participate in discussion sessions only minimally and participation increased only slightly as assignments and evaluations were on the horizon.

This research study had a total sample size of 37 with 14, 12, and 11 participants in each group. Additional research on the use of multiple computer monitors would be beneficial to determine if, as in the present study, cognitive load is reduced for students participating in online education. Studies using a larger sample size per group would be a great benefit to the literature of online learning and cognitive load theory.

Recommendations

Further research might be beneficial to determine if a method of communication could be used that would be more readily adopted by the students. Discussion assignments have often been used in online education with varying degrees of effectiveness. Additional research may be helpful to determine if there is an ideal method or rate of communication for successful completion of online classes. Research could be explored to identify if mandatory communication during the week between students and instructors would benefit the curriculum and create a classroom culture for individuals in distance and dispersed learning.

When instructors demonstrate to the students the requisite skills and steps to solve a problem, the student's cognitive load seems to be reduced when asked to perform similar tasks on their own. This concurs with research that demonstrates that worked examples reduce the amount of information that a student needs to recall to solve a given problem (Sweller, 1988). Further research should be conducted to determine the best way to incorporate "worked-examples" into online curriculum. It might benefit the online community to produce "worked-example" videos each of the courses being taught. This would allow the student to view the instructor demonstration before attempting to complete an assignment.

Summary

The study demonstrated that adding technology in the form of multiple computer monitors reduced the cognitive load in students learning in an online environment. Data suggests that the female participants benefited more profoundly with this intervention than male participants. The study also demonstrated that previous techniques in reducing cognitive load that have proven to work in traditional classroom environments also work in an online setting. The study illustrates that technology does not always simplify the educational experience, but the proper use of technology can create an environment that is comfortable, user-friendly and conducive to learning.

Education has undergone a transformation over the last several years. The push for more curriculum available to online students is an important trend that opens up educational opportunities for more individuals. Further research should be explored to ensure that educational online technology not only makes education more accessible, but also provides an efficient delivery system of information. It is important that as more students partake of this

opportunity that curriculum developers explore the most effective way to manage the online environment. Students in distance learning environments are often dispersed, and are asked to manage educational technology with little technical or educational support. Reducing the cognitive load in students should be the focus of online curriculum developers.

E-learning is an exciting delivery method that can be incorporated into Infotec's course offerings. It is a tool that can deliver efficient information to students who may not be able to access training in a traditional classroom format. Infotec should attempt to evaluate, and apply the study's suggestions for tailoring online content, presentation formats, and delivery features to their new e-learning courseware.

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Appendices

Appendix A

Educational Survey – Joe Price Old Dominion University

	Question	Completely Disagree	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree	Completely Agree
1.	Using a single monitor allowed me stay focused on my tasks.							
2.	Managing my educational resources and technology was difficult.							
3.	If given a choice, I would prefer to use a single monitor and hard copy manual in the future.							
4.	The use of multiple monitors is likely to create more errors in my work.							
5.	Focusing on two monitors as well as the instructor strained my eyes.							
6.	The use of multiple monitors made using my mouse and keyboard tools easier.							

7.	I feel I need more practice using the technology for it to really benefit me.							
8.	A training session on how to manage my resources would reduce confusion and increase efficiency.							
9.	I noticed a difference in the performance of the computer using multiple screens.							
10.	The use of multiple monitors made it more difficult to interact with the instructor.							
11.	The use of a single monitor made it more efficient to refer to and compare items.							
12.	The use of multiple monitors took up too much space for my liking.							
13.	Using multiple monitors allowed me stay focused on my tasks.							
14.	Using two monitors allowed me to view windows and applications in larger formats, which was more comfortable for my eyes.							
15.	The time spent juggling resources and scrolling across documents contributed to a loss of focus.							

16.	The technology used had no effect on my ability to remember the content of the lesson.							
17.	Short Answer (circle correct answers) In modern PCs, the procedure of replacing BIOS contents is sometimes referred to as: A) Hard boot B) Overclocking C) Flashing the BIOS D) Direct memory access (DMA)							
18.	Which Microsoft Windows OS utility can be used to view basic information about computer's BIOS? A) WINVER.EXE B) MSINFO32.EXE C) Control Panel D) SERVICES.MSC							
19.	After a normal system shutdown, when the computer is turned off, contents of the memory used to store BIOS settings are: A) Erased B) Retained C) Stored in a page file D) Saved on a hard drive							
20.	Which of the acronyms listed below refers to a series of basic hardware diagnostic tests performed by the startup BIOS after the computer is powered on? A) IDE B) POTS C) QoS D) POST							
21.	In order to work, an integrated component such as Network Interface Card (NIC) on a newly assembled computer system may need to be first: A) Enabled in Windows Control Panel							

22.	B) Updated with the latest driver in Device Manager C) Checked against the Hardware Compatibility List (HCL) D) Enabled in the advanced BIOS settings menu Please provide any suggestions to improve the educational experience with the technology provided:

Appendix B

OLD DOMINION UNIVERSITY

INFORMED CONSENT DOCUMENT

PROJECT TITLE: The Influence of Cognitive Load on Infotec Students Participating in Online Learning

INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in the research project "The Influence of Cognitive Load on Infotec Students Participating in Online Learning" and to record the consent of those who say YES.

RESEARCHERS

Dr. Karina Arcaute, Responsible Principal Investigator – Old Dominion University (ODU) – College of Education – STEM Education and Professional Studies Department
Joe Price, Investigator – ODU Master's candidate – Occupational and Technical Studies – STEM Education and Professional Studies Department

DESCRIPTION OF RESEARCH STUDY

Several studies have been conducted looking into the subject of Cognitive Load in Education. This study will determine if cognitive load is reduced for students using a second monitor and e-book as opposed to a traditional book and single monitor in a traditional or Webex classroom setting.

If you decide to participate, then you will join a study involving research of cognitive load in education for adult students. After training is completed a 10-15 question Likert scale and a 5-10 multiple choice question survey will be provided. If you say YES, then your participation will last for 5-10 minutes at the existing classroom. Approximately 50-75 of a similar population of students will be participating in this study.

EXCLUSIONARY CRITERIA

This research if voluntary and you should not feel pressure to participate.

RISKS AND BENEFITS

RISKS: If you decide to participate in this study, then you may find that the method of instruction (1 book one monitor, or e-book and 2 monitors) may have negative impact on recalling the content of the training. The researcher tried to reduce these risks by making participation voluntary. And, as with any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS: The main benefit to you for participating in this study is the ability to have both an e-book and traditional book after the study is complete. No other benefit is given or implied.

COSTS AND PAYMENTS

The researchers want your decision about participating in this study to be absolutely voluntary.

The researchers are unable to give you any payment for participating in this study.

NEW INFORMATION

If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY

All information obtained about you in this study is strictly confidential unless disclosure is required by law. The results of this study may be used in reports, presentations and publications, but the researcher will not identify you.

WITHDRAWAL PRIVILEGE

It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study -- at any time. Your decision will not affect your relationship with Infotec, or Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY

If you say yes, then your consent in this document does not waive any of your legal rights. However, in the event of any illness or injury arise from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participating in any research project, you may contact Dr. Karina Arcaute at (757) 683-4633 karcaute@odu.edu or Dr. Jill Stefaniak, the current IRB chair, at 757-683- 6696 or via email jstefani@odu.edu at Old Dominion University, who will be glad to review the matter with you.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**
Parent / Legally Authorized Representative's Printed Name & Signature (If applicable)	**Date**
Witness' Printed Name & Signature (if Applicable)	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws,

and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Jill Stefaniak at (757) 683-6696, or the Old Dominion University Office of Research, at 757-683-3460.

Appendix C

OLD DOMINION UNIVERSITY

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE:	August 15, 2017
TO:	Karina Arcaute, Ph.D.
FROM:	Old Dominion University Education Human Subjects Review Committee
PROJECT TITLE:	[1090166-1] The Influence of Cognitive Load on Infotec Students Participating in Online Learning
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	August 15, 2017
REVIEW CATEGORY:	Exemption category # *6.1*

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Jill Stefaniak at (757) 683-6696 or jstefani@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

Appendix D

	Question	**Group I (AVG)**		**Group II (AVG)**		**Group III (AVG)**	
		M	**SD**	**M**	**SD**	**M**	**SD**
1.	Using a single monitor allowed me stay focused on my tasks.	5	.32	4	.38	n/a	
2.	Managing my educational resources and technology was difficult.	3	.28	5	.32	2	.32
3.	If given a choice, I would prefer to use a single monitor and hard copy manual in the future.	4	.42	4	.28	3	.41
4.	The use of multiple monitors is likely to create more errors in my work.	4	.18	5	.36	3	.22
5.	Focusing on two monitors as well as the instructor strained my eyes.	n/a		n/a		2	.37
6.	The use of multiple monitors made using my mouse and keyboard tools easier.	n/a		n/a		6	.33
7.	I feel I need more practice using the technology for it to really benefit me.	3	.29	5	.31	3	.24

8.	A training session on how to manage my resources would reduce confusion and increase efficiency.	3	.34	5	.21	3	.18
9.	I noticed a difference in the performance of the computer using multiple screens.	n/a		n/a		6	.13
10.	The use of multiple monitors made it more difficult to interact with the instructor.	n/a		n/a		3	.25
11.	The use of a single monitor made it more efficient to refer to and compare items.	5	.31	3	.21	n/a	.31
12.	The use of multiple monitors took up too much space for my liking.	n/a		n/a		3	.29
13.	Using multiple monitors allowed me stay focused on my tasks.	n/a		n/a		6	.24
14.	Using two monitors allowed me to view windows and applications in larger formats, which was more comfortable for my eyes.	n/a		n/a		5	.26

15.	The time spent juggling resources and scrolling across documents contributed to a loss of focus.	3	.41	5	.34	3	.26
16.	The technology used had no effect on my ability to remember the content of the lesson.	4	.32	5	.24	3	.27
		Correct %	SD	Correct %	SD	Correct %	SD
17	Short Answer (circle correct answers) In modern PCs, the procedure of replacing BIOS contents is sometimes referred to as:	85	.14	82	.18	87	.24
18	Which Microsoft Windows OS utility can be used to view basic information about computer's BIOS?	75	.34	80	.31	86	.26
19	After a normal system shutdown, when the computer is turned off, contents of the memory used to store BIOS settings are:	88	.33	78	.23	84	.35

20	Which of the acronyms listed below refers to a series of basic hardware diagnostic tests performed by the startup BIOS after the computer is powered on?	82	.31	77	.26	84	.28
21	In order to work, an integrated component such as Network Interface Card (NIC) on a newly assembled computer system may need to be first:	78	.33	72	.28	84	.19
22	Please provide any suggestions to improve the educational experience with the technology provided:						

Note: SD = standard deviation

Appendix E

A+ Hardware Passing score = 675 Pass | Fail	Group I (Traditional)	Group II (Online, 1 Monitor)	Group III (Online, 2 Monitors)
CompTIA certification pass rate	**78.5%**	**66.6%**	**75.0%**
1. Student Score	700	680	665
2. Student Score	680	675	735
3. Student Score	650	680	720
4. Student Score	685	645	665
5. Student Score	730	685	710
6. Student Score	720	680	700
7. Student Score	645	700	725
8. Student Score	687	645	655
9. Student Score	665	658	680
10. Student Score	725	665	770
11. Student Score	755	650	775
12. Student Score	612	725	
13. Student Score	700		
14. Student Score	712		

Appendix F

Instructor record of Communication

	Group I	Group II	Group III
Informal (breaks and after class)	22	12	14
LMS Chat feature	3	5	4
Email	9	8	10