

Effective Use of Multimedia in Instructional Design

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Bill Bennett

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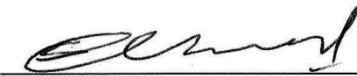
Approved by:



Cynthia Gautreau, EdD
Professor

5/2/11

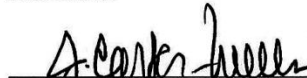
Date



Shariq Ahmed, M.S.
Lecturer

5/2/11

Date



JoAnn Carter-Wells, PhD
Professor

5-2-11

Date

Abstract

When it comes to the development of instructional technology “multimedia has been developed on the basis of its technological capacity, and rarely is it used according to research based principles” (Moreno & Mayer, 1999). In order to create effective and efficient learning objects, instructional designers (IDs) must be well versed in what knowledge, epistemology, and cognition are; and understand the ramifications of cognitive loads placed on short term memory by their multimedia instructional presentations. Instructional Designers must also consider that learners entering into a learning environment are extremely diverse in their existing knowledge base. In order for the appropriate instruction to be applied to each individual learner, a learner’s existing knowledge base must be identified in order to avoid applying instruction which might cause cognitive load problems which reduce the effectiveness and thereby the efficiency of the instruction. Taking into account cognitive load theory (CLT) research on the spatial-contiguity effect, the temporal-contiguity effect, the modality effect, the expertise reversal effect, and the redundancy effect, is an important part of being a successful modern-day instructional designer. With ever increasing media choices, now more than ever, in order for instructional designers to be able to optimize their instructional designs they need to be cognizant of all the variables that can result in either a positive or negative impact on a learner’s cognitive load in order to produce effective learning environments. An analysis of published research articles on the positive and negative effects of multimedia on cognitive load and how best to determine a learner’s existing knowledge base regarding a particular subject matter are the subjects of this literature review.

Acknowledgements and Dedication

I would like to thank my colleagues at Mt. San Jacinto College who have given me their friendship and support over the last decade. Thank you to the students who have made my teaching career an enjoyable and meaningful experience. Special thanks goes out to the team of professors from the California State University, Fullerton MSIDT program for their help and encouragement over the course of the past two years while this paper was being developed and written. Especially, Dr. Carter-Wells the MSIDT program coordinator for recognizing my potential and Jim Schools a fellow scholar of geekdom. I would also like to thank the members of the CSUF MSIDT Cohort #8 who took this journey with me and provided invaluable assistance during the numerous projects and assignments. It was an honor and a pleasure to work with each and every one of you.

I would like to dedicate this thesis to my mother and father who took the time to raise me to be inquisitive, organized, and to have a good work ethic; to my brother Tom who is a friend to the end; to my son Rob who warmed my heart during the tough times; to Mohammad Qamaruddin of CIT who has been like a second father to me and makes me believe in myself; to my lovely wife Karen, without her support, inspiration, patience, and encouragement this paper would not have been possible; and to Mary Payne the world's best proofreader and without whom Karen would not have been possible.

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CHAPTER ONE

According to Mayer (2011, p. vii), “the central mission of education is to help people learn.” Whether it be for education or training, the goal of an instructional designer is to design “plans for effective, efficient, and appealing instruction” (Moore, 2009, p. xii). “Well-designed educational programs take both human cognitive architecture and multimedia principles into account to ensure that learners will work in an environment that is goal-effective, efficient, and appealing” (van Merriënboer J. J., The four-component instructional design model, 2010).

One of the most influential learning theories in instructional design is the Cognitive Load Theory (CLT). CLT has been empirically researched for decades and provides instructional designers with many principles that help make instruction effective and efficient (Plass, Moreno, & Brücken, Cognitive load theory, 2010). Two more specialized theories which are aligned with CLT, the cognitive theory of multimedia learning (CTML) and the cognitive-affective theory of learning with media (CATLM) provide both complimentary and additional principles which help instructional designers make CLT-based decisions about how to design instructional presentations in the most effective and efficient manner possible (Mayer & Moreno, 2010; Moreno & Mayer, Techniques that increase generative processing in multimedia learning: Open questions for cognitive load research, 2010). Van Merriënboer’s (2002) four-component instructional design model provides a framework which incorporates CLT, CTML, and CATLM principles into a structured model for instructional designers to follow.

CTL is mainly concerned with four areas of the learning process, (a) the intrinsic load the concepts being presented have on a learner’s short term memory, (b) the extraneous load the selected methods of instruction place on the learner’s short-term memory, (c) increasing the germane load during instruction, and promoting effective and efficient transfer of learning. Although CTML, and CATLM generically organize multimedia into visual and auditory

modalities of presenting words and images, from the designer's perspective there are many methods and tools available for designing, developing, and implementing those words and images. Integrating them into a seamless fabric that is effective, efficient, and appealing is the challenge that all modern day instructional designers face.

Even after the instruction is implemented the designer's job is not complete, in order to evaluate an instructional design to determine if it is garnering the expected results, a valid and accurate assessment of the learner and the instructional methods being implemented must be applied and evaluated in order for the instructional presentation to evolve iteratively. Another consideration is that colleges and universities use a learning management system (LMS) as a prominent tool for student assessment, in order for any instructional implementation to be successfully integrated into the modern college's LMS it must be SCORM (Shareable Content Object Reference Model) compliant.

Research Question

The purpose of this thesis was to address the question: will an intelligent tutor, designed using cognitive load and multimedia principles using the 4C/ID framework and implemented via a SCORM compliant LMS, improve a learner's ability to learn and transfer complex learning tasks in college level information systems courses? In preparation for designing and developing the intelligent tutor and literature review the researcher investigated the history and evolution of several learning theories including cognitive load theory, cognitive theory of multimedia learning, and the cognitive-affective theory of learning with media. Two instructional system design (ISD) models are examined – the ADDIE (analyze, design, develop, implement, and evaluate) model and the four-component instructional design (4C/ID) model. Valid assessment methods have also been analyzed, and there is a brief discussion of the need for and the purpose of implementing the shareable content object reference model (SCORM).

Statement of Purpose

Mt. San Jacinto College's Computer Information Systems (CIS) department offers four programs in which its students can obtain an Associate's degree: networking, programming, Internet authoring, and a general CIS category. Of the three core courses students are required to complete as part of their study in each of the Associate's degree programs, the CSIS 202 - Networking and Data Communications course has historically been one of the most difficult for students to complete successfully. One of the most difficult skills for students to learn in the CSIS 202 course is that of segmenting data communications networks, also known as subnetting. Subnetting is the process by which an information technology (IT) professional takes a single group of networked data communications devices and divides (segments) them into smaller more manageable groups of networked devices or *subnets*. In theory a well-designed intelligent tutoring system (ITS) could be developed which improves the instruction by making it more effective, efficient, and appealing to the students learning from it. More *effective* being defined as improving the success rate of students using the ITS by incorporating principles based on knowledge of how the human mind works. More *efficient* meaning that students using the ITS will learn with the least amount of effort expended as possible. The ITS will be *appealing* in that it will motivate the student to want to use it. In addition, the ITS should provide transfer to the student using it, where *transfer* refers to the students ability to take what they have learned and apply it to unique situations both similar and very different from the context in which the skill was learned.

The collegiate level of learning tends to be rigorous and complex, especially in programs which deal with the sciences, e.g. computer programming and information systems. Because of the increased rigor and complexity of these types of college level courses, instructional designers who design instructional blueprints for this market need to pay close attention to the intrinsic

load the instructional presentation puts on the learner's short-term memory. It is also important for instructional designers to make every effort possible to prevent the addition of any extraneous load created by the presentation itself. One of the four components of van Merriënboer's 4C/ID model is *learning tasks*. One of the steps involved in the learning tasks component is organizing the learning tasks into task classes, a step which involves task analysis; a step which can aid an instructional designer in evaluating and organizing the instructional materials in such a way as to reduce intrinsic load as much as possible. By being familiar with CTML and CATLM an instructional designer can make good decisions in the design process and avoid having the presentation add any extraneous load into the mix. In addition to incorporating the principles of the aforementioned cognitive load theories into its framework, the 4C/ID model also incorporates the ADDIE (analyze, design, develop, implement, and evaluate) model of instruction, a time-tested instructional model used by designers for over three decades and which helps to ensure that the design, development, and implementation of the instructional presentation goes through a rigorous iterative process of analysis and evaluation.

Most, if not all, colleges and universities now employ learning management systems (LMS) for both classroom and online learning environments. In order for a course developed by an instructional designer to be able to interact with an LMS the course needs to be shareable content object reference model (SCORM) compliant to be able to offer features like transferring assessments scores from the instructional presentation to the LMS grade book and allowing learners to bookmark their place in the course for a quick and easy way to return to where they left off.

Rationale

Taking what psychologists have discovered about complex learning and the cognitive architecture of humans during decades of empirical research and using it to improve instruction

is not a simple and straightforward matter. By taking theory and applying it to the development of an intelligent tutoring system which is implemented as a real world application, much can be gained by the experience and will help others in the field who follow in these footsteps. If it can be empirically proven that student success has increased due to the implementation of an intelligent tutoring system as described herein, then much can be learned about what does and does not work when it comes to using these methods as an attempt to improve student success when it comes to the design, development, and implementation of multimedia-based instruction as well.

Definition of Terms

The following key terms were used throughout this paper. These are terms that are most germane to the theories the reader will encounter throughout this paper and understanding these terms will help the reader better understand the concepts presented. The terms are listed alphabetically for the purpose of providing a point of quick and easy reference.

Cognition

The act or process of knowing (Cognition, 2010).

Cognitive load

The load placed on short-term (working) memory during instruction (Plass, Moreno, & Brücken, Cognitive load theory, 2010).

Constituent skill

Individual interdependent skills which need to be coordinated in order to develop a particular authentic learning task (van Merriënboer & Kirschner, 2009).

Extraneous load

The load placed on short-term (working) memory caused by the instruction (Kalyuga, 2009).

Germane load

Related to the processes that directly contribute to learning, in particular schema construction and rule automation (Kalyuga, 2009).

Instructional designer

“The person (or persons) responsible for researching, designing, and developing the instructional product” (Litchfield, 2007) .

Instructional design model

Indicates how to implement the instructional design process by describing how to conduct the various steps that comprise the process. Models vary by the degree to which they make assumptions about the user setting and ultimate implementation of the instruction.

Gustafson and Branch (2002) classified models according to the primary type of instruction they are designed to produce (a) instruction that is likely to be delivered in a *classroom* by an instructor, (b) instructional *products* such-as computer-based modules designed for wide distribution, and (c) large-scale instructional *systems* such as an entire distance learning course or degree program.

Intelligent Tutoring System (ITS)

An instructional system which provides dynamic feedback and instruction to its users based on an evaluation of the user’s pre-existing knowledge and progression through the instructional system.

Intrinsic load

The load placed on short-term (working) memory caused by the number of elements that must be simultaneously processed in short-term memory and the complexity of their interaction (Kalyuga, 2009).

Learner

The person who is receiving the instruction designed by the instructional designer (Mayer R. E., 2011).

Assumptions and Limitations

This research is subject to a few known assumptions. The researcher has made the following assumptions:

1. Students who use the intelligent tutor must be experienced users of the MSJC LMS.

This research is subject to a few known limitations. The researcher has recognized the following limitations:

1. In order for the intelligent tutor to be fully functional it must be implemented by a SCORM compliant LMS.
2. The intended audience for the intelligent tutor is students who enroll in the Mt. San Jacinto College's CSIS 202 – Networking and Data Communications course.

Overview of Remaining Chapters

This research consists of five chapters. Chapter One is an introduction which includes a statement of purpose, a rationale, operational definitions, assumptions and limitations, and this overview. Chapter Two reviews the related literature regarding the instructional principles of the cognitive load theory, the cognitive theory of multimedia learning, and the cognitive-affective theory of learning with media. A literature review is also conducted on learning transfer and the four-component instructional design model. Chapter Three describes the methods used to design and develop the intelligent tutor system as well as the evaluation process. Chapter Four describes the intelligent tutor system in detail. Chapter Five summarizes the project complete with a reference list, and appendix with all evaluation forms, a compact disc (CD) product, and Institutional Review Board (IRB) documentation. This thesis and companion intelligent tutor

will serve to detail the validity of developing intelligent tutors based on principles of cognitive architecture when instructing for complex learning.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

When it comes to the design of learning environments, The National Research Council (2000) frames the discussion this way, “learning theory does not provide a simple recipe for designing effective learning environments; similarly, physics constrains but does not dictate how to build a bridge” (p131). Humans have been studying and improving upon theories of learning dating all the way back to ancient human civilizations. Some of the earliest recorded attempts at producing learning theories are that of the Greek rhetors (Greek term for orator) who used memorization techniques like mnemonics to help them remember their speeches which, at that time, could not be easily written down. From this desire to better understand and increase one’s ability to learn, numerous learning theories and instructional methods have been developed.

Thanks to Pavlov’s dogs and researchers like Thorndike and B.F. Skinner, behaviorism dominated much of the twentieth century but, with advances in cognitive psychology and neuroscience, a new learning theory, cognitive load theory (CLT), has come onto the landscape and could plausibly dominate the twenty-first century. Two, more specialized, theories of CLT, the cognitive theory of multimedia learning (CTML) and the cognitive-affective theory of learning with media (CATLM) examine multimedia and its effects on the learning process by applying and extending the principles of CLT. Historically, in the development of instructional technology, “multimedia has been developed on the basis of its technological capacity, and rarely is it used according to research based principles” (Moreno & Mayer, 1999). Examples of poorly designed instruction using multimedia are numerous. Too many instructional designers are not trained how to properly use multimedia in instruction or are not knowledgeable in the area of cognitive load theory, or both. To be an effective instructional designer (ID), one must be aware of the research, the learning theories, and the learning principles concerning the effect

instruction have on a learner's cognitive load and the derivative instructional design models that have been developed to help implement effective and efficient instructional environments. Instructional designers must also understand that learners entering into a learning environment are extremely diverse in their existing knowledge base. In order for the appropriate instruction to be applied to each individual learner, a learner's existing knowledge base must be identified in order to avoid applying instruction which might cause cognitive load problems and thereby reduce the effectiveness of the instruction. Taking into account research in the areas of CLT, CTML, CATML and their accompanying principles is an important part of being a successful modern-day instructional designer. Both the nature and the skills needed for currently available jobs are rapidly changing while the information relevant to carrying out those jobs quickly becomes obsolete. This poses higher demands on the workforce with employers stressing the importance of problem solving, reasoning, and creativity to ensure that employees can and will flexibly adjust to rapid changes in their environment (van Merriënboer & Kirschner, 2007). Now more than ever, instructional designers need to be able to optimize their instructional designs in order to create successful students who can meet the demands of industry needs. This means being cognizant of all the variables that can result in either a positive or negative impact on a learner's cognitive load in order to produce effective and efficient learning environments. An analysis of published research articles on the positive and negative effects of instruction on cognitive load and how best to determine a learner's existing knowledge base regarding a particular subject matter is the focus of this literature review.

Knowledge and Learning

In order for an instructional designer to fully understand all of the principles involved in making good decisions about instructional design, they must start with a good foundation. In order to develop this foundation we will begin with the concepts of *knowledge* and *learning*.

Knowledge is defined by the *Oxford English Dictionary* as (1) facts, information, and skills acquired by a person through experience or education; the theoretical or practical understanding of a subject (Definition of Knowledge, 2010). In order to acquire knowledge one must utilize complex cognitive processes including: perception, learning, communication, association and reasoning (Knowledge, 2010). The knowledge acquisition method that instructional design has control over is learning, which we have just learned is a “complex cognitive process” (Knowledge, 2010). This would seem to imply that cognition then plays a large part in learning in order to gain knowledge.

Cognitive Learning Theories

Behaviorism, a long-standing standard in learning theories and cognitive learning theories are similar in that they both believe that the environment influences learning. Where the two differ is that cognitive learning theories are concerned with the internal processes involved in making sense of the environment (Eysenck & Keane, 2010; Reiser & Dempsey, 2007). Of the cognitive learning theories, the cognitive information processing theory was first on the scene and began its rise to prominence in the 1970s (Reiser & Dempsey, 2007). Since then, other cognitive learning theories like semantic networks, schema theory and cognitive load theory (CLT) have been developed and have become more influential in the development of instructional design (van Merriënboer & Sweller, 2005). There is a lot of commonality among these four cognitive theories, among those that are most important to modern multimedia rich learning environments are: (a) perception and attention, (b) encoding of information, memory, (c) comprehension, (d) active learning, (e) motivation, (f) locus of control, (g) mental models, (h) metacognition, (i) transfer of learning, and (j) individual differences (Alessi & Trollip, 2001).

Perception and attention.

Perception and attention are shaped by three principles: (a) information, whether it's received in visual or aural form, it needs to be received as simply as possible, (b) the method by which information is arranged, spatially and/or temporally, affects student's attention to and perception of it, (c) varying the way information is presented helps to maintain a student's attention (Alessi & Trollip, 2001).

Encoding

Although humans possess five senses, for the most part instructional input is received via sight and sound (visual and aural). Cognitive psychologists believe that the incoming stimuli must be transformed into a format that can be stored in the brain; this process is called encoding. Studies on how students encode information have shown that simultaneously receiving the right types of information visually and audibly can actually improve learning (Clark & Paivio, 1991; Mayer R. , 1997).

Memory

Learning does absolutely no good if what a student learns cannot be recalled when needed. Alessi & Trollip (2001) state that there are two principles that underlie almost all memory enhancing methods: principle of organization and the principle of repetition. The principle of organization states that things are remembered better if they are organized. This is why advance organizers are a good instructional tool; they both organize the material prior to learning and call attention to the organizational structure of the information. Mnemonics is also a form of organizing information to enhance retrieval. It has been said that practice makes perfect, actually the truth of the matter is that only *perfect* practice makes for perfect performance and

studies have shown that practice does logarithmically improve performance (van Merriënboer & Kirschner, 2007).

Comprehension

A big part of cognitive theories is how to build and modify schemas in long term memory; this is where comprehension comes in. Comprehending a concept, a skill or an attitude means that we are able to classify it, apply it, evaluate it, discuss it, manipulate it, and teach it to other people. This is why teachers who have been teaching a subject for a while have a deeper insight about it – teaching information to others is one of the best ways to learn a subject in-depth (Alessi & Trollip, 2001).

Active Learning

Active learning means to learn by doing. Good instructional design will include student interactions that are frequent, relevant, interesting, and apply just the right amount of difficulty. Primarily, applying the appropriate level of active learning depends on the learner's prior knowledge. Pre-testing can be very helpful in selecting the appropriate active learning strategy (Clark, Nguyen, & Sweller, 2006; Alessi & Trollip, 2001).

Motivation

Motivation is also a key factor in designing instructional content. Two models are frequently used in multimedia design Malone's motivation theory and Keller's ARCS motivational theory (Alessi & Trollip, 2001).

Malone's motivation theory.

This theory identifies four factors that are necessary for instruction to be motivational. First, the instructional material must not only be challenging for the students but also individualized and adjusted for the specific learner, varying the difficulty of the material as the

learner's performance improves keeps the learner motivated throughout the instruction. Second, Malone suggests that the instruction should pique the learner's sensual curiosity as well as their cognitive curiosity. Sensory curiosity consists of visual and audio variations that are surprising or attract attention. Cognitive curiosity occurs when the information conflicts with the learners existing information, is contradictory, or is in some ways incomplete. These situations encourage the learner to seek new information that resolves the conflict. Third, is control, which refers to a learner's ability to control the instructional environment either by actions and responses, choices that allow the learner to determine the sequencing, and the notion of power that a learner feels from having some type of creation to show as a result of the instruction. Malone's final motivational factor is fantasy. Fantasy is when a student can imagine themselves in environments that are realistic to the subject being learned or even surrealistic such as in games or simulations (Alessi & Trollip, 2001).

Keller's ARCS motivational theory.

This theory is all in the acronym ARCS: *attention, relevance, confidence, and satisfaction*. Keller makes the point in his theory that a student's attention must be captured early in the lesson and then maintained throughout (Keller & Suzuki, 1988). This reinforces the idea that piquing a student's curiosity and varying content throughout the instructional process are good strategies to implement. *Relevance* can prove motivational if the instructor or instructional method can demonstrate to students why the material is important to their lives. Developing a student's *confidence* can be implemented by giving the user more control of the learning environment, offering many attempts at being successful during the learning process, and making the expectations for learning clear to the learner. *Satisfaction* can come from encouragement, a sense of progress, and fairness just to name a few strategies (Alessi & Trollip, 2001).

Locus of Control

Locus of control is another way of saying give the learner the ability to take control of the learning process by enabling them to control sequencing, pace, content, methodology, or other instructional factors like the amount of support provided (Alessi & Trollip, 2001).

Mental Models

A mental model refers to the schemas a learner has built into their long term memory. By recalling these schemas learners can reduce the amount of working memory required to solve problems (Alessi & Trollip, 2001). Studies which compare novices to experts, as in the famous chess master studies (Chase & Simon, 1973), show that experts have considerably more schematic structures from which to draw for problem solving than novices; schemas that have been developed from years of experience working with a particular subject.

Metacognition

Metacognition refers to a person's ability to be aware of their own cognitive capabilities. Research shows that high achievers have good metacognition in addition to good cognitive abilities. General strategies for increasing a learner's metacognitive skills are self-evaluation, reflection, and practice activities aimed at actually developing metacognitive skills (Alessi & Trollip, 2001). Journaling, blogging, and peer evaluation are methods proven to increase a learner's metacognitive abilities.

Transfer of Learning

Transfer of learning is one of the most studied principles of cognitive learning (Cormier & Hagman, 1987). Its focuses on transference of problem solving techniques and psychomotor skills, and determining which instructional methods enhance a learner's ability to take what they learn and apply it to situations either similar to those that existed during instruction (near

transfer) or to situations considerably different than the context in which they were learned (far transfer) (Alessi & Trollip, 2001; Atkinson, 2010).

Individual differences

The principle of individual differences centers on the fact that not all people are alike and thereby instruction shouldn't be presented in the same way to each and every person. This is where the development of intelligent tutors can have the most impact in instructional design. By adapting the learning process to a learner's pre-existing knowledge and preferred learning method could have a significant improvement on the learning outcome (Anderson, 2007).

Cognitive Load Theory

Although Mary Driscoll (2007), Moreno and Park (2010), and Alessi & Trollip (2001) don't agree precisely on the origins of the cognitive load theory, there does appear to be a consensus among them and other researchers that CLT is currently among the more popular of the cognitive learning theories and is considered one of the most influential theories in instructional design. This is due in part to many recent advances in cognitive neuroscience, like PET scans and fMRIs, which have provided increasing evidence for the validity of many principles of the cognitive load theory (Merriam, Caffarella, & Baumgartner, 2007; Dual-coding Theory, 2009). The main precepts of cognitive load theory are the following: (a) working memory (also known as short-term memory) is limited to holding seven items, plus or minus two (Miller, 1994); (b) if a learner does not possess any schemas (pre-existing cognitive structures) in long-term memory related to the subject being learned then working memory can be quickly overloaded with information, causing a cognitive overload that reduces a person's ability to learn. Essentially, what cognitive load means to instructional designers is that in order for instruction to be both effective and efficient, designers need to be cognizant of these three factors (a) the number of elements being presented and the amount that they interact with each other

cannot exceed the amount of available working memory, (b) the instructional presentation should not hamper the learning process by adding to the cognitive load in working memory and (c) the instruction should utilize techniques which afford the learner to effectively produce subject matter schemas in long term memory and rule automaticity. In CLT terminology the previous three factors are referred to as *intrinsic load*, *extraneous load*, and *germane load* respectively (Moreno & Park, 2010).

An effective analysis of an instructional presentation needs to identify ways to reduce extraneous load (Sweller, 1994). Instructional designers should make every attempt to reduce the effect of extraneous load on cognition by adhering to the following principles: the goal-free effect, the worked-example effect, the split-attention effect, the completion effect, and the redundancy effect. The goal-free effect demonstrates why instructional designers should use goal-free problems instead of means-ends analysis in order to focus a student's attention on problem states and available operators (Owen & Sweller, 1985; Sweller, Mawer, & Ward, 1983; Tarmizi & Sweller, 1988). The worked-example effect encourages instructional designers to replace means-ends analysis with worked-examples thereby reducing extraneous cognitive load by focusing a student's attention on problem states and solution steps (Cooper & Sweller, 1987; Sweller & Cooper, 1985). The split-attention effect is cause for replacing the placement of multiple sources of mutually referring information with a single, integrated source of information in order to reduce extraneous cognitive load by avoiding the need to mentally integrate the information sources (Chandler & Sweller, 1991; Chandler & Sweller, 1992; Sweller & Chandler, 1994; Sweller, Chandler, Tierney, & Cooper, 1990). The completion effect encourages instructional designers to design instruction that uses partially completed problems rather than having students' solve entire problems in order to focus attention by reducing the size of the problem space (Paas, 1992; van Merriënboer & de Crook, 1992). Instructional designers can

eliminate the redundancy effect by replacing multiple sources of information that can be understood in isolation with one source of information; in this case extraneous cognitive load is reduced by eliminating the processing of redundant information (Chandler & Sweller, 1991; Sweller & Chandler, 1994).

Considered to be a tougher if not impossible challenge for the instructional designer is the reduction of intrinsic load which deals with the number of elements being presented in the instruction and how much those elements interact with each other. There has been some disagreement as to whether instructional design can affect intrinsic load or not (Sweller, 1994; Paas, Renkl, & Sweller, 2003). Recent research however, seems to support the argument that it can (van Merriënboer & Sweller, 2005). Intrinsic load also factors in the learner's prior knowledge of the subject matter and is referred to as the *first additivity hypothesis* (Moreno & Park, Cognitive Load Theory, 2010) which states that:

when people are faced with new material, the cognitive load imposed by the material will consist of the intrinsic cognitive load due to element interactivity and extraneous cognitive load determined the instructional design used. If the total cognitive load is excessive, learning and problem solving will be inhibited (Sweller, 1993)

This too is a hypothesis that is still open for debate, the question being whether intrinsic and extraneous loads are indeed reducible (Paas, Renkl, & Sweller, 2003; Paas, Tuovinen, Tabbers, & van Gerven, 2003), but again new research seems to be in favor of the argument that intrinsic load may be altered by reducing element interactivity, although “by artificially reducing intrinsic cognitive load, understanding is also reduced” (van Merriënboer & Sweller, 2005).

Optimally, by reducing extraneous load and controlling intrinsic load, instructional designers can turn their focus to increasing germane load in their instructional materials so that

the cognitive resources of working memory can be devoted to schema acquisition and rule automation (Plass, Moreno, & Brücken, Cognitive load theory, 2010). Schema acquisition is the transfer of new information from short term memory to long term memory which either becomes a new schema in long term memory or modifies an existing one. Schema automation, also known as rule automation, is the ability to recall a schema from long term memory without having to think about it, which is pragmatic for recurring tasks (van Merriënboer & Kirschner, 2007). Freeing available cognitive capacity by reducing extraneous load will not necessarily result in increased learning unless the freed activities are directed to activities that are relevant for schema acquisition and rule automation. If designed properly germane load can increase a person's ability to learn whereas extraneous load will reduce their ability to learn when intrinsic load is high. There are studies that show that extraneous load has little or no effect when intrinsic load is low (ibid).

The Effects of Multimedia on Cognitive Load

Mayer (2009) defines multimedia instruction as “presentations involving words and pictures that are intended to foster learning”. When designing instruction, one of the most important cognitive load principles to keep in mind is that of dual coding theory (DCT). The dual coding theory, as Alessi and Trollip (2001) put it, “suggests that learning is enhanced when complementary information codes are received simultaneously”. Although there had been some research written about dual coding by Yates (1966) and Rossi as early as the 1960s, research by Clark & Paivio (1991) is considered to be the seminal paper on the subject. Moreno and Mayer (2010; Mayer R. E., The Cambridge handbook of multimedia learning, 2010; Mayer, Heiser, & Lonn, 2001) have used the term *multimedia principle*, displayed in figure 1, to describe the benefits of combining different visual and aural information. It follows from dual coding theory and applies directly to interactive multimedia (Alessi & Trollip, 2001).

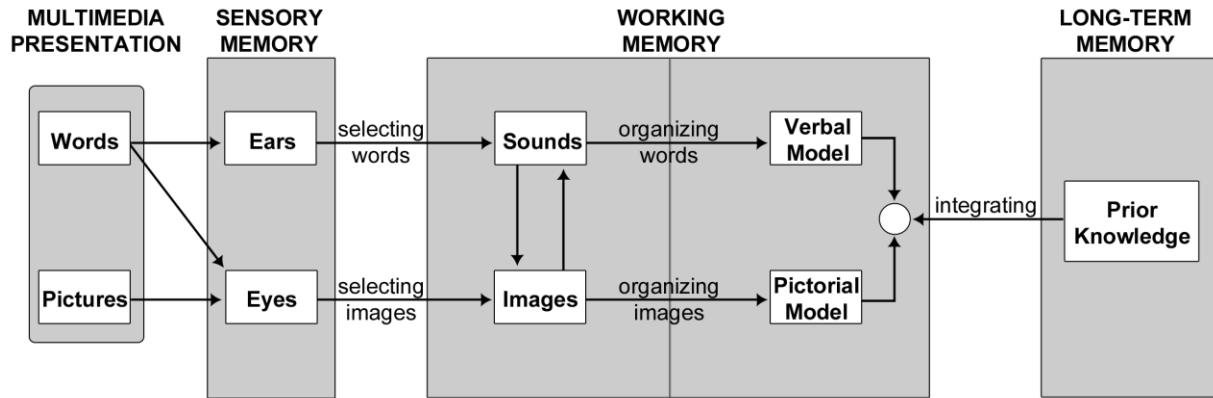


Figure 1. Cognitive theory of multimedia learning. Adapted from figure 7.1 Mayer & Moreno in Cognitive load theory Jan L. Plaas, Roxana Moreno, Roland Brünken (Eds.), 2010

In addition to the multimedia principle, Mayer (2009) describes the following eleven empirically tested principles to keep in mind when designing instructional content that utilizes multimedia elements: the *coherence principle*, the *signaling principle*, the *redundancy principle*, the *spatial contiguity principle*, the *temporal contiguity principle*, the *segmenting principle*, the *pre-training principle*, the *modality principle*, the *personalization principle*, the *voice principle*, and the *image principle*. The *coherence principle* states that people learn better when extraneous material is excluded rather than included. According to Mayer in thirteen out of fourteen tests, learners who received concise multimedia presentations performed better on tests of transfer and that the median effect size was .97. This principle agrees with cognitive load theory which also emphasizes the importance of reducing extraneous load in order to help facilitate learning. The *signaling principle* states that people learn better when cues that highlight the organization of the essential material are added, Mayer cites a smaller sampling for this principle five out of six tests where the principle showed better transfer, also a smaller median effect size of .52. The *redundancy principle* is the same as CLT's redundancy effect where people experience an extraneous cognitive load when graphics, narration, and printed text are presented simultaneously as opposed to graphics and narration, narration only. The median effect size was .72. The *spatial contiguity principle* is similar to CLT's split-attention effect where students

learn better when corresponding words and pictures are presented near, spatially or temporally, rather than far from each other. This principle has a rather high media effect size of 1.09. The *temporal contiguity principle* states that students learn better when corresponding words and pictures are presented simultaneously rather than successively. This principle has the highest median effect size of all of the multimedia principles, 1.31. The *segmenting principle* states that students learn better when multimedia messages are presented in a user-paced format rather than as a continuous unit. The media effect size is .98. The *pre-training principle* states that students learn more deeply from a multimedia message when they know the names and characteristics of the main concepts. This is consistent with CLT claims that intrinsic cognitive load is reduced when learners are able to work from existing schemas. The median effect size is .85. The *modality principle* states that people learn more deeply from pictures and spoken words than from pictures and printed words. This principle is similar to Clark and Paivio's dual coding theory which demonstrated that learners do better when both the visual and auditory perceptions are activated instead of having text and graphics both competing for attention by the learner's visual channel alone. The median effect size was 1.02. The *personalization principle* states that students learn better from multimedia presentations when words are in conversational style rather than formal style and has a comparatively high media effect size of 1.11. The *voice principle* states that students learn better when narration is spoken in a human voice rather than a machine voice. The median effect size is .78. The last of Mayer's principles is the *image principle* which states that people do not necessarily learn better when the speaker's image is added to the screen. In five experiments, the median effect size favoring adding the speaker's image to the screen was only .22.

The 4C/ID Model

Fortunately for instructional designers, a learning model has been developed which takes into account the principles of the cognitive load theory, the four component instructional design model (4C/ID) for complex learning. The 4C/ID model calls for learning tasks to be sequenced in ways that reduce cognitive load (van Merriënboer, Kirschner, & Kester, 2003). The 4C/ID model focuses on authentic learning tasks based on real-life tasks as the driving force for teaching and learning. The basic idea behind this focus is that such tasks help learners to integrate knowledge, skills and attitudes; stimulate them to coordinate constituent skills; and facilitate transfer of what is learned to new problem situations (Merrill, 2002; van Merriënboer J., 2007; van Merriënboer & Kirschner, 2001). The 4C/ID model instructional approach is a holistic design approach which can offer a solution for three persistent problems in the field of education: compartmentalization, fragmentation, and the transfer paradox (van Merriënboer & Kirschner, 2007).

Conclusion

Too often it has been the case that instructional designers have been ill-prepared to meet the challenge of properly preparing the modern day workforce to meet the needs of industry.

Primarily the problem has been that the instruction is being developed without regard to its actual impact on cognitive load which is stifling learning outcomes. In order to create effective and efficient instructional environments designers need to be cognizant of and apply the principles derived from cognitive theories like the cognitive load theory (CLT), the cognitive theory of multimedia learning (CTML) and the cognitive-affective theory of learning with media (CATLM). The four component instructional design model (4C/ID) embraces these theories in its framework and provides instructional designers a viable methodology to follow for developing rich multimedia instructional environments which will be both effective and efficient.

CHAPTER THREE

METHODOLOGY

A pre-determined group of subject matter experts and professors considered to be proficient in instructional design and in the development of online course content were selected from the faculties and staffs at Mt. San Jacinto Community College (MSJC); the University of California, Riverside; and the College of Infomedical Technology (CIT) to provide observations of usability, evaluation of content, and feedback about the intelligent tutoring system's (ITS) ability to promote effective and efficient learning.

Participants were provided a hyperlink for access to the ITS which was installed on a Web server housed in the Computer Information Systems department's intermediate distribution facility on MSJC's Menifee campus. Due to the fact that unique user access to the ITS on a SCORM compliant learning management system could not be easily provided for each participant, the SCORM component of the ITS was neither implemented nor evaluated.

Participants

During both the alpha and the beta release phases of the ITS an email requesting participation was sent to all potential participants. In the email the particulars of the project were explained and a hyperlink was included which provided a link to the current ITS release version. The recipients of the email consisted of a self-selected group of subject matter experts and professors who were determined to be proficient in instructional design and in the development of online course content selected from the faculties and staffs of Mt. San Jacinto College; the University of California, Riverside; California State University, Fullerton; California State University, San Bernardino; and the College of Infomedical Technology.

Instrument

Those who chose to participate in the assessments of the ITS prototype were provided with a Web-based evaluation form (see Appendix B) which recorded the participant's submissions to a Microsoft SQL server database allowing for both quantitative and qualitative analytical reviews at a later date. The evaluation form was adapted from Alessi and Trollip's book *Multimedia for Learning: Methods and Development* (2001) with non-applicable items omitted and prototype specific elements added. Although the evaluation form addressed specifics of multimedia learning such as affective considerations, interface, navigation, and pedagogy, a particular emphasis was placed on questions regarding the principles of the cognitive theory of multimedia learning (CTML) as explained by Mayer in his book *Multimedia Learning* (2009). The format of the CTML questions consisted of a brief explanation of the principle the question was addressing in addition to the actual question. A Likert scale was used to record the participants' responses in most of the questions. In some cases the participants were asked to fill-in-the-blank with their opinion, for example "if you were the author of this instructional component how might you change its presentation?"

Procedures

The ITS prototype was made available to the alpha and beta evaluation participants via an emailed hyperlink. A copy of the evaluation form (Appendix B) was included as an attachment to the email sent to the alpha and beta evaluators to allow the participants to familiarize themselves with the content of the questions prior to their accessing the ITS prototype. It was felt that this would provide the participants' with a more acute view of the focus of ITS prototype evaluation. The responses from the alpha evaluations were analyzed and where applicable changes were made to the beta version of the ITS. The results of the beta evaluations were

analyzed and, where applicable, changes were integrated into a refined version of the ITS, known as *Beta 2*, and was implemented in an actual MSJC online course utilizing the Blackboard[®] learning management system (LMS). Students who enroll in the online course are being asked (not compulsory) to complete an online course evaluation form upon their completion or abbreviated exit of the ITS-based course in order to promote feedback and upgrades to the ITS product as an ongoing iterative process.

Results

From the large pool a potential participants that were emailed only a handful actually completed the web-based survey for the alpha and beta versions of the ITS. The supposition is that this anomaly has nothing to do with the ITS product itself but has more to do with the busy schedules maintained by the pool of potential participants. From those responses received most were generally favorable and provided invaluable insights into aspects of the ITS that needed improvement. Primarily there were issues of continuity and in a couple of cases there were bugs in the system that could only be identified during alpha and beta evaluations in which operators of the ITS system performed or assumed unexpected selections of navigation. One issue that cropped up during the initial implementation of the ITS on the Blackboard[®] LMS was the issue of bandwidth. Since all of the beta evaluators had Internet broadband access equaling or exceeding download speeds of 10 Gbps, bandwidth was not an issue. But, because the students who were using the LMS are a broader, more diverse population when it comes to their ability to access the Internet, in some cases the largeness of the ITS files became an issue. In addition, the number of simultaneous users was not an issue during the alpha and beta evaluations, but became an issue during the initial implementation of the ITS product. Currently, file and program

optimization processes are being evaluated for development and deployment in future releases of the ITS product.

CHAPTER FOUR

Overview

Traditionally, for Mt. San Jacinto College's students electing to obtain their Associate's Degree in Computer Information Systems (CIS), the most difficult course to complete successfully has been the *CSIS 202 Networking and Data Communications* course. Consistently, in the *CSIS 202* course the biggest hurdle for students has been trying to learn the underlying concepts and the procedural process of segmenting a data communications network, also known as subnetting. Subnetting is the process by which an information technology (IT) professional takes a single group of networked data communications devices and divides (segments) them into smaller more manageable groups of networked devices or *subnets*. It was theorized that a well-designed intelligent tutoring system (ITS) could be developed which improved upon the instruction of subnetting by making it more effective, efficient, and appealing to the students learning from it. More *effective* being defined as improving the success rate of students using the ITS by incorporating cognitive psychological principles based on knowledge of how humans learn best. More *efficient* meaning that students using the ITS will learn with the least amount of effort expended as possible. The ITS would be *appealing* in that it would motivate the student to want to use it. In addition, the ITS needed to provide transfer to the student using it, where *transfer* refers to the student's ability to take what they have learned and apply it to unique situations which are both similar as well as very different from the context in which the skill was learned.

Instructional Problem

In order to design, develop, and implement this project, a multitude of computer software products and technologies needed to be employed including: Adobe Dreamweaver, Adobe Photoshop, Adobe Captivate, Adobe Media Encoder, Adobe Soundbooth, Adobe Presenter,

Adobe Illustrator, Adobe Flash Builder, Adobe Flash Professional, Adobe Flash Player, TechSmith Camtasia Studio; Trivantis Lectora Inspire; JavaScript, ActionScript, and Microsoft Visual Studio utilizing C# and ASP.NET. In order for the intelligent tutoring system to be successful and efficient it needed to follow proven pedagogically-based instructional design techniques and be developed using empirically established principles derived from cognitive load theory (CLT), the cognitive theory of multimedia (CTML), and the cognitive-affective theory of learning with media (CATLM) . The design and development of the intelligent tutoring system also needed to follow time-tested guidelines of interface design including the use of strategies such as: sign posting, intuitive navigation, breadcrumbs, and the ability for the user to save and return to the point where they left off. In order for the Web-based intelligent tutoring system to be implemented through a learning management system like Moodle or Blackboard it also had to be SCORM compliant to provide proper integration with a learning management system.

Proposed Solution

Developing the intelligent tutoring system required advance planning to ensure its success; planning ahead also reduced the amount of debugging and editing required throughout the development of the project. In order to ensure that the intelligent tutoring systems is effective, efficient, engaging and promotes transfer, throughout the design, development, and implementation of this project, the principles of CLT, CTML, and CATLM were applied to all components of the design. Intrinsic cognitive load was reduced by structuring tasks in a modular and granular fashion allowing for the content to be divided into small enough pieces that would not violate the *seven plus or minus two* principle of cognitive load. Extraneous cognitive load was reduced by adhering to the principles set forth by the cognitive theory of multimedia learning and the cognitive-affective theory of learning multimedia. Consistent navigational

elements were maintained from the beginning to the end of the presentation. This also helped ensure that all multimedia content presented did so without adding to the intrinsic cognitive load. Germaine cognitive load was increased by calling attention to key elements on the screen with highlighting and animated techniques. In addition just-in-time help was incorporated throughout the product allowing learners to easily recall previously covered topics while learning new ones. Learner interaction was incorporated wherever possible and whenever applicable to help promote retention and transfer.

Goal

The goal of this project was to develop an intelligent tutoring system which would increase the number of students who can successfully subnet a network by their completion of Mt. San Jacinto College's CSIS 202 course.

Learning Task Analysis/Instructional Objectives

This project aimed to deliver effective, efficient, and engaging instruction that will enhance a student's schema acquisition and construction abilities, rule automation, and transfer of learning which transfers to both near and far problem solving skills. If it can be empirically determined that the methodology used to develop the intelligent tutoring system improves student learning in the topic of subnetting, a topic that has proven to be the most difficult for students to learn, then those methodologies can be applied to other networking and data communications topics to enhance student learning and improve upon MSJC's CIS program completion rates.

Project Description

The intelligent tutoring system incorporated an instructional design based on the latest research in cognitive psychological learning theories. It implemented a time-tested interface design with the most recent software development tools available today to create an interactive and engaging web-based and CD distributable tutoring system. The ITS consisted of several types of instructional media including real world tasks, interactive tutorials, instructional videos, learning objectives to focus learners on intended outcomes, part-task practice, just-in-time feedback, random practice, partially worked examples, faded-worked examples, as well as cognitive and skills-based assessments. The intelligent tutoring system enhances a learner's ability to learn effectively and efficiently resulting in acquisition of the necessary cognitive schemas and internalizing the skill of being able to execute the task of logically subnetting a data communications network under varying circumstances.

Target Audience

The target audience for the intelligent tutoring system will be college students seeking to complete an Associate's degree in Computer Information Systems at Mt. San Jacinto College. The age range will vary from recent high school graduates transferring to the community college and older workers who are looking to change their career path.

Task Analysis

In order to achieve the goal established for the intelligent tutoring system a task analysis was performed by interviewing IT networking professionals and IT networking instructors; reviewing textbooks on networking, Internet Engineering Task Force (IETF) requests for comments (RFCs) 791, 950, 1009, 1219, 1375, 1517, 1518, 1519, 1520, 1817, and 1918, and web-based instructional materials published by Cisco for their certified computer network

associate (CCNA) course. The tasks that were deemed necessary for the accomplishment of the goal set forth are as follows.

Learners will be able to:

- Analyze a network diagram and determine the number of subnetworks it depicts.
- Translate classless inter-domain routing (CIDR) notation into a subnet mask value in dotted decimal notation.
- Calculate decimal to binary and binary to decimal conversions.
- Apply Boolean anding to two binary values.
- Construct a new subnet mask using variable length subnet mask (VLSM) best practices.

Learning Objectives

In order to achieve the goal of this project the following learning objectives have been integrated into the intelligent tutoring system:

- Given a network diagram of a multi-segmented network the student will be able to accurately identify the number of subnets depicted.
- Given a network address which includes a CIDR value the student will be able to correctly write out the corresponding subnet mask value.
- Given an IP address in dotted decimal notation the student will be able to correctly convert the decimal values to their binary equivalent.
- Given two binary values the student will be able to correctly calculate the results of a Boolean *anding* process.
- Given a number of subnets that need to be created the student will be able to determine how many host bits in a subnet need to be borrowed to create the minimum number of subnets needed.

- Given a diagram of data communication subnets the student will be able to accurately identify the first, last and broadcast addresses for each subnet.

Media Selection

The intelligent cognitive tutor is designed to be distributed by standard http services utilizing a content management or learning management system, and as a self-contained unit via a compact disc. The presentational information incorporates a variety of media types including: text, still images, graphs, animations, screen captures, interactive screens, and narrated animations.

Navigational Controls

The intelligent tutoring system uses standard forward and backward navigation implemented by next and back arrows in a global navigation bar when applicable. Most of the intelligent tutoring system screens guide the user through the program step-by-step with buttons clearly marked as to their purpose. A context-sensitive Help button will be readily available from the global navigation bar at the top of each screen. Users who are operating the intelligent tutoring system within a learning management system will have the ability to bookmark their progress in the program for a quick and easy return to where they left off.

Interactive Controls

The intelligent tutoring system will use several types of assessment to evaluate the user's learning progress. All assessments are internally generated and, when installed in a learning management system, automatically recorded as the user progresses through the program. The assessment methods will include but are not limited to: partially-worked examples, faded examples, task completion assessment, concept attainment, reflection prompts, and random practice. The assessments are both cognitive and skills-based.

Personnel Analysis

The following milestones were identified as benchmarks for the progress of completing the development of the intelligent tutoring system project. The items are listed chronologically although those marked with an asterisk occur throughout the project iteratively.

- Assemble a team of developers proficient in the software tools required to complete this project.
- Build and test the front-end interface.
- Write scripts and record for narrated animations.
- Create animated tutorials.
- Write and debug code for interactive activities.
- Incorporate animations and interactive activity into the front-end interface.
- Evaluation of the product throughout the prototype, alpha, and beta development stages.*

Production Work Plan

The schedule time for the design, delivery and evaluation for this product was set for January – May 2011. The table 1 below displays the projected and actual dates for benchmark completions.

Table 1

Production Work Plan

Task Name	Projected Start Date	Projected Finish Date
IRB Application and Approval	11.15.10	12.09.10
Planning	01.4.11	01.13.11
Develop Prototype	01.13.11	03.2.11
Development Alpha Version	03.2.11	04.15.11

Initiate Alpha Testing	04.12.11	04.15.11
Development Beta Version	04.15.11	04.27.11
Initiate Beta Testing	04.22.11	04.27.11

The team assembly for the intelligent tutoring system consisted of one full-time developer and two outside contributors. The actual assembly amounted to more coercion than time expended. A lot of time was spent on evaluating which software tools would best complete each development task. Initially, it was thought that Adobe's Captivate would be the best tool for the job of building the front-end interface, but as it turned out it had a lot of flaws and limitations in its capabilities, the biggest of which was the inability to shrink textboxes to appropriate sizes and precisely align elements on the screen. Travantis' Lectora Inspire turned out to be the best tool for creating the front-end interface along with Adobe Photoshop which was used to create and edit the bitmap elements. Lectora Inspire handled most front-end building tasks well, but does have an antiquated closed captioning method for videos when compared to Adobe's Captivate. Adobe's Dreamweaver was used occasionally to edit HTML and style sheet information initially created by Lectora Inspire. Microsoft Word was used for writing the scripts and Adobe's Soundbooth was used for creating and editing the MP3 sound recordings.

Once the scripts were written and the narration recorded, the scripted text that was not being narrated and used in animations was copied into the pages built in Lectora Inspire. The scripted text that was recorded for narration was copied into Adobe After Effect compositions. The graphical elements that required animation were created using digital still and digital video cameras as well as TechSmith's Camtasia screen recording software and were then imported into Adobe's After Effect compositions to be synchronized with the narration. Next, interactive components were created using Adobe Flash Professional, Adobe Flash Builder, and Adobe Captivate. The animations and interactive elements were then incorporated in the Lectora Inspire

pages and several assessments were built and added in directly using the Lectora Inspire program.

Code debugging, for the most part, went very smoothly, the two Flash integrated development environments (IDEs) made writing and debugging ActionScript run quite smoothly. Writing C# and ASP.NET code in Microsoft's Visual Studio was a little more challenging due the fact that I had little experience with any of these technologies. Lectora Inspire handled all of the necessary JavaScript coding and made it a breeze, except for having to track down a few of the program's built-in JavaScript variables.

One distinct challenge that had to be overcome was that Flash video files imported into Adobe Captivate and exported as SWF files would not work when imported into Inspire. This is the main reason that After Effects was used to create most of the animations. As it turned out, After Effects was an extremely useful and powerful tool for creating animations and provided a lot more flexibility and options than did Flash Professional, Flash Builder, or Captivate.

Lectora Inspire was used to generate the final output of html and JavaScript files. It also generated the SCORM compliant manifest XML file and collected all supporting media files into appropriately named subfolders. Lectora Inspire's output options made it very easy to collect all of the necessary files into a single folder transferable to a content management system or learning management system. Lectora Inspire also included the ability to generate the appropriate executable files and folder structure for burning the completed project to compact disc media to run as a standalone product on a user's personal computer.

Estimated BudgetTable 2 *Estimated Budget*

	Projected Total	Actual Total
Prototype Phase		
Textbooks	\$179.00	\$179.00
Prototype Phase Subtotal	\$179.00	\$179.00
Design Phase		
Textbooks	\$239.00	\$239.00
Design Phase Subtotal	\$239.00	\$239.00
Development Phase		
Developer pay (400 hours) @ \$65/hr.	\$26,000.00	\$0
Microsoft Office Professional 2010	\$499.00	\$199.00
Adobe CS5 Master Suite	\$2,400.00	\$150.00
Tranvantis Lectora Inspire	\$2,000.00	\$500.00
Canon Image Class MF8050CN Scanner/Copier	\$599.00	\$599.00
Canon VIXIA HF S1 HD Video Camera	\$1,299.00	\$1299.00
Canon Rebel Xi Still Digital Camera	\$499.00	\$499.00
Square Perfect Light Box Kit	\$89.00	\$89.00
Behringer C-1U Condenser Microphone	\$129.00	\$129.00
Onkyo TS DX676 Audio Receiver	\$1,099.00	\$599.00
Dell Studio XPS Desktop Computer w/DVD burner	\$2999.00	\$2999.00
Dell SP2309W Monitor	199.99	199.99
Dell ST2310 Monitor	\$299.00	\$299.00
Textbooks	\$109.00	\$109.00
Blank DVD Media X 10	\$5.00	\$5.00
DVD Cases X 10	\$7.99	\$7.99
Development Phase Subtotal	\$ 38,232.98	\$ 7,682.98
Project Grand Total	\$ 38,650.98	\$ 8,100.98

The prototype and the design phases cost relatively little as the expenses were for research materials only. Most of the expense came during the development phase with the cost of the developer topping the list. The remaining costs for the development phase went towards the hardware and software required to complete the development. Fortunately we got some pretty good deals on the software. The evaluation phase cost was incurred for distributing, collecting

and tabulating the evaluations of the prototype, the alpha, and the beta versions of the product. The reporting costs went towards materials and presenter pay.

Implementation/Evaluation Plan

The ITS prototype was made available to the alpha and beta evaluation participants via an emailed hyperlink. The final version of the ITS was implemented in an actual MSJC online course utilizing the Blackboard® learning management system (LMS). A copy of the evaluation form (Appendix B) was included as an attachment to the email sent to the alpha and beta evaluators to allow the participants to familiarize themselves with the content of the questions prior to their accessing the ITS prototype, it was felt that this would provide the participants' with a more acute view of the focus of ITS prototype evaluation. The responses from the alpha evaluations were analyzed and where applicable, changes were made during the development of the beta version of the ITS. The results of the beta evaluations were analyzed and where applicable, changes were integrated into the initial online course implementation of the ITS. Students who enroll in the online course are being asked (not compulsory) to complete a course evaluation form online upon their completion or abbreviated exit of the ITS-based course to allow for an iterative process of evaluating and upgrading the product.

CHAPTER FIVE

This chapter presents the findings from data gathered from the evaluation of the *CIS Tutor Learning Unit 8: Advanced TCP/IP Network Design* collected during alpha and beta testing. Conclusions about the intelligent tutoring system product and its effectiveness are included. Recommendations that were presented to the project team, based on findings and evaluator comments, are discussed in detail.

Findings

The evaluation process for *CIS Tutor Learning Unit 8: Advanced TCP/IP Network Design* occurred in two phases. Alpha testing was completed from March 28, 2011 – March 31, 2011 by evaluation participants identified under the Participants heading in Chapter 3 of this document. Participants who responded using the online evaluation form offered feedback about the learning unit's content, functionality and design. An example of the evaluation form is in Section B of the Appendix. The feedback from the alpha test was incorporated during the development of the beta phase. The changes made were:

- Tool tip help was moved from the bottom of to the top of the buttons displayed in the global navigation system.
- Media player navigation was added to all of the animated lectures.
- The animated lecture on the relationship between IP addresses and subnet mask was modified to make the points clearer and more visual.
- All misspellings, grammar and punctuation errors were corrected.

Beta testing occurred from April 27, 2011 to April 30, 2011. As was done for the alpha evaluation, the same email request method was used to request help from potential evaluators, including a link to the beta version of the product. Many of those responding were the same participants who to part in the alpha testing phase, but some new evaluators responded also

providing valuable new input. Beta testing also included the addition of a quiz that was developed to evaluate the participant's knowledge of the subject prior to the presentation of the subject matter content and then again post presentation in order to evaluate how well the CIS Tutor improved their knowledge of the subject. During the final release of the CIS Tutor the pre-test will be used for placing the learning at the appropriate starting point on the presentation. This placement feature was disabled during the beta evaluation stage to allow participants to view all of the content available throughout the entirety of the CIS Tutor. Most of the participants were already very knowledgeable in basic networking concepts so it was no surprise that the cumulative score of 95% was achieved on the quiz during pre-testing and 99% during post-testing. The contents of both quizzes were identical and were designed to identify the learner's knowledge in the four key areas taught in Learning Unit 8 of the CIS Tutor. In addition, the quizzes had several questions to evaluate the participant's pre-existing foundational knowledge of the subject matter which was critical for both understanding the lecture material and successfully completing the learning unit which included a skills-based assessment in tutorial number four of the learning unit.

The evaluation questions were adapted from fig. 12-2 in the Alessi & Trollip (2000) book. The answer to each question was ranked on a Likert scale utilizing the five point levels of 1 – very poor, 2 – poor, 3 – neutral, 4 – good, and 5 – very good. The questions were grouped into the following eight categories: subject matter, auxiliary information, affective considerations, interface, navigation, pedagogy, invisible features, and robustness. The first three questions dealt with subject matter construction; how well the content was structured, how accurate the content was, and whether or not the participant felt that the goals of the project of the project had been met. Overall the subject matter construction questions received high ratings all falling in the 4 to 5 range; averaging 4.8. The next five questions were subject matter related

as well and dealt with reading level, cultural biases, technical terms and jargon, spelling, grammar and punctuation. This grouping of questions all received 5 point ratings. The auxiliary grouping of questions dealt with how well the subject matter was introduced and the quality of the directions, the help system, and the conclusion. This grouping was the most varied in its results, with the help system receiving the lowest score. This could be that the evaluators didn't realize when the dynamic help system was invoked. The average score for the auxiliary information grouping was 3.9. The affective considerations category consisted of only one question; how well the learner was motivated by the presentation - it scored an average of 4.7. The interface category, which dealt with the display, presentation modes, text quality, animation, graphics, input and spacing, scored very well averaging 4.9 points. The navigation category was pared down to two questions, navigation aids and restarting, scoring an average of 4.8. Bookmarking was removed from the navigation category because the system was not being evaluated on a learning management system and the ability to save the user place in the presentation was not functional. Overall the pedagogy category, which included questions about methodology, interactivity, cognitive capacity, learning metaphor, learning strategies, user control, quiz questions, quality of feedback, format of feedback, and mastery level, all scored well except in the two questions about feedback. This was understandable and was one of the areas the developers felt they needed to focus on before the final release of the product. In the category of invisible features there was only one question which was about the accessibility of the CIS Tutor and scored a 4.1 average. It is believed that this score is because of the antiquated closed-captioning (CC) method incorporated into the Lectora design tool. Originally it was thought that all of the closed captioning would be done in either Camtasia or Captivate which have a more advanced method of closed-captioning video than Lectora. In the end the development team did not have enough time to add captions to all of the animated tutorials. The

security question was removed from this category because the product demonstration was not implemented using an LMS and it was felt that there were no additional security features needed during the evaluation phases. The final category, robustness, included questions about how robust the product was during normal user actions and unusual user actions as well as its ability to perform in cross-platform and cross-browser compatibility. No metrics were added to the evaluation to discern if evaluators actually tested this ability or not, it is assumed that the majority of the evaluators tested the product on a Windows-based PC using Internet Explorer as their Web browser. The assumption of homogeneity is made because of the 5.0 average score received during evaluation. However, the product was tested during development using several different Web browsers types, Gecko, Presto, Trident, and WebKit, so the results of the evaluation should have garnered a 5 point rating anyway.

Conclusions

The purpose of this thesis was to address the question: will an intelligent tutor, designed using cognitive load and multimedia principles using the 4C/ID framework and implemented via a SCORM compliant LMS, improve a learner's ability to learn and transfer complex learning tasks in college level information systems courses? The results are inconclusive in that the difference in the scores between the evaluators' pre-test scores and post-test scores are negligible. It is felt that this is due in part to the fact that the majority of the participants who took part in the beta evaluation phase already had extensive pre-existing knowledge in the fields of information technology and data communications networks. It is planned to take the modifications suggested by the evaluators during the beta testing phase, apply them to the product and then implement the CIS Tutor learning unit 8 in a community college online course and to track the increase or decrease of the student completion rate in order to discern if the product is having a positive or negative impact on learners in this environment.

Recommendations

Based on the quiz results and comments made by participants of the alpha and beta evaluations, recommendations were made to the project team to improve the CIS Tutor. The development team also had several suggestions for improving the product as well. One of the evaluator recommendations was to add more interactive elements to the CIS Tutor suggesting that at least one after each lecture component would be beneficial. Another evaluator had a similar suggestion of checking for comprehension more frequently throughout the tutorials. Several evaluators made comments about adding closed-captioning to the narrated lectures. The development team, as stated previously, was already aware of this and planned to do so when more time was allotted. Another evaluator suggested that the instructions that are displayed in the two number conversion games should remain on the screen while learners attempt to complete the game. This feature has already been modified and incorporated into the beta 2 version of the CIS Tutor that was released with this paper. Due to the complexities of adding database connectivity to the CIS Tutor the development was unable to vary the skills-based assessment portion of the product and has plans to add database functionality and related components to the CIS Tutor as soon as the kinks can be ironed out.

The information presented in this paper was compiled over eight months and consisted of five chapters. Chapter One included an explanation of why the researcher felt this topic was relevant, a statement of purpose, operational definitions of terms, assumptions, and limitations. Chapter Two contained a review of the literature associated with cognitive load theory and the effects of multimedia on cognitive load in complex learning environments. Information on the 4C/ID and ADDIE instructional design models was discussed as well. Chapter Three was comprised of the evaluation and assessment methodology of the product. Information specific to the sample group was reviewed as well. Chapter Four included the duty and task analysis, media

selection rationale, a description of the instructional product, a personnel analysis, a project work plan, an estimated budget, and an implementation and evaluation plan. The project work plan was designed to accommodate the process of creating the CIS Tutor learning unit with flexibility for any changes that occurred. Chapter Five concluded this research with an explanation of the findings, conclusions and recommendations for improvements. In the appendices the reference list, evaluation form, product flowchart, examples of pages from the instructional product, and an IRB approval letter were provided. Additionally, a compact disc of the instructional product was also included.

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APPENDIX A
PLANNING DOCUMENTS

Table 2 *Estimated Budget*

	Projected Total	Actual Total
Prototype Phase		
Textbooks	\$179.00	\$179.00
Prototype Phase Subtotal	\$179.00	\$179.00
Design Phase		
Textbooks	\$239.00	\$239.00
Design Phase Subtotal	\$239.00	\$239.00
Development Phase		
Developer pay (400 hours) @ \$65/hr.	\$26,000.00	\$0
Microsoft Office Professional 2010	\$499.00	\$199.00
Adobe CS5 Master Suite	\$2,400.00	\$150.00
Tranvantis Lectora Inspire	\$2,000.00	\$500.00
Canon Image Class MF8050CN Scanner/Copier	\$599.00	\$599.00
Canon VIXIA HF S1 HD Video Camera	\$1,299.00	\$1,299.00
Canon Rebel Xi Still Digital Camera	\$499.00	\$499.00
Square Perfect Light Box Kit	\$89.00	\$89.00
Behringer C-1U Condenser Microphone	\$129.00	\$129.00
Onkyo TS DX676 Audio Receiver	\$1,099.00	\$599.00
Dell Studio XPS Desktop Computer w/DVD burner	\$2,999.00	\$2,999.00
Dell SP2309W Monitor	199.99	199.99
Dell ST2310 Monitor	\$299.00	\$299.00
Textbooks	\$109.00	\$109.00
Blank DVD Media X 10	\$5.00	\$5.00
DVD Cases X 10	\$7.99	\$7.99
Development Phase Subtotal	\$ 38,232.98	\$ 7,682.98
Project Grand Total	\$ 38,650.98	\$ 8,100.98

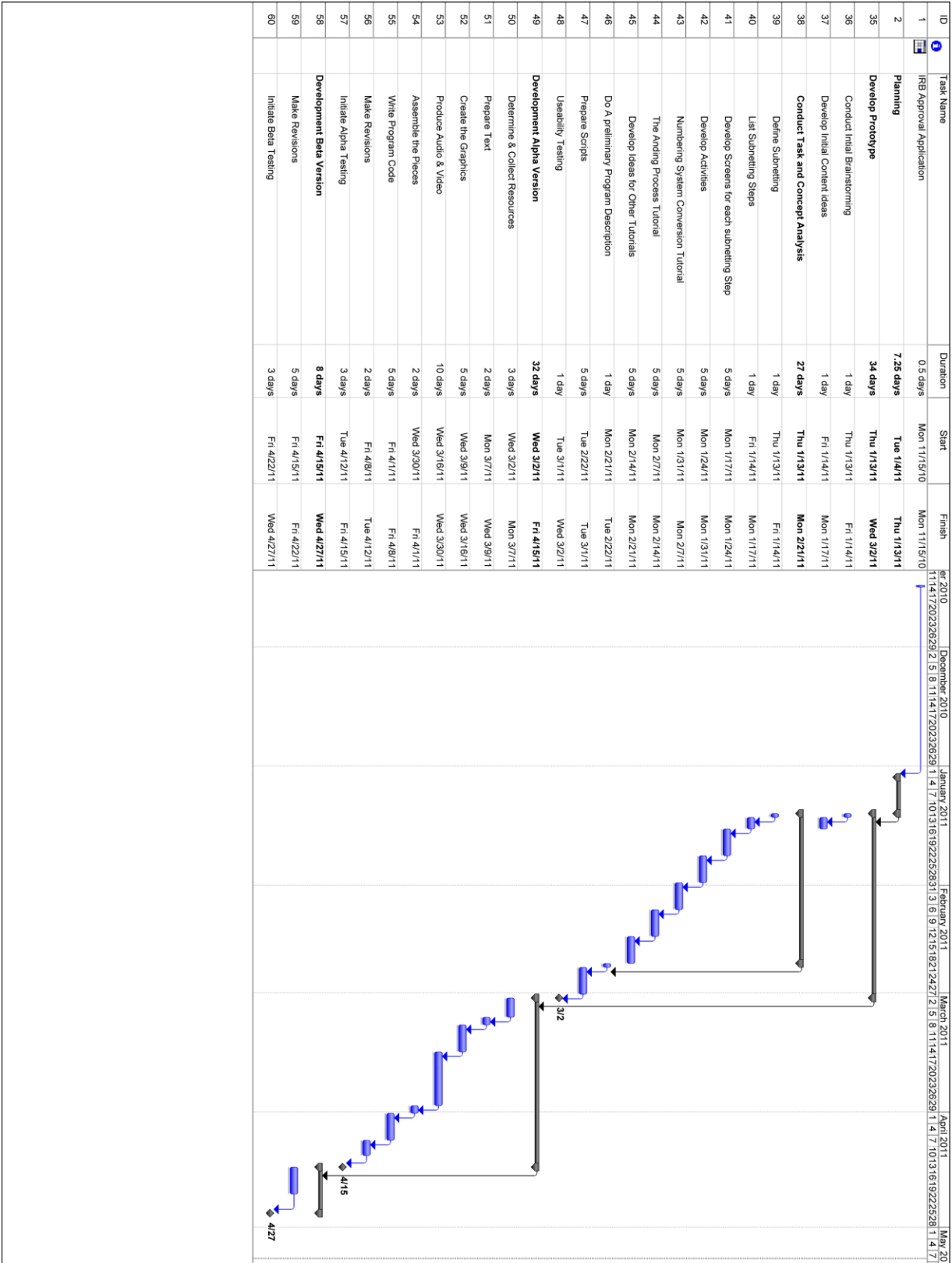


Figure 2 CIS Tutor Project Timeline

APPENDIX B

CIS Tutor Evaluation Instrument

The CIS Tutor was _____ at matching the goals set forth in the project thesis.

Very good Good Neutral Poor Very poor

The CIS Tutor's content structure was _____.

Very good Good Neutral Poor Very poor

The accuracy of the CIS Tutor's content was _____.

Very good Good Neutral Poor Very poor

The reading level of the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The lack of cultural bias, language or references, in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The use of technical terms in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

Spelling, grammar, and punctuation in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The CIS Tutor introduction was _____.

Very Good Good Neutral Poor Very poor

The directions used in the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The Help provided by the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The conclusion of the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The motivational aspects of the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The CIS Tutor screen displays were _____.

Very good Good Neutral Poor Very poor

The presentation modes offered by the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The text quality of the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The animations and graphics used in the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

User input in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The on-screen spacing of elements in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The navigational aids provided in the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The ease of which you could restart the CIS Tutor program was _____.

Very good Good Neutral Poor Very poor

The instructional methodologies used in the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The user interactivity in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The amount of cognitive capacity required by the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The learning metaphor used by the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The learning strategies used by the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The amount of user control provided by the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The quiz questions provided by the CIS Tutor were _____.

Very good Good Neutral Poor Very poor

The quality of feedback provided by the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The format of feedback in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The mastery level in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

Accessibility in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The robustness of normal user actions in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

The robustness of unusual user action in the CIS Tutor was _____.

Very good Good Neutral Poor Very poor

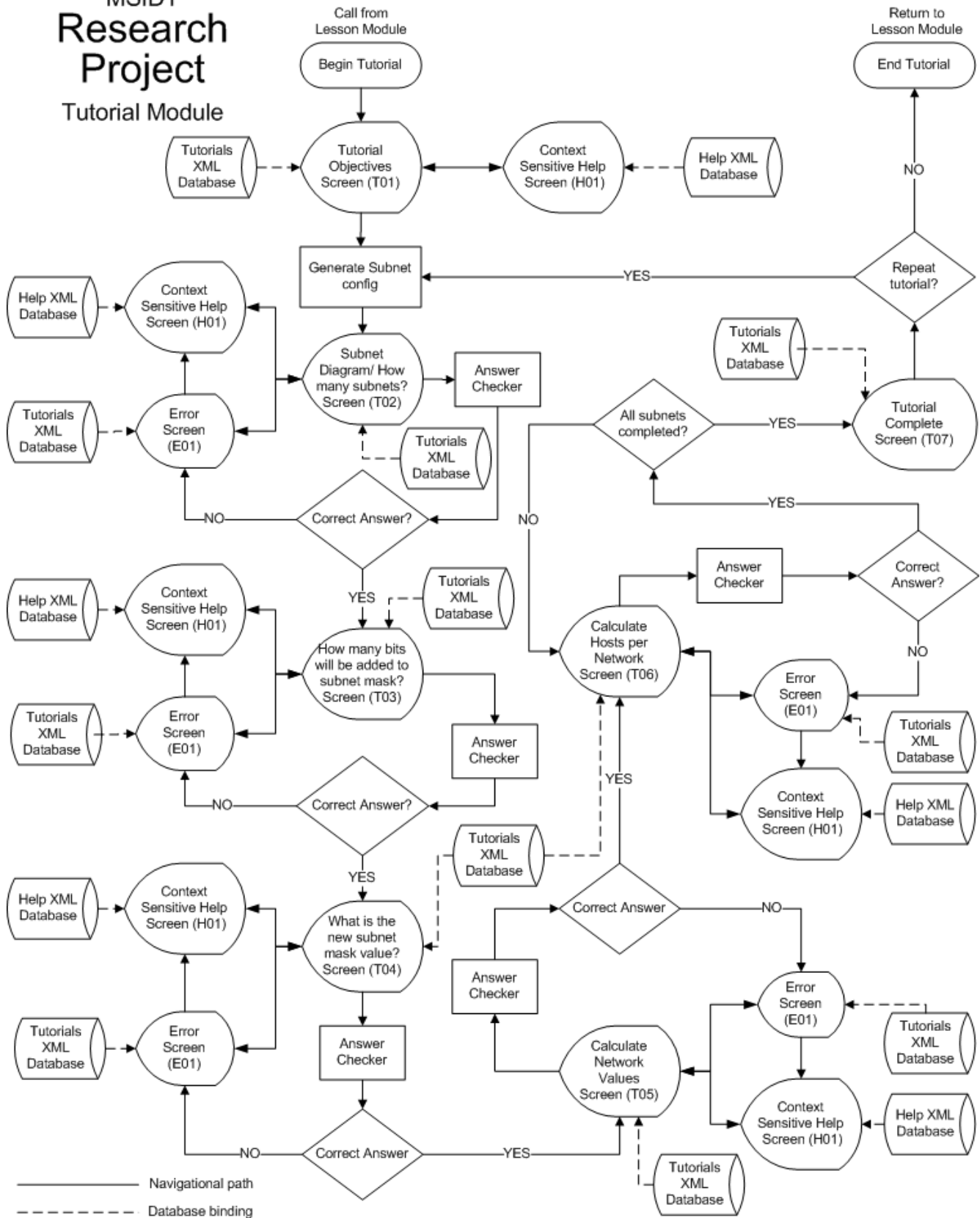
The ability of the CIS Tutor to operate correctly on different operating systems and Web browsers was _____.

Very good Good Neutral Poor Very poor

Please share with us any comments you have about the CIS Tutor.

APPENDIX C

MSIDT
Research
Project
Tutorial Module



APPENDIX D

**CALIFORNIA STATE UNIVERSITY, FULLERTON****College of Education**

P.O. Box 6868, Fullerton, CA 92834-6868 / T 657-278-3411 / F 657-278-3110

From: Bill Bennett
To: Ron Oliver, Chair, IRB Committee
California State University, Fullerton
CC: Dr. JoAnn Carter-Wells, Dr. Cynthia Gautreau, MSIDT Program

The purpose of this memo is to request that my project entitled, *Effective Use of Multimedia in Instructional Design* be given exempt status from review by the CSUF institutional review board (IRB). I am submitting this letter on recommendation from my faculty advisors in the Masters of Instructional Design and Technology (MSIDT) program so as to expedite the IRB process.

As a student in the Masters of Instructional Design and Technology Program at CSUF, I am required to submit an instructional product which demonstrates the knowledge and skills that I have acquired in the program. As you know the MSIDT program is an online Master's degree program designed for professionals working in a variety of settings including pre-K through higher education, the military, and business. The program focuses on the application of technology for teaching, learning and curriculum development used by professionals. A requirement for completion of the program is the creation and assessment of a unit of instruction that can be used to meet an instructional need.

Along with this letter I am submitting an abstract which describes my instructional product in more detail. Once this product has been developed I will need to conduct an assessment that will evaluate the products effectiveness with a specific group of learners. This assessment will also provide me with information that will help me improve the instructional



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College of Education

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product. The assessment is qualitative in nature and as such will not be generalizable to other situations. The results of the assessment will only appear in my Master's project. The anonymity of those individuals participating in the assessment will be maintained at all times.

If you have any questions or concerns please do not hesitate to contact me at the following address:

15441 Washington St., Riverside, CA 92506

951-780-1375

BBennett662@csu.fullerton.edu

I appreciate your help with this matter, as this will greatly facilitate the completion of my final instructional project for the MSIDT program.

Sincerely

Bill Bennett, MSIDT Cohort#8



CALIFORNIA STATE UNIVERSITY, FULLERTON

College of Education

P.O. Box 6868, Fullerton, CA 92834-6868 / T 657-278-3411 / F 657-278-3110

MEMORANDUM

December 9, 2010

Bill Bennett

Your Proposal entitled “Effective Use of Multimedia in Instructional Design” has been reviewed. Since your Masters project is not designed to develop or contribute to generalizable knowledge as described in CFR 46.102(d) but rather is producing and/or assessing an instructional product which does not involve human participants, IRB review is not required and you may commence immediately.

A handwritten signature in black ink, appearing to read "Ron Oliver", is written over a horizontal line.

Dr. Ron Oliver, Chair
Institutional Review Board (IRB)

A handwritten date "11/29/10" is written in black ink over a horizontal line.

Date of Approval

APPENDIX E

REQUEST FOR COMMENTS

The CIS Tutor is an ongoing project and is continually being developed and refined. To view the most recent published version of the project please visit this link

http://cis.msjc.edu/CIS_Tutor.

We would like to hear your comments about the project and would appreciate it if you would take the time to complete the evaluation form located at

http://cis.msjc.edu/CIS_Tutor/Evaluation.