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Multimedia Learning: Effect of Personalization and Segmentation on Recall, Transfer, and Motivation

by

Janna Verburg-Hamlett

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

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Committee Approval Page

To the Graduate Faculty
The members of the committee appointed to examine the dissertation of Janna Verburg-Hamlett find it satisfactory and recommend that it be accepted.

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September 18, 2020

Janna Verburg-Hamlett
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RE: Study Number IRB-FY2020-202: MULTIMEDIA LEARNING: PERSONALIZATION AND SEGMENTATION

Dear Ms. Verburg-Hamlett:

Thank you for your responses to a previous review of the study listed above. I agree that this study qualifies as exempt from review under the following guideline: Category 1. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
This letter is your approval, please, keep this document in a safe place.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

You are granted permission to conduct your study effective immediately. The study is not subject to renewal.

Please note that any changes to the study as approved must be promptly reported and approved. Some changes may be approved by expedited review; others require full board review. Contact Tom Bailey (208-282-2179; fax 208-282-4723; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

College of Southern Idaho Approval Letter

COLLEGE OF SOUTHERN IDAHO

Dr. Michelle Schutt
College of Southern Idaho
315 Falls Ave.
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January 21, 2020

Institutional Review Board
Idaho State University
Tom Bailey, Committee Coordinator
Business and Technology Center, Bldg 86
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Pocatello, ID 83209

Dear ISU IRB,

The purpose of this letter is to grant Janna Verburg – Hamlett, a student at Idaho State University, permission to conduct research at the College of Southern Idaho. The project titled, "Multimedia Learning: Personalization and Segmentation on Cognitive Assessment and Motivation" entails the study of Cognitive Theory of Multimedia Learning through a series of on-line tests administered by random sampling to approximately 120 College of Southern Idaho students.

After review of the study protocol, I, Dr. Michelle Schutt, do hereby grant permission for Janna Verburg - Hamlett to conduct the research title "Multimedia Learning: Personalization and Segmentation on Cognitive Assessment and Motivation" at the College of Southern Idaho.

Sincerely,

Michellè Schutt, Ph.D.
Vice President of Student Services
College of Southern Idaho

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Acknowledgments

I would like to thank everyone who has helped me in my academic accomplishments. I appreciate my committee members who have provided excellent guidance and advice throughout the research process. I especially want to thank my committee chair Dr. Coffland for meeting with me so often and providing great insights and support.

I appreciate Dr. Schutt and the Trades and Industry Department at the College of Southern Idaho for allowing me to interrupt their class time to gather my data.

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Multimedia Learning: Effect of Personalization and Segmentation on Recall, Transfer, and Motivation

Dissertation Abstract – Idaho State University (2021)

This study analyzed two of the multimedia principle's effects - personalization and segmentation - of the cognitive theory of multimedia learning (CTML) on both learning and motivation. The subject matter of the learning material was hazard recognition; the participants were community college students. Data were collected from both a content test and a motivation survey (Keller's IMMS). The content test measured both recall and transfer. A MANOVA was used to analyze the effects of the four combinations of personalization and segmentation on three dependent variables (recall scores, transfer scores, and IMMS scores). The results of this study found no main effects for personalization, segmentation, nor an interaction between the two CTML principles. Additional analysis of the IMMS subscales (attention, relevance, confidence, and satisfaction); showed only confidence had a statistically significant difference between the ps (no segmentation and no personalization) and the pS (no personalization and segmentation) groups. There are several possible reasons why this study did not find the same results as numerous other studies including: small effect size, variability in scores reduced the power, brevity of treatment, the individual lesson not being included in larger unit, lack of diversity in gender and race, diversity in participant's age, and amount of prior experience and safety training. These results are in disagreement with prior published research, although the findings did seem to support Spanjers, et al. (2011) and McLaren, et al. (2011) in regards to students with higher knowledge.

Keywords: ARCS, Cognitive Theory of Multimedia Learning, hazard recognition, Personalization Principle, Segmentation Principle, recall, transfer

CHAPTER 1

Introduction

The number of participants in online or distance learning continues to increase (US Department of Education, N.D.). According to the US Department of Education, in fall 2018, 6,932,074 postsecondary students took at least one course via distance; this number represents 35.3% of all postsecondary students. Even within traditional face-to-face formal instruction, computers and tablets are used to enhance learning (Means, Blando, Olson & Middleton, 1993). With the changing educational environment, researchers are exploring how to effectively teach in the different delivery methods (Means, et al., 1993). In many cases, technology-based lessons make use of a variety of multimedia (Mayer, 2001). Research has shown that these lessons are found to be more effective than lessons that only contain spoken or written words (Mayer, 2001). With the wide variety of delivery methods, researchers are studying how best leaners can achieve the necessary cognitive development (Keller, 2017; Mayer, 2001; Mayer & Moreno, 2003; Rouet, Levonen, & Biardeau, 2001).

The cognitive theory of multimedia learning (CTML) is one way of explaining the efficacy of multimedia versus a single medium (Mayer, 2001; Rouet, et al., 2001; Sweller, 1999). CTML is based on three assumptions: learners have auditory and visual channels to process information; leaners have limited capacity in each channel; and learning is an active process that involves organizing and filtering, selecting, and then integrating information (Mayer, 2001; Mayer & Moreno, 2003).

Multimedia can be defined as a combination of text and pictures; CTML emphasizes that people learn more deeply from both words and pictures than just words alone (Mayer, 2001, 2014). Technology makes it easy to combine words (whether spoken or written) and pictures (whether illustrations, photos, animations, or videos) into learning material (Mayer, 2014a). An important component is to ensure that the multimedia platform reduces, rather than increases, cognitive load (Mayer & Moreno, 2003; Paas, Renkl, & Sweller, 2003; Van Merrienboer, Kirschner, & Kester, 2003). If cognitive load is reduced, there is more capacity in working memory that can be devoted to understanding the material presented and increase the interest of the learner (Harp & Mayer, 1998; Mayer, Sobko, & Mautone, 2003; Moreno & Mayer, 2000; Renninger, Hidi, & Krapp, 1992).

Clark and Mayer (2011) researched and presented on twelve basic principles involved in CTML: coherence, signaling, redundancy, spatial and temporal contiguity, segmenting, pre-training, modality, multimodal, personalization, voice, and image. They identified the coherence, signaling, redundancy, and spatial and temporal contiguity principles as designed to reduce extraneous processing, while segmenting, pre-training, and modality principles manage essential processing. Lastly, the multimodal, personalization, voice, and image principles are applied to increase germane cognitive load.

Another component in educational research is how much motivation affects learning. Keller (2010) states that “motivation refers broadly to what people desire, what they choose to do, and what they commit to do” (p. 3). Keller (1979) designed the ARCS model of motivational design as a systematic approach to designing instructional materials so that a student wants to learn the material. ARCS is an acronym representing the four dimensions of motivation: attention, relevance, confidence, and satisfaction (Keller, 1999, 2010, 2017). Keller believed that conditions could be created and constructed to both facilitate and increase learner motivation (Keller, 2010). In order to measure whether the ARCS model was applied appropriately Keller designed the Instructional Materials Motivation Survey (IMMS) (Keller, 2010). The IMMS “was designed to measure reactions to self-directed instructional materials” (p. 277).

Purpose of the Study

This study seeks to measure the effect that two principles (segmentation and personalization) have on recall and transfer knowledge acquisition. Keller's IMMS survey was used to measure the difference between the variables to determine if there is a difference in motivation among the four treatments. And a researcher created content assessment was used to measure differences in knowledge acquisition.

Research Questions

1. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect recall scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on recall scores for personalized instruction?
    b. Is there a main effect on recall scores for segmented instruction?
    c. Is there an interaction effect on recall scores for personalized and segmented instruction?
2. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect transfer scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on transfer scores for personalized instruction?
    b. Is there a main effect on transfer scores for segmented instruction?
    c. Is there an interaction effect on transfer scores for personalized and segmented instruction?

3. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect motivation scores as measured by Keller's Instructional Materials Motivation Survey (IMMS)?
    a. Is there a main effect on motivation scores for personalized instruction?
    b. Is there a main effect on motivation scores for segmented instruction?
    c. Is there an interaction effect on motivation scores for personalized and segmented instruction?

Four versions of the learning material on hazard recognition were created two with segmentation (present and not present) and two with personalization (formal and conversational).

Limitations

Campbell and Stanley (1963) described eight sources of limitations, Cook and Campbell (1979) added four more elements of limitations to an experimental design. "A limitation of a study design or instrument is the systematic bias that the researcher did not or could not control and which could inappropriately affect the results" (Price & Murnan, 2004, p. 66). The four limitations most likely to affect the study are discussed below.

Sample Size

One limitation is the number of subjects in the study. Since this study obtained a sample from the programs in one department at an Intermountain Western community college, only a limited number of participants per treatment were available. Sample sizes were 24-27 subjects per treatment. The sample size is considered to be sufficient to show a meaningful effect with appropriate amount of power (Myers, Well, & Lorch, 2010).

Instrumentation

The assessment measurement was made up of multiple-choice questions and while reviewed by both subject matter experts and experts in designing educational assessments, did have a few short-answer questions. There could have been some bias in how those short answers were graded; in order to combat this situation, a grading rubric was created. The grading rubric removed potential grading biases. This will be further discussed in Chapter III.

Experimental treatment diffusion

Using the school-issued student identification numbers, students were randomly placed within one of four treatments. The students only had access to their version of the presentation. However, students were in the same computer lab and sitting beside another student who may, or may not, be viewing a different version. In addition, the timing between the material presented and the assessment was partially-controlled by the student. Students could take time between the instruction and the assessment; in which case they could talk about the topic with students in other groups of the study. All assessment questions were the same regardless of treatment; therefore, there could have been some data distortion if students copied or watched other students. The presentations look very similar and so some students may not have even recognized that their presentation was different from the student beside, or in front, of them. In addition, not all students interacted with the materials at the same time. Students were taken to the computer lab by class sections. It took two weeks to cycle all the students through the computer lab. Consequently, some students could have talked to other students about the material and assessment instruments. In order to combat the issue, students were asked to not talk about the material or the experiment.

Prior Knowledge

The researcher could not control how much prior knowledge students had of the subject matter. Within each program of study, students receive safety training applicable to the equipment and tasks within their school laboratory environment from their instructors. In addition, because of the different backgrounds of each student some of them may have worked in a trades environment, or similar industries, for many years before deciding to go back to school to earn a degree or certificate. Consequently, some students may have already received extensive safety training in either a workplace or academic setting. However, students were randomly assigned to one of four groups, allowing equal chance that students who have more experience will be mixed with students who do not have a lot of experience.

In order to measure the amount of prior knowledge and experience in hazard recognition, questions were added to the demographic survey. In order to obtain Institutional Review Board approval to conduct the study, the demographic questions were used to only describe the sample. Data from all four treatments were removed and combined and so additional analysis of the work history question by treatment was not able to be conducted.

Delimitations

Delimitations are choices made by the researcher that affect external validity. "External validity deals with the problem of knowing whether the findings are generalizable to other cases" (Baskarada, 2014). "To the extent and manner in which the results of an experiment can be generalized to different subjects, settings, experimenters, and, possibly, tests, the experiment possesses external validity" (Bracht & Glass, 1968, p. 437). According to Bracht and Glass (1968), there are twelve potential factors affecting external validity. The delimitations that are most likely to affect the generalization of the study are discussed below.

Experimentally accessible population vs. target population

The population in the study does not reflect a population of another area or region. The ethnicity and age of the subjects may not be the same as other regions. "In other words, "… experiments, are generalizable to theoretical propositions and not to populations or universes" (Baskarada, 2014).

Racial / Ethnicity. The demographic of department sample will be discussed further in Chapter IIII. Briefly, however, the students in the department's programs are primarily male, mostly of white, non-Hispanic origin. This community college in the Intermountain West may not have the same ethnic diversity as other community colleges.

Non-Traditional Student. Only one department in one community college was part of the study; consequently, it may be difficult to extrapolate the findings to a larger population. Many people who attend a community college belong to the non-traditional category of students. In 2012 at four-year traditional colleges, 58.1% of students fell into the non-traditional category by one or more characteristics, 16.7% by four or more characteristics (Wladis, Conwey, & Hachey, 2015). This is compared to 87.9% of students attending community colleges who were categorized with one or more characteristics and approximately 33% by four or more characteristics (Wladis, et al., 2015). Fewer than 16% of college students today fit the traditional category of students (Pelletier, 2010).

According to the National Center for Education Statistics, a non-traditional student meets one of the following seven characteristics: delayed enrollment into postsecondary education; attends college part time; works full time; is financially independent for financial aid purposes; has dependents other than a spouse; is a single parent; or does not have a high school diploma (Pelletier, 2010). The American Association of Community Colleges statistics reflect many of these characteristics. The average age in 2015 enrolled in community colleges was 28, with 49% of the population between 22 and 39 (AACC, 2015). In 2011-2012, 22% of students attending school full time were also employed full time, 41% of students attending school part time were employed full time, and 17% of students were single parents (AACC, 2015).

Hawthorne effect (observer effect)

Each student explicitly opted into the study; consequently, the subject (student) knew they were part of an experiment. Furthermore, students knew that the results of the assessment and survey were not part of their grade in their program of study. There could have been some change in behavior because the students knew they were participating in an experiment and the results would not impact their grade. Because the data was collected in one time period, and students were randomly assigned, the observer effect was be minimized.

Length of Assessment

The content assessment contained eight questions to measure recall and nine questions to measure transfer knowledge. The assessment was given only once and no additional lessons or assessments were given after the initial training material. The number of questions and the fact that the assessment was given once could have restricted the range of the dependent variable.

Definition of Terms

Cognitive Theory of Multimedia Learning (CTML): The cognitive theory of multimedia learning is based on three assumptions. Those assumptions include: learners have auditory and visual channels to process information; leaners have limited capacity in each channel; and learning is an active process that involves organizing and filtering, selecting and then integrating information (Mayer, 2001; Mayer & Moreno, 2003).

Extraneous Cognitive Load: Also called incidental processing "refers to cognitive processes that are not required for making sense of the presented material, but are primed by the design of the learning task" (Mayer & Moreno, 2003, p. 45).

Far Transfer: It is considered far transfer when a learner uses the skills or knowledge they learned in a different situation than the specific training context (Macaulay, 2001).

Germane Cognitive Load: Also called essential processing, this "refers to cognitive processes that are required for making sense of the presented material, such as the five core processes in the CTML – selecting words, selecting images, organizing words, organizing images and integrating" (Mayer & Moreno, 2003, p. 45).

Hazard Recognition: In the safety management process, hazard recognition is the first step. Hazard recognition requires the employee to observe and recognize risks to their health (Namian, Albert, Zuluaga, & Behm, 2016).

Intrinsic Cognitive Load: Sweller (1994) defines intrinsic cognitive load as the amount of element interactivity inherent in the material being learned.

Near Transfer: When a student learns something and then is assessed on a very similar situation or task, it is considered near transfer. (Macaulay, 2001).

Personalization Principle: The personalization principle surmises that we learn better from a conversational style rather than a formal style. Simply changing a few words from a passive ambiguous voice, words like "the or they" to "you or I" invites the learner to join into the example or join the conversation (Clark & Mayer, 2011; Mayer, 2014).

Retention: Implies the skills once learned are retained (Vera, Alvarez, & Medina, 2008). "Asking whether learners can recall what was presented in a lesson" is an example of testing for retention (Mayer & Moreno, 2003, p. 43).

Segmentation Principle: The segmentation principle refers to the need to break lessons into manageable portions to manage essential processing (Mayer, 2008, 2014). Essential overload can occur when a large amount of information is presented at a fast pace and exceeds the cognitive capacity of the learner (Mayer, 2014).

Transfer: Transfer refers to the degree the learned skills can be used in new situations (Vera, et al., 2008). Asking students to use the knowledge they learned to "solve novel problems using the presented material" is a method to measure transfer (Mayer & Moreno, 2003, p. 43).

Significance of the Study

This research specifically examined the effectiveness of two principles of CTML (personalization and segmentation) on both recall of knowledge and transfer of knowledge and motivation. One group had instruction with neither of the personalization nor the segmentation principle applied (ps version). One group had segmenting applied (pS version) while the second had the personalization principle applied (Ps version). The fourth and final group had both principles applied (PS version). Each group was compared to each other. Numerous studies have shown the effectiveness of both personalization and segmentation multimedia principles separately compared to control groups on cognitive tests (Boucheix & Schneider, 2009; Clark & Mayer, 2011; Doolittle, Bryant, & Chittum, 2015; Ginns, Martin, & Marsh, 2013; Hasler, Kersten, & Sweller, 2007; Hassanabadi, Robatjazi, & Savoji, 2011; Kartal, 2010; Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009; Mayer, 2008, 2014a, b; Mayer, Dow, & Mayer, 2003; Mayer & Chandler, 2001; Mayer, Fennell, Farmer & Campbell, 2004; McLaren, DeLeeuw, & Mayer, 2011; Moreno & Mayer, 2000; Schneider, Nebel, Pradel, & Rey, 2015; Spanjers, Spanjers, Van Gog, & Van Merrienboer, 2012; Stiller, Freitag, Zinnbauer, & Freitag, 2009; Wang, et al., 2008; Wouters, Van Gog, & Van Merrienboer, 2011). However, no research exists that compares the effectiveness of one principle against the other. This study has the ability to add to the research body of knowledge comparing these specific principles.

Another significance of the study is to analyze how principles from two different domains affects cognitive development. Although it would seem obvious that all 12 principles in the cognitive theory of multimedia learning should be used in all instructional materials. An instructional designer in the professional field often has limited resources and time; consequently, the designer must determine what principles are most effective in cognitive development. Personalization is meant to foster generative processing and assist with germane load. Segmentation is designed to manage essential processing and consequently mange intrinsic load. Another significance of this study is to analyze and determine if the principles have an interaction effect or if one principle limits the effect of the other principle. This study could have helped answer the question on whether there is a diminishing return and, if so, given limitations in instructional design one reducing/managing one type of cognitive load should be empathized over another.

CHAPTER II

Literature Review

Learning via distance methods is increasing (US Department of Education, N.D.). United State Department of Education reported that in fall of 2018, 6,932,074 students; representing 35.3% of all postsecondary students, took at least one course via distance. The terms e-learning, distance learning, and online learning are sometimes used interchangeably in educational literature; however, to some practitioners the terms represent different learning environments and educational tools required (Moore, Dickson-Deanne, & Galyen, 2010). Moore and his colleagues completed a literature review and survey to try to define the different terms. They defined distance learning as “some form of instruction [that] occurs between two parties (a learner and an instructor), it is held at different times and/or places, and uses a varying forms of instructional materials” (p. 2). Online learning is difficult to define; the authors found many different definitions. Some described online learning as completely taking place in an online environment. Others referenced online learning as “a learning experience via the use of some technology.” (p. 2). The authors also described online learning as a new form of distance learning. e-Learning is defined sometimes by the equipment used to deliver the instruction such as web-based or web-distributed. Other definitions are based on the type of experience or level of interactivity. These authors define the term e-Learning as “all forms of e-Learning, whether they be as applications, programs, objects, websites, etc., can eventually provide a learning opportunity for individuals” (p. 2).

Clark and Mayer (2011) define e-Learning as “instruction delivered on a digital device such as a computer or mobile device that is intended to support learning” (p. 7). These authors state online or computer-based learning is a relevant mode of information gathering and education. Researchers are exploring how to teach, and consequently, learn information through computerized methods. E-learning is a type and method of multimedia learning. The cognitive theory of multimedia learning (CTML) is one way of exploring those challenges (Mayer, 2001; Rouet, et al., 2001; Sweller, 1999).

The chapter begins with a review of the theoretical foundation of cognitive theory of multimedia learning including the assumptions and principles that define the theory. In addition, a critical analysis of specifically the personalization and segmentation principles is reviewed. Lastly the chapter reviews the Keller's ARCS-V model and the role of motivation in cognitive development.

Cognitive Theory of Multimedia Learning (CTML)

The multimedia principle asserts that "people learn more deeply from words and pictures than from words alone" (Mayer, 2014a, p. 31). Mayer and colleagues have developed and researched to create the cognitive theory of multimedia learning. "A fundamental hypothesis underlying research on multimedia learning is that multimedia instructional messages that are designed in light of how the human mind works are more likely to lead to meaningful learning that those that are not" (p. 32).

Assumptions

Cognitive theory of multimedia learning (CTML) is based on three assumptions. Learners have multiple channels, both auditory and visual to process information and those channels have limited capacity. Lastly, learning is an active process that involves organizing and filtering, selecting and then integrating information (Mayer, 2001; Mayer & Moreno, 2003). Multimedia can be defined as a combination of text and pictures; the CTML emphasizes people learn more deeply from both words and pictures then just words alone (Mayer, 2001, 2014a).

Today with technology, it makes it easy to combine words (whether spoken or written) and pictures (whether illustrations, photos, animations or videos) into learning material.

The instructional material presented in a multimedia platform needs to reduce cognitive load and not add to it, which is one purpose of applying the CTML principles (Mayer & Moreno, 2003; Paas, et al., 2003; Van Merrienboer, et al., 2003). If cognitive load is reduced, there is more capacity in working memory that can be devoted to understanding the material presented and increase the interest of the learner (Harp & Mayer, 1998; Mayer, et al., 2003; Moreno & Mayer, 2000; Renninger, et al., 1992). The CTML model states we have three levels of memory storage: sensory memory, working memory and long-term memory (Clark & Mayer, 2011; Mayer, 2001, 2014b). Sensory memory is the "part of the cognitive system that briefly stores visual information received by the eyes and auditory information received by the ears" (Clark & Mayer, 2011, p. 470). Working memory is the "part of the cognitive system in which the learner actively (consciously) processes incoming information from the environment and retrieves information from long-term memory" (p. 474). Long term memory is the "part of the cognitive system that stores memories in a permanent form" (p. 465). Long-term memory is thought to be infinite and can store "seemingly unlimited amount of information" (Sweller, Van Merrienboer, & Paas, 1998, p. 254). The memory must be moved from the long-term memory back into the working memory in order for the learner to be conscious of the thoughts (Sweller, et al., 1998). A learner's sensory memory only holds the information for a short period, then it needs to be utilized by the working memory or lost (Clark & Mayer, 2011; Sweller, 1994; Sweller et al., 1998). It is the job of working memory to select appropriate information from the sensory memory, to process and integrate (Sweller, et al., 1998). However, working memory is limited, "anything beyond the simplest cognitive activities appear to overwhelm working memory" (Sweller et al., 1998, p. 252-253).

In order to retain information, the working memory needs to process that material into schemas, which are stored in long-term memory for later use (Sweller, et al., 1998; Sweller, 2005). Schemas allow a learner to store and process knowledge (Sweller et al., 1998). "According to schema theory, it is through the building of increasing numbers of ever more complex schemas by combining elements consisting of lower level schemas into higher level schemas that skilled performance develops" (p. 253). The learner's already developed schemas reduce working memory load, and can be applied automatically (Sweller, et al., 1998). Once a learner has developed a schema they no longer have to spend energy or time understanding the process. A person can drive a car because they have developed schemas on the mechanics of how to drive the car, how to turn the car on, how to use the key, how to work the radio, stop signs, traffic patterns, etc. Every time a person gets into a car, they do not need to re-learn all the components of the car because they have a schema to draw from. However, when encountering something new, a learner will search their already existing schema to integrate the new knowledge (Sweller, 1991; Sweller, et al., 1998). Less working memory is needed to pin that new knowledge to an existing schema; however, if there is no existing schema, the learner must exert additional cognitive energy building the schema and learning the new material (Chandler & Sweller, 1991; Sweller, et al., 1998).

The second assumption of the cognitive theory of multimedia learning regarding limited capacity is based on Sweller's cognitive load theory (Chandler & Sweller, 1991; Sweller, 1994, 2005). Cognitive load is "generally considered a construct representing the load that performing a particular task imposes on the cognitive system. It can be conceptualized as a task-based dimension (i.e., mental load) and a learner-based dimension (i.e.; mental effort), both of which affect performance" (Sweller, et al., 1998). There are three types of cognitive load: intrinsic, extraneous and germane (Sweller, et al., 1998).

Intrinsic cognitive load is inherent in the material and can be characterized by the amount of element interactivity (Sweller, 1994). According to Sweller high element interactivity refers to when many elements interact and must be learned concurrently which causes higher intrinsic cognitive load. Sweller defined low intrinsic cognitive load occurs when elements can be learned as individuals and do not interact. "The elements of most schemas must be learned simultaneously because they interact and it is the interaction that is critical" (Sweller, 1994, p.295).

Extraneous processing, also called incidental processing "refers to cognitive processes that are not required for making sense of the presented material, but are primed by the design of the learning task" (Mayer & Moreno, 2003, p. 45). Although extraneous materials may be interesting, the material is not essential to meaningful learning (Mayer, 2014a). Extraneous material requires the learner to use precious cognitive load to understand or dismiss (Clark & Mayer, 2001).

Germane, also called essential processing "refers to cognitive processes that are required for making sense of the presented material, such as the five core processes in the CTML – selecting words, selecting images, organizing words, organizing images and integrating" (Mayer & Moreno, 2003, p. 45). Germane cognitive processing is essential in developing and accessing schemas stored in long-term memory (Paas, et al., 2003; Sweller, et al., 1998). It is difficult for instructional designers to influence intrinsic cognitive load; however, extraneous and germane cognitive load are directly influenced by instructional designers (Paas, et al., 2003; Sweller, 1994; Sweller, et al., 1998).

Instructional designers can manage load by breaking larger components into smaller components giving time for students to understand and match the material to a schema. Once new information is applied to an already existing schema, students can free working memory to start understanding additional concepts. Achieving schema design reduces cognitive load (Paas, et al., 2003; Sweller et al., 1998). "Whereas extraneous cognitive load interferes with learning, germane cognitive load enhances learning" (Paas, et al., 2003, p. 2). The three levels of cognitive load work together and add to each other. "Intrinsic, extraneous, and germane cognitive loads are additive in that, together, the total load cannot exceed the working memory resources available if learning is to occur" (Paas, et al., 2003).

Mayer's (2014a) third assumption of CTML states that learning is not a passive but an active process of reviewing, selecting and then absorbing information into schemas and existing memory channels. The brain does not interpret pictures and text at the same rate or in the same method. In order to process visual images and auditory information in a multimedia presentation the leaner constructs logical mental pathways and integrates with the appropriate prior knowledge (Mayer, 2014a).

CTML Principles

Clark and Mayer (2001) researched and presented on the basic principles involved in CTML: coherence, signaling, redundancy, spatial and temporal contiguity, segmenting, pre-training, modality, multimodal, personalization, and voice. The five principles that are meant to reduce extraneous processing and so also reduce cognitive load are coherence, signaling, redundancy, and spatial and temporal contiguity principles (Mayer, 2014b). Mayer also identified three multimedia principles that manage essential processing and intrinsic load; segmenting, pre-training, and modality principles. To foster generative processing and assist with germane load Mayer emphasized the multimedia, personalization, and voice principles.

CTML Principles that Reduce Extraneous Processing

Coherence, signaling, redundancy, and spatial and temporal contiguity principles are meant to reduce extraneous processing and so reduce cognitive load (Mayer, 2014b). Material that does not directly assist the learner in understanding the lesson being taught is considered extraneous material (Mayer & Moreno, 2003). Removing or restructuring the material allows cognitive processes to be focused on the material being taught (Mayer, 2014b).

Coherence Principle. The coherence principle states that people learn better when unnecessary extraneous material is not included in the lesson (Mayer, 2014b). This has been shown in numerous studies, including on how a cold virus infects the human body and how digestion works (Mayer, Griffith, Jurkowitz, & Rothman, 2008). In both cases differing amounts of seductive detail, information that is interesting but not relevant to the instructional outcome, was added. In both cases when there was a lower amount of extraneous material the students scored higher on tests of transfer when compared to students who viewed material that had high amounts of extraneous materials (Mayer, et al., 2008). Another study taught students about the formation, propagation, and dispersion of ocean waves (Mayer & Jackson, 2005). In the expanded version additional mathematical formulas and illustrations were added to the material. Students who viewed the concise version (non-expanded) scored better on transfer tests then students who viewed the material with the additional items (Mayer & Jackson, 2005).

Signaling Principle. The signaling principles adds cues to draw attention to the main ideas of the material being studied (Mayer, 2014b). By adding a sentence to the beginning of the material stating the main idea, or adding main idea headings, vocally stressing main ideas, or adding additional visual cues like highlighting or arrows to the material are all examples of signaling (Mayer, 2008). In one study the researchers designed four versions of a computer-based, user-controlled, animation teaching how an upright piano mechanism functions (Boucheix, Lowe, Putri, & Groff, 2013). In addition to a knowledge assessment, researchers also tracked eye movements to ensure students were utilizing the cues. The students who received the versions with cues scored higher than the students who did not get the cues in the material (Boucheix, et al., 2013). In another study, researchers designed a lesson on how a turbofan jet engine works (Ozcelik, Arsian-Ari, & Cagiltay, 2010). The material was narrated and had a static image. As the narration discussed certain sections of the engine, the labels changed color. On a transfer test, students who viewed the signaled presentation scored higher than students who did not have the signaled lesson (Ozcelik, et al., 2010).

Redundancy Principle. The redundancy principle states that people learn more deeply from animation and narration then from the combination of animation, and narration, and on-screen text (Mayer, 2014b). Craig, Gholson, and Driscoll (2002) used an animated pedagogical agent in the form of a bug named Herman, and a lesson on plant environments, to study redundancy. Three multimedia lessons were created using either printed text, spoken narration, or both spoken narration with redundant printed text. The spoken-narration version outperformed the other two options on the assessment (Craig, et al., 2002). In addition, several studies involving learning material on how lightening is formed found similar results (Austin, 2009; Moreno & Mayer, 2002). Two versions were studied; a version with narration, and a version that used the same narration, but also added some additional on-screen text. Students in the narration only group scored higher on a transfer test than students who received the narration and on-screen text supplements (Austin, 2009; Moreno & Mayer, 2002).

Spatial Contiguity Principle. Where the printed words are located in relation to the graphics is the basis of the spatial contiguity principle (Mayer, 2014b). It has been found that people learn better when the printed text and corresponding graphic(s) are placed near each other, rather than on another page or far from each other (like in a caption) (Mayer, 2008). In an experiment on lessons about how car brakes work, students viewed a presentation with the words presented near the area of the diagram, as a paragraph under the diagram, or lastly in a legend below the diagram (Johnson & Mayer, 2012). On a transfer test, the students that viewed the text near the area of the diagram better than the other two groups (Johnson & Mayer, 2012). This also occurred in a study by Moreno and Mayer (1999) when studying the formation of lightening. Students viewed a narrated presentation with either the text appearing near, or far from the animation. Students learned better when the text and animation where near to each other on retention, transfer and matching tests (Moreno & Mayer, 1999).

Temporal Contiguity Principle. The temporal contiguity principle states that students learn better when the graphics and narration are presented concurrently rather than in sequence (Mayer, 2014b). The spoken words are presented with the graphics on the screen, rather than the narration occurring before or after the animation (Mayer, 2017). One may believe that words then graphics would be better because the learner is being exposed to the same material repeatedly (Mayer, 2017). However, the learner must try and keep the entire narration in working memory while also viewing the animation or graphics and so has less space/time to integrate the material into a schema (Mayer, 2017). Ginns (2006) completed a meta-analysis on this principle and found 50 independent studies supporting the theory.

CTML Principles that Manage Essential Processing

Segmenting, pre-training, and modality manage essential processing (Mayer, 2014b). Managing essential processing will also assist in managing intrinsic load (Mayer, 2014b). Intrinsic load is based upon the inherent complexity of the material being taught (Sweller, et al., 1998).

Segmenting Principle. The segmenting principles states that learners perform better on material when they have control of the pace of the instruction (Mayer, 2014b). The segmenting principle is a variable of this research study; consequently, it will be discussed in more depth later in this chapter.

Pre-Training Principle. In order to manage essential processing, some concepts need to have training on main concepts or vocabulary before the lesson (Mayer, 2014b). For example, in the case of how car brakes function, prior to the multimedia lesson, students are able to click on the parts of the brake system to learn about the name and basic function (Mayer, Mathias, & Wetzell, 2002). Students scored higher on the posttest, both transfer and retention, after they received the pre-training before the actual presentation. Another study examined pre-training with a lesson on electrical circuits (Kester, Kirschner, & Van Merrienboer, 2007). The study created four presentations; supportive material (prerequisite knowledge and definitions) presented before or after the task practice, and procedural information before or during the task. Transfer testing showed that students who received the supportive material before scored higher when compared to the other groups (Kester, et. al., 2007).

Modality Principle. The modality principle states that people learn more deeply from graphics and spoken narration then from graphics and printed text (Mayer, 2014b). This allows learners to use both their visual channels (graphics) and auditory channels (hearing) (Mayer, 2017). The modality principle is one of the most studied of the principles (Mayer, 2017). Ginns (2005) performed a meta-analysis on the modality effect and found 43 independent effects (39 between-subjects designs, 4 within-subjects designs). Mayer (2014b) found 42 out of 51 experimental research studies showing that people learned better from narration when compared to the written words printed on the screen.

CTML Principles that Foster Generative Processing

The multimedia, personalization, and voice principles foster generative processing and also assist with germane load (Mayer 2014b). If the learning material is designed so that students are interested and choose to use their cognitive capacity to make sense of the material, learning has a greater chance of occurring. According to Mayer, these principles motivate the learner to become interested in the material.

Personalization Principle. The premise of the personalization principle is people learn more deeply when the content is presented in a conversational style rather than a formal style (Mayer, 2014b). One of the variables of this research paper is the personalization principle, it will be discussed in further detail later in the chapter.

Voice Principle. People learn better when the voice in the spoken narration is a human voice instead of a machine voice (Mayer, 2014b). In one study participants learned about proportional reasoning with a pedagogical agent who spoke with either a human voice or machine synthesized voice (Atkinson, Mayer, & Merrill, 2005). Students scored higher on both near and far transfer tests, and more positively rated the speaker when the agent used the human voice (Atkinson, et al., 2005). In another study, Mayer and DaPra (2012) studied the embodiment effect of a pedagogical agent. Students viewed a short 4-minute narrated presentation on how solar cells function. In the screen the pedagogical agent stood on the side of each slide. The study found in three different experiments that students learn better when the pedagogical agent uses human-like gestures, facial expressions, and a human voice, (embodiment effect) than compared to students who reviewed a presentation when the pedagogical agent did not use the embodiment effects (Mayer & DaPra, 2012).

There is sufficient evidence to support all of these multimedia principles; however, this research specifically looks at two principles: the personalization principle and the segmenting principle. The personalization principle is meant to increase learner interest using conversational style rather than formal style (Clark & Mayer, 2011). The segmenting principle is used to reduce cognitive load and allow the learner to engage by controlling the pace of material (Clark & Mayer, 2011).

Personalization Principle

The personalization principle surmises that we learn better from a conversational style rather than a formal style. The more passive ambiguous voice like "the or they" are changed to the conversational voice of "you or I" inviting the learner to join the conversation (Clark & Mayer, 2011; Mayer, 2014a). The purpose is to engage the listener by bringing them into the conversation (Clark & Mayer, 2011; Mayer, Fennell, Farmer, & Campbell, 2004; Mayer, 2014a; Moreno & Mayer, 2000). Moreno and Mayer (2000) refer to this as the "cocktail party effect, in which a person who is attending to one conversation is able to detect his or her own name in a separate conversation that is taking place simultaneously in the same room" (p. 724). The personalization principle assumes that learners who feel they are involved in the material are more likely to process the material and perform better on transfer or retention tests (Mayer et al., 2004; Mayer 2014a; Moreno & Mayer, 2000; Rogers et al., 1977; Symons & Johnson, 1997). There have been several studies that show the conversational type style can make the training more engaging and increase retention (Clark & Mayer, 2011; Ginns, Martin, & Marsh, 2013; Kartal, 2010; Mayer, et al., 2004; Mayer 2008, 2014a; McLaren, et al., 2011; Moreno & Mayer, 2000; Schneider, et al., 2015; Wang et al., 2008).

In a meta-analysis on personalization Ginns, Martin and Marsh (2013) reviewed research conducted on personalization. Overall the study found students perceived the lesson as friendly with moderate effect ($d = 0.46$). However, the effect size ($d = 0.16$) was small in how participants perceived the personalized lesson in assisting the actual learning. Conversational instruction generated higher levels of interest although it had a small effect size ($d = 0.15$); however, there was variability among the studies. Some studies had small or no effect size, however some studies had higher effect size. Personalized text did support more effective cognitive processing with a large effect ($d = 0.62$). The last two hypothesis reviewed involved results from tests of retention and tests of transfer. Conversational style had a statistically significant effect on assessments both on retention ($d = 0.30$) and transfer ($d = 0.54$).

Moreno and Mayer (2000), used a computer-based game on botany in a set of five studies. In all five studies, students performed better on transfer tests when the instruction used the conversational style versus the formal style. On a transfer test, the personalized group scored 20 to 46 percent higher than the formal style group (Moreno & Mayer, 2000).

Moreno and Mayer (2000) also designed a study involving a lesson on lightning. The lesson used conversational style speech instead of formal style speech. For example, the third party “people,” was changed to first person “you” in the lesson. Students who were presented with the personalized version scored better on a transfer test with effect size greater than one (Clark & Mayer, 2011).

Mayer, Fennell, Farmer and Campbell (2004) conducted a study using narrated animations to teach students about how people's lungs worked. The materials were developed using a computer-based program. Both presentations were 60 seconds, showed the same animation of lungs inhaling and exhaling, and were narrated by the same male voice. The following was the last sentence of the formal style: "During exhaling, the diaphragm moves up, creating less room for the lungs, air travels through the bronchial tubes and throat to the nose and mouth where it leaves the body" (Mayer, et al., 2004, p. 390). The sentence was changed by substituting the word "the" with the word "your" (Mayer, et al., 2004). The personalized version read: "During exhaling, your diaphragm moves up, creating less room for your lungs; air travels through your bronchial tubes and throat to your nose and mouth where it leaves your body" (Mayer, et al., 2004, p. 390). Results showed that scores on the retention test were not significantly different but the scores on the transfer test showed the personalized group scored significantly higher (Clark & Mayer, 2011; Mayer, 2008; Mayer, et al., 2004).

Another study created three different formatted computerized instructional material on the stages of stellar evolution in Turkish (Kartal, 2010). The materials used the same visuals and text, except additional expressions were added for personalization or conversational style. Material was either personalized informal (conversational – informal direct comments to the user), personalized formal (direct comments to the user in a formal manner) or neutral formal (no direct comments to the user, third person formal). The study participants included 89 college students, a majority of the students were Turkish first-language speakers. After reviewing the material, students were given a retention and transfer assessment. Data supported other research studies, with students scoring higher on assessments whom were in the personalized information material. In addition, the researchers asked questions on their perception of the computer program for difficulty and motivation. Learners reported that the personalized information group was friendlier than those in the other two groups. Lastly, students found that the neutral formal group material was more difficult when compared to those who viewed the personalized informal group (Kartel, 2010).

In a German upper secondary school, 166 children ranging in age from twelve to fifteen participated in a lesson about photosynthesis (Schneider, Nebel, Pradel, & Rey, 2015). The lesson used youth slang words in place of formal text (Schneider, et al., 2015). For example, “wicked” was used instead of “very bad”. Additionally, youth slang typical prefixes and reductions were used wherever possible (e.g., “What’*s up*?”). The performance of the learners was measured with both a retention test and a transfer test. The authors found little difference in scores between the personalized group and the standard German group (Schneider, et al., 2015).

Although several studies do show an improvement in transfer with personalized style over formal style, there is little data to show when the personalized version starts detracting from the educational material. In order to prevent this weakening from occurring, instructors must fully understand their students and audiences. How much personalization is too much, causing the students to doubt the validity of the material, or losing the leaners’ interest and engagement? For example, “Wow, hi dude, I’m here to teach you all about …. so hang onto your hat and here we go!” (Clark & Mayer, 2011, p. 165). Is that statement too personalized, does that tone create an inappropriate learning environment? The personalization principle should be used to “write with sufficient informality so that the learners feel that they are interacting with a conversational partner but not so informally that the leaner is distracted or the material is undermined” (Clark & Mayer, 2011, p. 165).

Another type of personalization is politeness theory. The politeness effect is drawn from research by Brown and Levinson (1987). In one study, students interacted with a web-based factory modeling simulation system called Virtual Factory Teaching System (Wang, et al., 2008). The simulation is frequently used in industrial engineering courses for practice on product inventory and management topics. The study used polite and direct suggestions in both hints and feedback. Fifty-one students from the University of Southern California and University of California, Santa Barbara participated. Subjects who received the polite versions learned more than those who received the direct feedback. However, in the additional analysis there was no statistically reliable differences between conditions on ratings of self-efficacy, sense of control, interest or tutor helpfulness (Wang et al., 2008).

McLaren, DeLeeuw, and Mayer (2011) also studied the politeness effect. Previous research looked at politeness in relation to feedback. Feedback that was considered polite was cooperative and suggestive (McLaren, et al., 2011). For example, “You could press the ENTER key” or “Let’s click the ENTER button” (McLaren, et al., 2011, p. 576). Feedback that was considered negative was more imperative and direct, it did not consider cooperation, and limited the student’s freedom. For example, “Press the ENTER key” or “The system is asking you to click the ENTER button” (McLaren, et al., 2011, p. 576). Students (132 participants) were enrolled in a chemistry class learning about stoichiometry in a three U.S. high schools in two states. Students were randomly assigned to one of four treatments; polite/text, polite/audio, direct/text and direct/audio. Students were given a pre-questionnaire on their background and understanding of chemistry. From the questionnaire, students were classified as low prior knowledge or high prior knowledge learners. There did not appear to be a benefit in the polite feedback in the higher prior knowledge groups. However, in the lower prior knowledge there was a slight statistical difference in the polite feedback on the immediate posttest when compared to direct feedback (McLaren et al., 2011). This study shows that although personalization has an effect on low prior knowledge leaners, it may not have an effect on learners who have an advanced understanding of the material and concepts.

Segmenting Principle

The segmenting principle refers to the need to break lessons into manageable portions to manage essential processing (Mayer, 2008, 2014a). Essential overload can occur when a large amount of information is presented at a fast pace and exceeds the cognitive capacity of the learner (Mayer, 2014a). Sweller referred to this situation as the amount of intrinsic cognitive load (Paas, et al., 2003; Sweller, et al., 2011). As learners, we have a finite amount of cognitive processing or working memory (Paas, et al., 2003; Sweller, 1994, 1999; Sweller, et al., 2011). Working memory can only handle a limited number of new or novel interacting elements, "possibly no more than two or three" (Paas, et al., 2003, p. 2). In order to maximize a learner's ability, instructional techniques that do not contribute to schema acquisition must be avoided (Paas, et al., 2003; Sweller, 1994, 1999; Sweller, et al., 2011). "Different materials differ in their levels of element interactivity and thus intrinsic cognitive load, and they cannot be altered by instructional manipulations; only a simpler learning task that omits some interacting elements can be chosen to reduce this type of load" (Paas, et al., 2003, p.1). Low-element interactivity only requires a few elements processed in the working memory at a time (Sweller, et al., 1998). High element interactivity requires several elements to be processed and manipulated by the working memory concurrently (Sweller, et al., 1998). Some concepts are just difficult to understand. However, the concepts and materials cannot be disregarded; consequently, the course designer must find ways to reduce cognitive load. Since the concept cannot be reduced, the essential overload must be managed with the amount of essential material (Mayer, 2014a).

Rather than overloading the cognitive processes of the learner with a continuous amount of information, the material is broken into manageable sections that allow the learner to press a button to continue after the learner is cognitively ready to move forward (Mayer, 2008, 2014a). Research has shown that, when learners have control of the pace of information they are better able to manage the cognitive load (Boucheix & Schneider, 2009; Doolittle, Bryant, & Chittum, 2015; Hasler, Kersten, & Sweller, 2007; Hassanabadi, Robatjazi, & Savoji, 2011; Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009; Mayer, 2008, 2014a; Mayer & Chandler, 2001; Mayer, Dow, & Mayer, 2003; Spanjers, Wouters, Van Gog, & Van Merrienboer, 2011; Stiller, Freitag, Zinnbauer, & Freitag, 2009; Spanjers, Van Gog, & Van Merrienboer, 2012).

Mayer and Chandler (2001) designed an experiment using instructions with 16 steps of information that showed how a lightning storm develops. The 140 second narrated animation was broken into 16 segments each lasting 10 seconds; with a continue button after each segment. The learners who received segmented lessons performed better on a retention test than the learners who learned from the continuous lessons. The segmented version allowed the learner to interpret and complete the necessary cognitive processes before continuing to the next segment (Mayer & Chandler, 2001).

Mayer, Dow, and Mayer (2003) performed another experiment with a narrated animation of how an electric motor works. In the experiment, learners were presented with a list of questions and the parts of the motor. Then the leaner could click on a question, or on part of the motor to either hear, or see a short lesson on that portion. In this experiment rather than a continuous presentation of the same information, the learner had control of the order and pace of information. The group of learners who received the segmented version performed better on transfer tests than the group that received the continuous version (Mayer, et al., 2003).

Moreno (2007) presented prospective teachers with a video or animated lesson on teaching skills. In the experiment, the segmented version was broken down into seven segments, and between each segment had to click to continue. The non-segmented group received a continuous lesson with the same information. The segmented group performed better on transfer tests then the non-segmented group (Moreno, 2007).

Elementary school students, interacted with a lesson about how day and night are caused (Hasler, Kersten, & Sweller, 2007). The low interactivity was a static, learner-controlled lesson. The high element interactivity provided interaction opportunities between the learner and the lesson. The study showed the segmented group performed better on low element interactivity questions, high element interactivity questions, and overall performance (Hasler, et al., 2007).

Boucheix and Schneider (2009) conducted a study with college students that also explored the effects of segmentation. They created instruction on how a pulley system works. The authors found the segmented group performed better on the functional mental model test when compared to the non-segmented group.

An experiment about human eye structure was conducted with college students (Stiller, Freitag, Zinnbauer, & Freitag, 2009). One group of students saw a continuous version of the material, and the other group of students saw a segmented version. The group shown the segmented version performed better on the transfer test than the group that saw the continuous version (Stiller, et al., 2009).

Hassanabadi, Robatjazi and Savoji (2011) conducted an experiment using two versions of segmentation and two versions of modality to see if there was a difference in learning. Four groups of 96 students were divided between: system-controlled segmentation and learner-controlled segmentation, and narration versus on-screen text. The system-controlled segmentation paused for three seconds between slides. The learner-controlled segmentation required the learner to press a play button. The findings showed that the learner-controlled group had a higher retention score and reported less cognitive load than the system-controlled group (Hassanabadi, et al., 2011).

Spanjers, Wouters, Van Gog, and Van Merrienboer (2011) argued that segmentation may be more important for students with low level of prior knowledge than students with a higher level of prior knowledge. The argument is that students with a higher level of prior knowledge are able to process the new concepts and handle the cognitive load (Spanjers, et al., 2011). The authors even argue that the segmentation may be detrimental to those students with the higher level of prior knowledge because the instructional design may affect their already developed schemas. The researchers studied the concept of expertise reversal in the context of segmentation in their study of 76 Dutch secondary education students using calculations on probability. The pedagogical agent was a dolphin, and the narration was spoken by a male voice with a neutral accent. A prior knowledge test was given, eight animated worked-out examples were presented, and then a transfer test was conducted. The non-segmented version was shown as a continuous lesson. The segmented version was devised by three experts; and varied between five and seven portions, with a two-second pause in between each portion. Results showed that students with lower level prior knowledge did better with the segmented version of the material. However, there was no difference between the segmented and the non-segmented version with the higher-level prior knowledge students (Spanjers, et al., 2011).

To continue the Spanjers, et al. (2011) study, Spanjers, Van Gog, and Van Merrienboer (2012) used the same material but, instead of the animations, students read the text instead of interacting with the pedagogical agent. The segmented version was separated from the non-segmented version with blank lines to give the leaner a time to pause before continuing to the next information (Spanjers, Van Gog, & Van Merrienboer, 2012). A third version was added to the experiment, which required the learner to actively segment the lesson into greater than three but less than nine segments. Both a pre-test and post-test were used to assess learning. The authors found that scores increased between the pre-test and post-test for all three versions; consequently, students learned regardless of the instructional strategy. However, students in the actively segmented group had to expend more mental effort then either the segmented or the unsegmented group. Between the segmented version and the unsegmented version, students used the least amount of mental effort in the segmented group. This suggests that the version already segmented for the student required the least amount of mental effort (Spanjers, et al., 2012).

Doolittle, Bryant, and Chittum (2015) studied the degree of segmentation, and how many segments affect learning or become a distraction. The study was designed to determine exactly how many segments would be most effective. Researchers used a transfer test to assess the amount of learning, and a survey to assess learner disposition to the material. 212 undergraduate students interacted with a multimedia tutorial on historical inquiry which was broken into one, seven, 14, or 28 segments in the study. Students used a continue button to control the speed of the presentation. Results showed those students who interacted with the 28-segment version did better on the transfer test than the students in the other conditions; supporting the cognitive load theory. On the disposition questionnaire, students supported segmentation and reported positive feelings throughout all segments except for the version with 28 segments. On the questionnaire, students reported the increase in pauses were “annoying and inappropriate” (Doolittle et al., 2015 p. 1340). Although students reported a negative perception of the increases in segmentation, they learned the best with the increased segmentation; unfortunately, students do not always know the best ways to study or learn (Doolittle et al., 2015).

Specifically looking at segmentation and working memory capacity, Lusk, Evans, Jeffrey, Palmer, Wikstrom, and Doolittle (2009) designed an experiment with 133 undergraduate students who were given a series of basic math problems and at the same time asked to remember a series of unrelated words. Researchers used the scores to classify the participants into two groups: the high working memory capacity group or low working memory capacity group (Lusk et al., 2009). The segmenting portion of the study exposed learners to the Summarizing, Contextualizing, Inferring, and Monitoring (SCIM) Historical Inquiry Tool. Students were given either the segmented version or the non-segmented version. Participants were given both a recall and application test. As in previous studies, students engaged in the segmented version scored higher on the recall and application test when compared to the students in the non-segmented group. In addition, segmentation showed a positive effect on both low working memory and high working memory groups. Their findings suggest that, as an instructional strategy, segmentation can be used to alleviate some of the stress associated with learning new material by controlling the cognitive load (Lusk et al., 2009).

Since the concept cannot be reduced, the essential overload must be managed with the amount of essential material (Mayer, 2014a). Segmentation works by breaking up materials in manageable sections. Rather than overloading the cognitive processes of the learner with a continuous stream of information the material is broken into manageable sections and allows the learner to press a button to continue (Mayer, 2008, 2014a). In order to maximize a learner's ability, instructional techniques that do not contribute to schema acquisition must be avoided (Paas, et al., 2003; Sweller, 1994, 1999; Sweller, et al., 2011). The learner needs to reduce the amount of cognitive load and items in the working memory to be able to develop and modify existing schema. In order to ensure that unnecessary information does not utilize necessary working memory resources, instructional designers need to use good tools and techniques. In addition, segmenting allows learners to have control over the pace of the material. When learners control the quantity of information, they are better able to manage their cognitive load. The studies reviewed above provide strong evidence that learners perform better when material is broken into different segments and the learner has control of the speed of material. However, what is unclear is whether segmentation or personalization or both have a greater impact on transfer or retention this study will attempt to address those particular elements. This study will attempt to address those particular elements.

Motivation

Keller (2010) stated that "motivation refers broadly to what people desire, what they choose to do, and what they commit to do" (p. 3). Keller (2017) designed the ARCS model of motivational design to be a systematic approach to designing instructional materials so that a student wants to learn the material. ARCS is an acronym representing the four dimensions of motivation: Attention, Relevance, Confidence, and Satisfaction (Keller, 1999, 2010, 2017). The ARCS model will be discussed further in the chapter.

Keller designed the model from the expectancy-value theory (Li & Keller, 2018). The expectancy-value theory "assumes that people are motivated to engage in an activity if it is perceived to be linked to the satisfaction of personal needs (the value aspect), and if there is a positive expectancy for success (expectancy aspect)" (Keller, 1987a, p. 2-3). Historically, course designers have spent time on components that influence learning effectiveness, but not necessarily on the components that stimulate or motivate the leaner to actually learn the material (Visser & Keller, 1990). For many ages, humans have tried to understand what motivates us to do the things we do.

In educational research, Salomon (1984) described the importance of self-efficacy in the amount of invested mental effort (AIME). The author described AIME as the "number of non-automatic elaborations applied to material measured by learner's self-reports" (p. 647). Sixth graders (n=124) either were shown a silent film called A Day of a Painter or read the narrative text of the material. Students self-reported their AIME. Cognitive ability was measured with a multiple-choice achievement test. This researcher found the student's perceived self-efficacy was positively correlated with their mental efforts and learning. Students viewed the silent film as easier, and so spent less cognitive effort to understand the material and, consequently, scored lower on the achievement test. When students self-scored the narrative as more difficult, they spent more mental effort in learning; the material showed a higher performance on the achievement test (Salomon, 1984).

Logan, Lundberg, Roth, and Walsh (2017) examined ability and motivation in distance education. Citing Campbell (1976), Logan et al. (2017); defined motivation as "the choice to initiate effort on a certain task (direction), the choice to expend a determined amount of effort (intensity), and the choice to continue expending that amount of effort (duration)" (p. 85). Ability is associated with task skills and task knowledge. Referencing Motowidlo et al. (1997), Logan et al. (2017) defined task knowledge "including both declarative and procedural facets – as knowledge of facts and principles related to functions of the organization's technical core …

[and] knowledge of procedures, judgmental heuristics, and rules for processing information and making decisions about matters related to the technical core" (p. 85). This study showed that those students who had higher general mental ability and higher levels of motivation showed higher academic performance in the distance learning medium. This study also showed that both motivation and ability need to be present to demonstrate the higher performance. In the absence of either motivation or mental ability, performance levels were lower, than when they when both motivation and ability were present (Logan et al., 2017). The authors studied 96 undergraduate students in a business management course using ACT (American College Test), IPIP (International Personality Item Pool) to study motivation, and the results of four timed multiple-choice exams.

Intrinsic and Extrinsic Motivation

There is a difference between intrinsic and extrinsic motivation. Intrinsic motivation "is something internal, either primal (such as the need to eat) or learned (such as the knowledge of healthful eating)" (Repovich, 2018, p. 1). Extrinsic motivation "is something external and may be both positive (such as rewards) or negative (such as punishment)" (Repovich, 2018, p.1). Researchers have gone back and forth on which is the larger factor in motivation and numerous studies can be found supporting one or the other. Keller's ARCS model explains that "motivation is … a continually changing set of factors influencing the individual's learning behavior before and during the learning task" (Visser & Keller, 1990, p. 469). The model is focused on the factors and strategies during instruction that motivate people to learn (Keller, 1987a, b, 2010, 2017; Visser & Keller, 1990).

ARCS Instructional Design Model

Historically course designers have spent time on components that influence learning effectiveness, but not necessarily on the components that stimulate or motivate the leaner to actually learn the material (Visser & Keller, 1990). In order to motivate students, according to the model, "the instructor or instructional materials need to: (1) catch and sustain students' attention; (2) state why the students need to learn the content; (3) make students believe that they are able to succeed if they exert effort; (4) help student's feel a sense of reward and pride" (Li & Keller, 2018, p. 54).

Motivational design is defined as "the process of arranging resources and procedures to bring about changes in people's motivation" (Keller, 2010, p. 22). In developing the model Keller believed that conditions could be created and constructed that could both facilitate and increase learner motivation. "Motivation is influenced by the degree to which a teacher and the instructional materials provide a curiosity arousing and personally relevant set of stimuli together with the challenge levels that encourage feelings of confidence and whether there is an absence of the kinds of stressors that would inhibit effort" (Keller, 2010, p.6).

In the ARCS model, *Attention* "represents a synthesis of several related concepts including arousal theory, curiosity, boredom, and sensation seeking" (Keller, 2010, p.76). Arousal theory, which is associated with motivation, looks at the "patterns of low levels of arousal being associated with low levels of performance extending through a phase of optimal arousal and performance to a decline in performance resulting from excessive stress" (Keller, 2010, p.76). With attention, it is important to have enough interest that a student is willing to devote the time and energy to learn, but not to the extreme, where a learner is so worried or stressed that they may actually reduce cognitive ability and working memory. Regarding curiosity, research has not shown a strong correlation between curiosity and intelligence; however, there is research to show the relationship between curiosity and learning (Keller, 2010). Boredom can be described as the opposite of curiosity. Carl Jung said "I'm sometimes driven to the conclusion that boring people need treatment more urgently then mad people" (Brome, 1978). Friedrich Nietzsche (1886) said "Is life not a thousand times too short for us to bore ourselves." An instructional designer must ensure that the material and presentation create attention and not invite boredom.

Relevance "refers to people's feelings or perceptions of attraction toward desired outcomes, ideas, or other people based upon their own goals, motives, and values" (Keller, 2010, p. 98). Pragmatically, relevance can be explained with two simple questions. What is in it for me, or how does this affect my life?

Confidence "refers generally to people's expectancies for success in the various parts of their lives (Keller, 2010, p. 135). People want to be in control, most people do not feel comfortable in a situation where they lack all control. As humans, we feel anxiety and fear in these kinds of situations. Those feelings affect the leaner's working memory and cognitive load. Yeigh (2007) classified people into two groups: internally oriented and externally oriented. Students had to remember a set of words while doing simple math problems the experiment continued several times increasing in difficulty (Yeigh, 2007). With the difficulty, subjects were not able to complete the tasks, some blamed the issue on internal ability or effort and others on external task difficulty or a combination of both. How they managed the situation affected their working memory and interfered with the ability to problem solve. (Yeigh, 2007). Keller (2010) argues research like the Yeigh study "has clear implications for instructional design in that interactions between motivational factors such as perceived controllability and information processing activities in the working memory can influence cognitive load and student capabilities for effective learning" (p. 141).

Satisfaction has its basis in psychological research on intrinsic or extrinsic rewards and consequences (Keller, 2010). Intrinsic motivation "which can also be called intrinsic satisfaction, can result from feelings of mastery and from the pleasure of having succeeded at a task which was meaningful and challenging" (Keller, 2010, p. 166). Extrinsic motivation is outside oneself. For example, rewards or items like money or grades or praise drive a person to succeed (Keller, 2010). Keller argued that many educators try to instill intrinsic motivation in their students, the desire to learn something, however can also sparingly use extrinsic motivation to keep student's interest (Keller, 2010).

The ARCS design model is meant to be a problem-solving model (Keller, 2017). "The purpose of the ARCS design process is to determine what specific motivational problems occur in a given situation and then design strategies that target these problems (Keller, 2017). For example, the problem in a group of "unmotivated students" might be that even though the students believe the content is relevant, and they are confident that they can learn it, the instruction does not hold their attention (Keller, 2017). The ARCS design process includes an "analysis procedure that helps you pinpoint the problem and doing this makes it easier to solve the problem" (Keller 2017, p. 18). The ARCS is a ten-step process summarized as:

1. Obtain course information such as purpose and requirements;

2. Obtain audience information regarding background and reasons for taking the course;

3. Analyze audience to determine their pre-course motivational attitudes;

4. Analyze other course elements such as instructional materials and environment with regard to their motivational properties;

5. List motivational objectives and assessments based on the identified motivational problems;

6. List potential tactics by brainstorming and collecting potential tactics related to the problems;

7. Select and design tactics based on a systemic review of the potentially useful ones;

8. Integrate with instruction;

9. Select and develop materials; and

10. Evaluate and revise. (p. 18).

Keller (2017) states that, although all the steps are important, Step Three -- analyzing the audience -- is the most critical to the success of the course design. The ARCS model requires extensive analysis of the learner or audience (Visser & Keller, 1990). Motivation is complex and cannot be easily classified into categories of low or high; also motivation is continually changing it is not a static characteristic (Keller, 2017). According to the model, in order to motivate students, “the instructor or instructional materials need to: (1) catch and sustain students’ attention; (2) state why the students need to learn the content; (3) make students believe that they are able to succeed if they exert effort; (4) help student’s feel a sense of reward and pride (Li & Keller, 2018, p. 54). Figure One is a checklist with prompting questions that course designers and instructors can use to analyze both self and the student’s motivations (Keller, 2017).

Categories	Instructor's Self-Analysis	Instructor's Analysis of Learners
Attention	Am I excited about this learning experience and how I can make it interesting?	Are the learners going to be interested? What tactics will stimulate their curiosity and interest?
Relevance	Do I believe that this learning experience will be valuable for my learners?	Will learners believe it is valuable? What can I do to help them believe it is important?
Confidence	Am I confident in my ability to lead this learning experience effectively and interestingly?	Will the learners feel confident about their ability to learn this? What do I need to do to help them be confident?
Satisfaction	Do I expect to have positive feelings about this learning experience?	What can I do to help the learners feel good about their experience and desire to continue learning?
Volition	Will I provide effective supervision and support to the learners throughout this learning event?	What can I do to help the learners maintain their goal orientation and task focus throughout this learning event?

Figure 1. Course Designer Checklist. A checklist that the course designer can use to both gauge the student's motivations as well as the course designer's motivations. Adapted from "The MVP Model: Overview and Application by Keller. *New Directions for Teaching & Learning, 2017(152)*, 13-26.

The ARCS model has been used in numerous studies and validated frequently (Astleitner & Lintner, 2004; Bellon & Oates, 2002; Chang & Lehman, 2002; Li & Keller, 2018; Li & Moore, 2018; Turel & Sanal, 2018). Li and Keller (2018) completed a literature review of peer-reviewed journals published in English who used the ARCS model in designing instruction and/or instructional materials. Among four search engines (Academic Search Complete, Education Resources Information Center, and Educational Full Text), they found 1294 relevant articles (Li & Keller, 2018). Over 6000 articles were found searching Google Scholar (Li & Keller, 2018). Using set selection criteria, the number of articles were narrowed down to 27 (Li & Keller, 2018). A review of the articles showed that the ARCS model had been used among many different educational environments and subject areas, across many different geographical and cultural areas, and across a broad classification of participants (Li & Keller, 2018).

Bellon and Oates (2002) used the ARCS model to challenge their own thinking about how to teach online classes and looked specifically at motivating online learners. Initially, Bellon and Oates believed that an online course would not allow for the face-to-face interaction that is critical in engaging the student. However, they were able to utilize emails and online bulletin boards to replicate that interaction. Results from the study were gathered over three years. The authors looked at their student's personality types: extroverts versus introverts, sensing versus intuitive, feeling versus thinking, and judging versus perceiving using the Jung Typology Test. All personality types reported that emails were engaging and motivating, but mixed results with bulletin boards (Bellon & Oates, 2002). The authors were able to use the ARCS model to analyze and improve their online course materials.

Chang and Lehman (2002) investigated both achievement and perceptions of motivation of learners from a computer-based interactive multimedia program designed for English as a foreign language. The study focused specifically on relevance, the second portion of Keller's ARCS model (Chang & Lehman, 2002). Two versions were created; one version of the program was created with embedded relevance strategies and the other without those strategies. The Intrinsic Motivation Orientation Scale (IMOS), the Modified Instructional Material Motivation Survey (MIMMS), and a comprehension test were used to analyze the results of the 313 students enrolled in a university in southern Taiwan who participated in the study. Results showed "learners who are intrinsically orientated learn more and are more highly motivated when learning. The findings also support Keller's declaration that embedded instructional strategies can enhance learner's motivation and cognitive performance" (Chang & Lehman, 2002, p. 94).

One study specifically looked at students' achievements in mathematics, using the Mathematics Achievement Test (MAT), student's motivations using the Instructional Materials

Motivation Scale (IMMS), and student's anxiety levels using the Mathematics Anxiety Scale (Turel & Sanal, 2018). The researchers created a digital book using Adobe InDesign program integrating attention, relevance, confidence, and satisfaction elements into the curriculum. The results showed that students who used the digital book, compared to print book, scored higher on achievement and motivation; however, they scored lower on anxiety scores (Turel & Sanal, 2018).

As discussed previously, the traditional classroom for learning has changed and modified with the increase in technology resources. Many students have turned to online platforms to learn a wide variety of ideas and concepts. One general category increasingly available are Massive Open Online Courses (MOOCs). However, students who participate with MOOCs historically have a low persistence rate (Li & Moore, 2018). "It is plausible the design of these MOOCs lacks attention to motivational design principles, which may lead to decreased leaner motivation and engagement" (Li & Moore, 2018, p. 102). MOOCs are a unique learning environment; students come from a diverse background and have different reasons for engaging in learning through MOOCs. Researchers studied two introductory chemistry courses provided on Coursera and delivered in Fall 2014 and Spring 2015. Researchers analyzed the existing curriculum specifically looking for ways they could improve the material based on the ARCS model. They used the Instructional Materials Motivation Survey (IMMS), semi-structured interviews, and the researcher's design journal to gather data from the participants. 163 out of 10,399 leaners in course one and 266 out of 10,996 learners in course two completed the IMMS survey. "The IMMS from both courses indicated that respondents considered attention the best component and relevance the worst even after" the researchers "revised relevance strategies in the second course (p. 110). Researchers summarized, from comments gathered, that it was difficult to make the concepts relevant to the learner's everyday life and career. The diversity in reasons why people choose to take a MOOC class is one possible reason why it is difficult to make the concepts applicable to all students' current career and life (Li & Moore, 2018).

Astleitner and Lintner (2004) looked at material developed with ARCS strategies (strategies to enhance attention, relevance, confidence, and satisfaction). Seventy-five undergraduate students participated in the experiment, divided between the treatment (ARCS strategies material) and the control (material not specifically designed with ARCS strategies) (Astleitner & Lintner, 2004). Results showed that students who had the ARCS strategies material actually scored lower on the first test; by the second test the differences were not significant; and then by the third test, the treatment group showed an increase in learning when compared to the group of students who viewed the material without motivational factors added. Researchers' hypothesized that the negative results could have been the result of the additional time to complete the material created with ARCS strategies; the material was 5% longer because of the added strategies. However, the study also found that, although there was an increase in motivation and achievement with lower situational outcome expectancies using the ARCS influenced materials, there was not a difference among the higher situation outcome expectancies group (Astleitner & Lintner, 2004).

Woo (2014) studied learning motivation and cognitive ability specifically with digital game-based learning (DGBL). The study investigated 63 university students who interacted with an online game titled "Operating a Small Factory in Computer-Aided Manufacturing" (Woo, 2014). Woo used Keller's MVP theory (motivation, volition and performance) and Mayer's cognitive theory of multimedia learning to combine the importance of understanding both, how students are motivated and how students process information using an online game platform.

The study used “six cognitive levels, specifically knowledge, comprehension, application, analysis, synthesis, and evaluation as the scope of the cognitive domain” (Woo, 2014, p. 301). Woo’s research found that although textual and animated messages can attract learner’s attention, and thus enhance their motivation, they do not necessarily provide a good use of the limited cognitive load of the learner (Woo, 2014).

Instructional Materials Motivation Survey

In order to measure whether the ARCS model was used appropriately, Keller designed the Instructional Materials Motivation Survey (IMMS) (Keller, 2010). The IMMS “was designed to measure reactions to self-directed instructional materials” (Keller, 2010, p.277). Many of the studies previously discussed have used the IMMS or a shortened modified version as an instrument to measure motivation (need to list all the studies cited). The IMMS is made up of 36 items with nine items measuring Relevance and Confidence, six measuring Satisfaction, and 12 measuring Attention. The IMMS can be scored as a whole or by construct. The survey is scored using a Likert-type scale ranging from one to five: one = Not true, two = Slightly true, three = Moderately true, four = Mostly true and five = Very true (Keller, 2010). The minimum score is 36 and the maximum is 180; the midpoint is a score of 108. In order to obtain a score for either a specific subsection or the total score, the points from each section are added; however, there are several questions in each section that are reversed and so the score on those questions has to be reversed before they can be summed (Keller, 2010).

Table 11.9. IMMS Scoring Guide.

Attention	Relevance	Confidence	Satisfaction
2	6	1	5
8	9	3 (reverse)	14
11	10	4	21
12 (reverse)	16	7 (reverse)	27
15 (reverse)	18	13	32
17	23	19 (reverse)	36
20	26 (reverse)	25	
22 (reverse)	30	34 (reverse)	
24	33	35	
28			
29 (reverse)			
31 (reverse)			

Figure 2. The IMMS scoring guide developed by Keller to score motivation using the ARCS Model . Adapted from Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach.* New York: Springer, 285.

Validation of the IMMS Tool. Keller (2010) validated the IMMS with 90 undergraduate students in two different classes for a large Southern university of pre-service teachers. Materials discussing the concept of behavioral objectives on lesson planning and instructional design were created (Keller, 2010). One set had motivational ARCS tactics, and one was created without the enhancements. After analyzing the IMMS survey using Cronbach's alpha, all subsections were found reliable with scores of .89 (Attention), .81 (Relevance), .90 (Confidence), .92 (Satisfaction) and .96 (Total Scale) (Keller, 2010).

Huang, Huang, Diefes-Dux, and Imbrie (2006) sought to confirm the reliability of the IMMS. The results showed that although the original IMMS survey contains 36 sections, only 20 items were found to be statistically significant (Huang, Huang, Diefes-Dux, & Imbrie, 2006). Only one item was left in the satisfaction section (Huang, et al., 2006). In addition, some of the items did not seem to fit in the original section they were designed to measure (Huang, et al., 2006). In order to examine the findings of Huang et al. (2006) Loorbach, Peters, Karreman, and

Steehouder (2015) looked at the IMMS specifically "in two ways the IMMS was not originally developed for: 1. In a self-directed and therefore non-interactive setting, which focused on learning and performance instead of learning per se; and 2. With senior users instead of students" (p.208). The study involved 79 Dutch seniors in the first study and 59 seniors in the second study (Loorbach, Peters, Karreman, & Steehouder, 2015). In the first study the full 36-item scale of the IMMS was used, it was translated into Dutch and adapted to fit the appropriate language of the study (Loorbach, et al., 2015). In the second study, a shorter 12-item scale with three items in each subsection was used. Their findings suggest the shortened version of the IMMS (called RIMMS) was statistically preferred over the original IMMS. The shortened version did not have any of the reverse items, was shorter to limit response fatigue, and had an even number of questions for each section (Loorbach, et al., 2015). However, the researchers did discuss that the study is limited because of the small sample size (Loorbach, et al., 2015).

The IMMS has been validated by Keller and other researchers, however there are gaps in whether the whole IMMS is needed or if a shortened version can be just as effective. This research will not analyze or seek to solve this problem. The whole IMMS will be used as a way to measure motivation.

Retention versus Transfer

Both retention and transfer tests are used to measure a change in performance. Retention implies the skills once learned are retained (Vera, Alvarez, & Medina, 2008). "Asking whether learners can recall what was presented in a lesson" is an example of testing for retention (Mayer & Moreno, 2003, p. 43). Transfer tests measure to what degree the learned skills can be used in new situations (Vera, et al., 2008). Asking students to use the knowledge they learned and "solve novel problems using the presented material" is a method to measure transfer (Mayer & Moreno, 2003, p. 43).

Transfer can be further classified into either near or far (Macaulay, 2001). Near transfer occurs when a student learns something and the new task is very similar to the learned task (Macaulay, 2001). When the training has the same steps or process as the work situation then near transfer has occurred (Clark & Mayer, 2011). For example, the lesson on driving a manual transmission vehicle which happens to be a Ford truck. A person could use those same skills and drive a Chevy manual transmission. The actions are similar even if the exact same vehicle is not used.

Far transfer requires a person to apply the new skills and knowledge in a different situation then the specific training (Macaulay, 2001). "The situations presented in the training may not be exactly the same as the situations that occur on the job" (Clark & Mayer, 2011 p. 21). Students must use the training and adapt to a new situation. For example, learning how to drive a manual transmission and then learning how to drive an automatic transmission. There are many similarities, but there are also quite a few differences. Students would have to use the existing schema and modify for the changing situation.

Summary

Online or e-learning is a growing way of educating adults and youth. It is important to learn how to manage the educational medium in order to maximize learner's abilities. Researchers have studied the CTML as one way of ensuring both retention and transfer ability. CTML is comprised of twelve principles that influence either intrinsic, extrinsic or germane cognitive load. This research seeks to compare two principals: segmenting and personalization. The personalization principle is meant to increase learner interest using conversational style rather than formal style. The segmenting principle is used to reduce cognitive load and allow the learner to engage by controlling the pace of material. This researcher has not found any published research that compared these two principles to see which had a greater effect on retention and/or transfer a gap in the published research. Another important component in learning is motivation. Keller (2017) designed the ARCS model of motivational design to be a systematic approach to designing instructional materials so that a student wants to learn the material. Keller's IMMS instrument is used to measure the amount of motivation a student exerts to learn educational material. This research seeks to understand whether students feel more motivated after reviewing the segmented version, personalization version, both segmented or personalized, or the version with neither principle. This is another gap the researcher has found in the published literature. No research has used Keller's IMMS to see which of these two principles will receive a higher score. Given the gaps in previous research, the study proposed here will compare the effects of applying both segmentation and personalization CTML principles – alone, together, or absent – on knowledge recall and transfer, and on motivation, among non-traditional community college students.

CHAPTER III

Method

The purpose of this experimental, post-test only study was to use Mayer's cognitive theory of multimedia learning (CTML) to determine whether personalization or segmentation had a bigger influence on a test of far and near transfer and motivation. Four treatments were created. The dependent variables that were measured were recall and transfer of knowledge and motivation. Keller's IMMS was used to measure motivation. The following research questions were generated.

Research Questions

1. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect recall scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on recall scores for personalized instruction?
    b. Is there a main effect on recall scores for segmented instruction?
    c. Is there an interaction effect on recall scores for personalized and segmented instruction?
2. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect transfer scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on transfer scores for personalized instruction?
    b. Is there a main effect on transfer scores for segmented instruction?
    c. Is there an interaction effect on transfer scores for personalized and segmented instruction?

3. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect motivation scores using Keller's Instructional Materials Motivation Survey (IMMS)?
    a. Is there a main effect on motivation scores for personalized instruction?
    b. Is there a main effect on motivation scores for segmented instruction?
    c. Is there an interaction effect on motivation scores for personalized and segmented instruction?

Research Design

This study used an experimental design to compare a 2x2 array of sample groups with all possible combinations of the use of segmentation and personalization principles. The study utilized a lesson that was developed using CTML personalization principle and/or segmentation principles (independent variables) or a presentation with neither principle. The dependent variables were recall and transfer of content knowledge, as measured by an achievement test, and motivation as measured by Keller's IMMS. The data was analyzed using a 2x2 factorial MANOVA.

Learning Materials

A narrated PowerPoint presentation was created on hazard recognition for personal safety in a general workplace. The multimedia presentation was created using several of Keller's ARCS motivational strategies (Appendix A) and most of the CTML principles for a multimedia presentation. Details on the strategies on the multimedia presentations follows in the next section. Four versions of the learning material were created. Data were then gathered using a summative assessment with both transfer and retention questions and Keller's IMMS to measure motivation.

Development of the Instructional Material

The development of the instructional modules began with the version that used neither principle using Keller's ARCS 10-step process. Then the different versions were created to reflect the elements of the rules being challenged. The independent variable of multimedia instruction has four levels: presentation with personalization principles (Ps), presentation with segmentation principles (pS), presentation with both segmentation and personalization principles (PS), presentation with neither personalization or segmentation (ps). Appendix B contains screenshots of the four materials.

Four narrated PowerPoint presentations were created. The four represent all combinations of the use, or non-use, of personalization and segmentation principles. Version ps did not use any personalization or segmentation. It was one continuous lesson and the language was in formal third person tone.

Version Ps was created with elements of personalization in one continuous lesson. Personalization was used and segmentation was not. Version ps had independent third-party language; for example, "a person" or "people" "theirs" "a student." In the Ps version those words were replaced with first person language; for example, "you" or "yours." The language is meant to invite the reader into the conversation and create an image of the person being immersed in the safety situation shown on the screen. For instance, on one screen, the impersonalized version "Risk is managed whenever a person modifies the way he/she is doing something to minimize the chances of injury or loss" was changed to the personalized version "Risk is managed whenever you modify the way you are doing something to minimize the chances of injury or loss."

Version pS was created using the elements of segmentation but no personalization. So, the language was formal third person. This version also segmented the lesson: at periodic points in the instruction, between each slide of the PowerPoint, the instruction paused, and a button appeared for the student to be able to continue the instruction; that gave the student an ability to control the pace of the material.

Version PS was created using both the personalization and segmentation principles. The combined version used both the first-person language with "you" or "yours", reflecting the personalization principle. And the "next" button was present so that the student could control the pace of the material reflecting the segmentation principle.

CTML Principles Used in Instructional Material

Each of the treatments applied consistently some CTML principles and did not apply others. These principles (or lack thereof) were held constant across each of the treatments except for those treatments that were being studied (personalization and segmentation).

The five principles designed to reduce extraneous load - coherence, signaling, redundancy, spatial and temporal contiguity - were all utilized in each of the treatments. No additional pictures or non-relevant material were included (coherence), and some text was highlighted to draw attention to important key words (signaling). Text, narration, and pictures were not used at the same time (redundancy). Pictures were present when being discussed and not displayed later (temporal contiguity), and lastly pictures were placed near the relevant text (spatial contiguity).

To manage essential processing (modality, pre-training and segmenting principles), only static images were used when the image would assist in the learning. Three images in 12 slides were used. Pre-training was not deemed necessary and not applied, because the level of complexity was not considered high enough to require it. Modality was used consistently across the treatments. Segmenting was only used in the pS and PS version since it is one of the independent variables being measured in the study.

Research has shown that the multimedia, voice, image, and personalization principles are used to increase generative processing (Atkinson et al., 2005; Clark & Mayer, 2011; Mayer, 2014b). The multimedia principle was applied in all of the treatments as images were used in five of the slides to increase generative processing rather than depend on words alone to teach the material. The voice principle was held positive in all versions, using a human female voice. Following the image principle, the quality of images was held constant, the same images were used in all the presentations. Personalization was only present in version Ps and PS; again, because, it is one of the principles being studied in this research. However, only personalization that involved the use of informal tone and speech was used. The pedagogical agent that can also be part of the personalization principle was not used in any version.

As stated in Chapter II, the segmentation principle is used to manage intrinsic load. Personalization is used to foster generative processing. While both of these have been shown to be beneficial to learning individually, studying principles that affect different types of cognitive load, intrinsic and germane, may show us how they interact to improve learning. Add some more stuff. The treatments do in fact address different cognitive load – reduce intrinsic load to manage essential processing the other one is trying to increase generative processing through personalization.

Development and Test

After the material was created and the author made numerous changes the material was shown to subject matter experts (SME). The SMEs included instructors from the Automation

Engineering Program, the HVAC program and the Renewable Energy program. The instructor of the Automation Engineering program, and the researcher are authorized instructors of Occupational Safety Health Administration General Industry material. In addition, the instructors of both the HVAC and Renewable Energy program have taught applicable safety topics in both the workplace and in academic settings. All four experts have their Limited Occupational Specialists certifications from the Career and Technical Department within the Idaho Department of Education. The SMEs have both career and technical skills that are applicable to the material being presented, but also are aware of educational methods.

The material was shown to the SMEs as a narrated PowerPoint and the summative assessment questions (short term quiz) were shown on a word document. After the SMEs viewed the material and answered the questions a verbal discussion occurred with all in attendance. Much discussion occurred over the actual objectives and if they were applicable to what the researcher was attempting to measure. This safety presentation is not meant to be the only safety training the students will hear or see within their respective programs of study. It was determined that there was too much information, and it was too unfocused to make sense as one very small lesson. Based on these discussions, the researcher discussed new objectives with the group. During this initial conversation, rough draft storyboards were created with new material and objectives. Once the new material was created again in the form of a narrated PowerPoint and the questions typed in a word document, the SME's met again to review and make comments. It was determined that the content was acceptable. It is in-depth enough on the objectives to be useful, but short enough to cover the objectives of the study. However, the group had additional comments and changes to make to the summative assessment. In order to measure recall on the first objective the researcher had several terms with definitions and meant to have the subjects match the correct term to the correct definitions. However, the SME's felt it would be easier to change the matching into a few multiple-choice questions. Therefore, the researcher modified the questions as recommended.

Data Collection Instrumentation

This research study used two different instruments. The IMMS adapted from Keller's ARCS motivational model, appendix C. As well as the researcher created multiple-choice and short answer summative assessment for comprehension, appendix D and E.

IMMS

In order to measure the effect of the ARCS model on instruction, Keller designed the Instructional Materials Motivation Survey (IMMS) (Keller, 2010). The IMMS "was designed to measure reactions to self-directed instructional materials" (Keller, 2010, p. 277). The IMMS is made up of 36 items total with nine items measuring relevance and confidence, six measuring satisfaction and 12 measuring attention. Each section can be used and scored independently or as a total score. The survey is scored using a Likert-type scale ranging from one to five. The minimum score is 36 and the maximum is 180, the midpoint is a score of 108. In order to obtain a total score for either a specific subsection or the total score, the points from each section are added; however, there are several questions in each section that are reversed, and so the score on those questions has to be reversed before they can be summed (Keller, 2010). The IMMS tool has been used in numerous studies and independently validated as a measurement of motivation (Chang & Lehman, 2002; Huang, et al., 2006; Keller, 2010; Li & Moore, 2018; Loorbach, et al., 2015; Turel & Sanal, 2018).

Summative Assessment

The summative assessment to measure learning was created by the instructional designer. Content validity was tested by subject matter experts who are knowledgeable in the content and in instructional design and assessment techniques. The assessment is made up of a mix of multiple choice and short answer questions. The questions are evenly divided between recall questions and transfer questions among both objectives (Appendix D and E). The assessment was intended to provide evidence of student attainment of recall and transfer knowledge. The results were used to determine if there is a statistically significant difference between the four combinations of the two independent variables on content knowledge with an assessment on either recall, transfer or both.

After the SMEs found the material and summative assessment appropriate to the topic and student body a small pilot study was conducted. The researcher placed the material into the LMS. Once the material was loaded into the LMS, a group of four students, who are graduating members of several of the programs (and so would not be part of the research since they would be gone from school once the actual data collection began) viewed the materials, and took the summative assessment. This was done to ensure there were no technical glitches that needed to be fixed prior to data collection. No issues were reported.

Data Collection

After the small pilot test, all materials were loaded into the College's LMS. The researcher ensured all materials for all four treatments were in place and no technical issues were present. The researcher then asked the program managers if she could visit with their students to ask for volunteers for the study. The researcher sent an email to the program managers asking if they were willing to have her chat with their class/programs about participating in the study. If the program manager's agreed then the researcher talked to the students about the purpose of the research.

Participants and Sampling

The participants in the study were a convenience sample of available students in the Trades and Industry Department at a small community college in the Intermountain West during the Fall 2020 semester. The Trades and Industry Department includes programs in: Diesel Technology, Agricultural Diesel Technology, Welding, Automation Engineering, Food Processing Technology, HVAC (Heating, Ventilation, and Air Conditioning), Cabinetmaking (Woodworking), Auto Body Technology, Automotive Technology, Industrial Systems Maintenance, and Manufacturing.

Procedures

The learning materials were loaded into Canvas; the College's learning management system (LMS). Students were brought to a computer lab at the College. Students were brought to the specific computer lab in class/program groups during their normal class time. For most students the computer lab was located in a different building from their normal classrooms and labs. The students were brought to the computer lab by their teacher or program manager to specifically participate in the study. The material was self-directed. There was no face-to-face instruction of the material. However, a person was present to answer questions on how to log into the modules and the requirements to complete the material and then the quiz and survey.

After a short presentation of the purpose of the study, students were allowed to either consent or withdraw from the experiment. There were no adverse consequences to their grade or program if they choose to opt-out. Participants names were held in strict confidence and for the purpose of review and publication were noted by a random three-digit code. No monetary incentives were used; however, program managers could give extra credit to students who participated in the study. All data was treated as sensitive and confidential. As expected, most students consented to participate. Based on each program manager's anticipated class size, approximately 25-30 students were in each treatment group. Once the list of students who were willing and present in the computer lab choose to participate, their student ID was entered into an online random sequence generator to randomly assign the participants to one of four treatment groups. With the independent random assignment, every participant had an equal chance of being assigned to one of the four groups.

Participants completed a one question quiz in Canvas to give informed consent to use their data in the study. Based on the treatment group, the appropriate narrated PowerPoint was displayed. All students received the same post-test with transfer and recall questions (Appendix D and E). All students received the same IMMS (Appendix C). Immediately following the instruction participants were given the IMMS (also referred to as a survey) to assess their motivation. Then, the content assessment containing both recall and transfer questions in a randomized order, was administered. After participants completed the IMMS and the content assessment, the scores were downloaded, and all identifying information was removed. The data was entered into SPSS.

The mean instructional time frame of the narrated PowerPoints regardless of version was 17 minutes long. During the SME review of the material the 36 question IMMS took an average of 16 minutes to complete. The assessment consisted of eight recall questions and nine transfer questions (Appendix D and E); during the SME review, the average time to complete the assessment was 21 minutes. At the end of the content assessment, demographic questions were added for additional analysis (Appendix F). Overall students took between 32 minutes and 68 minutes to complete the informed consent, lesson, survey, and content assessment.

The data was collected at the end of the content unit. Students took the IMMS immediately after the instructional content to ensure the content assessment did not affect the motivation score. Although the learners could have chosen to take a break between instruction, the IMMS, and the content assessment, they do not have to. It was recommended the learners complete the IMMS content assessment immediately after the instruction.

Data Analysis

A 2x2 MANOVA was executed with the segmenting (present/not present) and personalization (personal/formal) as the independent variables, leading to four treatments (ps, PS, pS, Ps). Recall and transfer knowledge as well as motivation from the IMMS were the dependent variables, and measured by the content assessment and the IMMS respectively.

The data from the IMMS and the content test was downloaded from the LMS into a spreadsheet with all identifiers removed. Since there are multiple dependent variables to compare (recall scores, transfer scores, and IMMS scores), the data sets were analyzed using a Multiple ANOVA (MANOVA). If a statistical difference was found between the groups for any of the dependent variables, then a Scheffé post-hoc test would be used to determine which groups' means were significantly different from the others. An eta squared (η^2) value was calculated and used for an effect size measurement.

CHAPTER IV

Results

The purpose of this study was to analyze two of the principles (personalization and segmentation) in the cognitive theory of multimedia learning (CTML) on both learning and motivation. The four multimedia presentations on hazard recognition were designed by the researcher as discussed in Chapter III. A researcher-created summative assessment and Keller's IMMS were used to collect data on recall and transfer knowledge and motivation. Extensive research has been conducted on the CTMLprinciples; however, no research could be found that specifically compared personalization and segmentation as discussed in Chapter II. Because most course designers have limited resources lessons need to be designed to be efficient and effective.

This chapter describes the sample participants including the rationale for three exclusions and presents descriptive statistics relating to the study parameters before moving to analysis of the data as related to the three research questions. Raw data can be found in Appendix G.

Study Participants

The study participants were students in the Trades and Industry Department at a community college in the Intermountain West during the Fall 2020 semester. A total of 104 students participated in the study. Three students were excluded from the study. One chose to opt out of the study, another did not finish the learning material, summative assessment, or IMMS, and so no data was entered into the study. Lastly one student was excluded from the study based on their test scores. The outlier was determined based on the Tukey method. The Tukey method determines outliers by examining the interquartile range to filter out the very large and very small values (Myers, Well, & Lorch Jr., 2010). Subject 19 had a combined recall and transfer score of three, the average for their cohort group on the combined score was 13.28. Consequently, the final sample size was n =101. Twenty-five students participated in ps (no personalization and no segmentation), 25 students participated in pS (with segmentation), 24 students participated in Ps (with personalization), and 27 students participated in PS (both segmentation and personalization). Tables 1 – 3 shows self-reported demographics of the study participants. Ninety study participants were male and 10 were female; one participant selected a gender identity not listed. Fifty percent of participants were in the 18-24 age range, and the next highest group at 28 percent reported being in the 25-34 age group.

Table 1

Demographic Information by Gender, Age

		N	Percent
Gender			
	Male	90	89
	Female	10	10
	Trans or Transgender	0	0
	Non-binary	0	0
	A gender identity not listed	1	1
	Preferred not to answer	0	0
Age			
	Less than 18	0	0
	18-24	51	50
	25-34	28	28
	35-44	15	15
	45-54	3	3
	55 and over	4	4
	Prefer Not to Answer	0	0

Note. Percentages are based on the total number of participants in the research study(N = 101)

Seventy-seven percent of students are not of Hispanic or Latino origin. Eighteen percent are of Mexican, Mexican-American or Chicano/a ethnicity. Seventy-four percent reported the white race category. Demographics are reported in Table 2.

Table 2

Demographic Information by Ethnicity, Race

		N	Percent
Ethnicity			
	Hispanic or Latino/a Origin		
	No	78	77
	Yes, Cuban	0	0
	Yes, Puerto Rican	0	0
	Yes, Mexican, Mexican American or Chicano/a	18	18
	Yes, Other Hispanic or Latino/a	3	3
	Prefer Not to Answer	2	2
Race			
	African American or Black	0	0
	American Indian or Alaska Native	2	2
	Native Hawaiian / Pacific Islander	1	1
	Asian	3	3
	White	75	74
	Other Race or Origin	13	13
	Prefer Not to Answer	7	7

Note. Percentages are based on the total number of participants in the research study(*N* = 101)

To determine the participants, work history two questions were posed. One question asked if they had worked in trades previously. The other question asked whether they had received hazard recognition training previously. Seventy-seven students had worked in the trades and 74 percent had received hazard recognition training prior to this lesson. Work history demographics are reported in Table 3. Of the 78 students who had worked in the trades previously, 18 answered no to the second question about receiving hazard recognition training before. Of the 75 students who had received hazard recognition training previously only 15 had not worked in the trades' environment. Consequently, out of the n = 101 participants, 59% had both worked in the trades previously and received hazard recognition training previously.

Table 3

Work History Questions

		N	%
Work History (Worked in Trades)			
	Yes	78	77
	No	23	23
	Preferred not to answer	0	0
Work History (Received hazard recognition training prior)			
	Yes	75	74
	No	26	26
	Preferred not to answer	0	0
Worked in trades (yes) and received hazard recognition training prior (yes)		60	59
Worked in trades (yes) but have not received hazard recognition training prior (no)		18	18
Did not work in trades (no) but received hazard recognition training prior (yes)		15	15
Did not work in trades (no) and did not receive hazard recognition training (no)		9	9

Note. Percentages are based on the total number of participants in the research study (*N* = 101)

Research Question 1

This research question has three subsections. This research questions specifically looks at the recall category in the summative assessment. The assessment included eight questions worth a total of eight points to measure recall.

1. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect recall scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on recall scores for personalized instruction?
    b. Is there a main effect on recall scores for segmented instruction?
    c. Is there an interaction effect on recall scores for personalized and segmented instruction?

Descriptive statistics for the recall scores were calculated for all four groups. Means and standard deviations for the recall test are included in Table 4.

Table 4.

Descriptive Statistics on Research Question 1 – Recall Scores

Variable	*N*	*M*	*SD*
Ps	25	6.12	1.45
pS	25	6.28	1.48
Ps	24	5.96	1.74
PS	27	6	1.83

The single 2x2 MANOVA was executed with the segmenting (present/not present) and personalization (personal/formal) as the independent variables. The results of the MANOVA indicated there was not a statistically significant effect on recall scores, [$F(1, 97) = .441$, $p = .508$]. These data indicated no main effect found on recall scores due to personalization.

The MANOVA also showed no statistically significant main effect on recall scores with segmentation [$F(1, 97) = .092$, $p = .762$]. Therefore, this study found no evidence that segmentation affected recall scores.

The results of that MANOVA also indicated there was no statistically significant interaction effect [$F(1, 97) = .032$, $p = .859$]. The negative results indicate neither personalization nor segmentation, nor the interaction between the two principles, affected recall scores. Discussion will be found in Chapter V.

Research Question 2

This research question also has three subsections, specifically looking at the transfer scores of the summative assessment. The research question is stated below. Nine questions were added to the summative assessment worth a total of nine points to measure transfer knowledge. Table 5 displays the descriptive statistics.

2. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect transfer scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on transfer scores for personalized instruction?
    b. Is there a main effect on transfer scores for segmented instruction?
    c. Is there an interaction effect on transfer scores for personalized and segmented instruction?

Table 5

Descriptive Statistics on Research Question 2 – Transfer Scores

Variable	*N*	*M*	*SD*
ps	25	7.16	1.49
pS	25	7.4	1.71
Ps	24	7	1.26
PS	27	6.59	1.45

To analyze the main effect with personalization and transfer scores the MANOVA was executed. Results of the MANOVA indicated there was not a statistically significant main effect on transfer scores due to personalization, [$F(1, 97) = 1.021$, $p = .315$].

The MANOVA results for transfer scores for segmentation also found no statistically significant main effect [$F(1, 97) = .770$, $p = .382$]. Consequently, according to the evidence from this study segmentation did not affect transfer scores.

Lastly the MANOVA was analyzed to determine if there was an interaction effect [$F(1, 97) = .229$, $p = .634$]. The results indicate there is no statistically significant difference in the results. Consequently, segmentation and personalization, and the interaction between the two principles does not affect transfer scores. Explanations are found in Chapter V.

Research Question 3

Research question number 3 is focused on motivation as measured by the IMMS scores between the independent variables and the four treatments. Table 6 displays the descriptive statistics for the total IMMS score (36 Likert scale scored questions). The research question is below.

3. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect motivation scores using Keller's Instructional Materials Motivation Survey (IMMS)?
    a. Is there a main effect on motivation scores for personalized instruction?
    b. Is there a main effect on motivation scores for segmented instruction?
    c. Is there an interaction effect on motivation scores for personalized and segmented instruction?

Table 6.

Descriptive Statistics on Research Question 3 – IMMS Scores

Variable	*n*	*M*	*SD*
Ps	25	131.52	14.33
pS	25	131.8	19.05
Ps	24	134.17	17.59
PS	27	137.15	17.4

To analyze the variable of motivation, as measured by the IMMS, one of the dependent variables of this study, the 2x2 MANOVA was executed with the independent variables of segmenting (present/not present) and personalization (personal/formal) principles of CTML. The MANOVA found no main effect on the IMMS scores due to personalization, [$F(1, 97) = 1.311$, $p = .255$].

The MANOVA was used to analyze the main effect on the IMMS due to segmentation. The result was not statistically significant [$F(1, 97) = .218, p = .641$]. This study found no effect on IMMS due to the segmentation principle.

Analyzing for an interaction effect the MANOVA [$F(1, 97) = .150, p = .700$] found no statistically significant results. Consequently, the results indicated neither personalization nor segmentation, nor the interaction between the two CTML principles, affected motivation as measured by the IMMS scores.

Due to the lack of statistically significance differences on the overall motivation score another ANOVA was run using the four subscales of Keller's IMMS as dependent variables (attention, confidence, satisfaction, and relevance); in order to determine if an increase in one subscale was hidden by a decrease in another subscale. The descriptive statistics of the subscales are found in Table 7. Please note that for satisfaction, the mean of the no personalization and no segmentation (ps) group had the lowest satisfaction mean. This may indicate that the lesson that lacked both principles caused students to be the least satisfied with the lesson. Conversely lessons with at least one principle scored higher.

Table 7.

Descriptive Statistics on Individual Components in the Total IMMS Score

		Attention		Relevance		Confidence		Satisfaction	
Variable	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
ps	25	42	6.32	33.64	5.1	39.48	3.06	16.4	3.95
pS	25	42.88	7.5	34.32	5.92	36.32	3.64	18.28	4.15
Ps	24	42.29	6.99	34.96	5.09	38.38	3.69	18.54	4.56
PS	27	44.19	7.56	34.89	5.18	38.67	3.9	19.41	4.92

The only statistically significant difference at the $\alpha = 0.05$ level was found on the confidence subscale. Analyzing for between subject's effect, there was a statistically significant interaction effect [*F(1*, 97*)* = 5.587, *p* = .020]. Since there were four groups examined in the interaction effect, a post hoc analysis was performed. The post hoc analysis found only one statistically significant difference [t*(48)* = 3.254, *p* = .002]. Students who received the lesson with no segmentation and no personalization (ps) (*M* = 39.48, *SD* = 3.06) had statistically significantly higher confidence scores than the group who received no personalization with segmenting lesson (pS) (*M* = 36.32, *SD* = 3.64).

In addition, there were two comparisons that neared statistical significance but did not meet the $\alpha = 0.05$ level. Those include the main effect of confidence due to segmentation (*p* = .052) and the main effect of satisfaction due to personalization (*p* = .072). The main effect of segmentation on confidence had an effect size of .038 and the power was .494. The main effect of personalization on satisfaction had an effect size of .033 and power of .437. Both results had a small to medium effect size (Myers, et al., 2010). The power value indicated approximately a 50% chance that the small to medium size effect from this study would be identified as statistically significantly different. These findings will be further discussed in Chapter V.

Summary

Based on the statistics the most direct interpretation is there was no difference in the use of personalization, segmentation, or interaction on any of the dependent variables (recall, transfer, and motivation as measured by IMMS). When the different motivation subscales measured by the IMMS were analyzed separately, confidence was the only subscale that showed a statistically significant difference. Although there were two subscales that approached statistical significance they did not meet the $\alpha = 0.05$ level and so might informal additional studies, which will be discussed further in Chapter V.

CHAPTER V

Discussion and Conclusions

This study examined the effects of personalization and segmentation, two multimedia principles in the cognitive theory of multimedia learning (CTML) on recall, transfer, and motivation. The research questions are repeated below.

1. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect recall scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on recall scores for personalized instruction?
    b. Is there a main effect on recall scores for segmented instruction?
    c. Is there an interaction effect on recall scores for personalized and segmented instruction?
2. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect transfer scores on a researcher developed assessment of hazard recognition?
    a. Is there a main effect on transfer scores for personalized instruction?
    b. Is there a main effect on transfer scores for segmented instruction?
    c. Is there an interaction effect on transfer scores for personalized and segmented instruction?
3. Does the use or non-use of the personalization and segmentation multimedia principles in workplace safety instruction statistically significantly affect motivation scores using Keller's Instructional Materials Motivation Survey (IMMS)?
    a. Is there a main effect on motivation scores for personalized instruction?

b. Is there a main effect on motivation scores for segmented instruction?

c. Is there an interaction effect on motivation scores for personalized and segmented instruction?

This chapter will provide discussion relative to the conclusions from the research questions. In addition, recommendations for future study and future practice will be included. Overall, this study did not find any statistically significant differences on recall or transfer assessment scores due to personalization, segmentation, or their interaction. Likewise, there were no differences in motivation as measured by the total IMMS score due to the independent variables. However, when analyzing the individual subscales measured by the IMMS (attention, relevance, confidence, and satisfaction), confidence showed a statistically significant difference between the ps and the pS groups. Possible explanations for the lack of statistically significant differences in the main and interaction effects of segmentation and personalization on the dependent values will be addressed below.

Discussion

The total sample for this study was $n = 101$ split among four treatment groups, with 25 in the ps group, 25 in the pS group, 24 in the Ps group, and 27 in the PS group. While these numbers are sufficient to run the MANOVA they are at the lower end of the acceptable values (Myers, et al., 2010). Using partial eta squares the effect size was very small ($\eta^2 = .004$) (Myers, et al., 2010). The standard deviations were high when compared to the possible range of data.

Wider variability in the assessment data scores reduced the power and so also reduced the effect size. This combination of low power and small effect sizes and large variability reduced the likelihood of finding statistically significant differences in this data set. Although previous research has found personalization and segmentation to be effective when designing educational materials (Boucheix & Schneider, 2009; Clark & Mayer, 2011; Doolittle, Bryant, & Chittum, 2015; Ginns, Martin, & Marsh, 2013; Hasler, Kersten, & Sweller, 2007; Hassanabadi, Robatjazi, & Savoji, 2011; Kartal, 2010; Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009; Mayer, 2008, 2014a, b; Mayer, Dow, & Mayer, 2003; Mayer & Chandler, 2001; Mayer, Fennell, Farmer & Campbell, 2004; McLaren, DeLeeuw, & Mayer, 2011; Moreno & Mayer, 2000; Schneider, Nebel, Pradel, & Rey, 2015; Spanjers, Spanjers, Van Gog, & Van Merrienboer, 2012; Stiller, Freitag, Zinnbauer, & Freitag, 2009; Wang, et al., 2008; Wouters, Van Gog, & Van Merrienboer, 2011). This study did not find any significant benefit or loss if the two principals were implemented or ignored. The relatively low power values seen in this study were due in no small part to the modest sample size. Additional study participants would be needed to make decisions about the non-randomness of the dependent variables with low effect size.

The mean time to complete the instructional material was 17 minutes, with a minimum of 12 minutes and maximum time of 32 minutes. The brevity of the treatment and the treatment not being part of a larger unit or semester long program could have impacted how much information the learner was able to comprehend. There may have been more impact if additional lessons with more depth into the specific safety topic were presented as part of the study.

In addition, the instructional material, although relevant to all trades, was not part of a larger unit in the students' chosen fields of study. Some students may have already been trained on safety as part of their educational curriculum, making this lesson out of the larger curriculum sequence. Having the material be an add-on to the program's existing curriculum, when that material was presented, may have influenced the outcome. The learning being reinforced with existing curriculum may have created a context for a multiplying effect and impacted the study participants differently.

The lack of diversity in prior training as well as demographics such as race and gender and other variables in relation could have impacted diversity. The participants of the study were heavily male (89%) and white (74%). In addition, 59% of participants had worked in trades and had prior hazard recognition training. Although variables such as race and gender are unlikely to be connected to performance, and therefore were not examined in this study, there may be correlates to these demographic variables (e.g., socio-economic status) which are correlated to performance. The relative homogeneity of the treatment group may have led to response patterns in the data which would have reduced the effect size and thus the potential for significance.

The age range was diverse with 50% of participants in the 18-24 age range, 28% in the 25-34 age range, 15% in the 35-44 age range, 3% in the 45-54 age range, and 4% in the 55 and over age range. Students were from a community college and so the diversity of age would be normal for a community college non-traditional study body (Pelletier, 2010). However, since the age was positively skewed, if age is related to the effectiveness of the different treatments, this could have increased the variability of the scores. As mentioned previously, higher variability worked to reduce the power of this study and thus the likelihood of a statistically significant result.

Another factor that could have influenced the study outcome was the amount of work history already experienced by the study participants. Most of the participants (76%) had worked in trades prior to attending the educational institution and 74% had already received hazard recognition training at some point prior to this lesson. Fifty-nine percent (60 out of 101) of the student participants indicated yes to both questions. In addition, the study did not measure where in the program of study the student was currently. Some may have just been starting out in the field, however some may have been in their last semester of the program. Consequently, in addition to most participants already having experience in the trade, they also may have been further along in their educational pathway. No pre-assessment was used to measure the amount of knowledge that the study participants may have already had prior to the short introduction lesson on hazard recognition. This situation was shown in some of the literature of prior studies which is why the two questions about work history were added to the demographics. In Spanjers, et al. (2011), there was no difference between the segmented and the non-segmented versions among students with a higher level of prior knowledge. McLaren et al. (2011), found that while personalization had a statistically significant effect on low prior knowledge leaners, it did not have an effect on learners who have an advanced understanding of the material and concepts. This study results seem to support both of those studies.

When analyzing each subscale measured in the IMMS, segmentation had an interaction effect with confidence. The no personalization and no segmentation group (ps) scored statistically higher than the no personalization with segmentation group (pS). This was the opposite of what segmenting principle predicted as well as previous studies (Boucheix and Schneider, 2009; Doolittle et al., 2015; Hasler, et al., 2007; Hassanabadi, et al., 2011; Lusk et al., 2009; Mayer, 2008, 2014a, Mayer & Chandler, 2001, Mayer, et al., 2003; Moreno, 2007; Spanjers, et al., 2011; Spanjers, et al., 2012; Stiller, et al., 2009). Many of the participants had high prior experience in the trades, they may have experienced confusion from this hazard recognition training. The training and assessment gave generalized scenarios that were not specific to any one trade. Although the scenarios were based on likely situations that a person in that trade would encounter, they were not restricted to any specific safety training. For example, depending on the task, glove usage or non-usage can be very different depending on the hazard and hazard classification. If a person is using a drill press, or grinding, or removing stock from a CNC lathe, gloves should not be worn. Although there is a hazard for cuts and one would think gloves should be worn, the greater hazard is the spinning or turning instrument grabbing the glove and pulling in a hand or arm. So if someone was not experienced in that specific trade and or safety training a person might think that gloves should be worn. While reviewing the generalized material for any trade, the added pauses and requirements to actually click the "Next" button that were part of the segmenting treatment, led to lower motivation in general and lower confidence specifically.

Recommendations for Future Research

Due to the low observed power of this study a repetition study with a larger sample size may provide more insight into these principles. Having 24 to 27 participants in each cohort affected the power of the statistics, there was not enough information to dispute that the small differences were not due to random chance. Having additional participants in each group would increase the chance of finding a statistically significant result. In addition, when analyzing the individual elements of motivation as measured in the IMMS, two elements approached statistical significance (segmenting affecting confidence $p = .052$, and personalization affecting satisfaction $p = .072$). It is recommended that a replication study with a larger sample size be completed in order to determine if any statistically significant difference exists as theory and prior research suggested.

The brevity of the treatment also could have impacted the results and compounded the effect on learning. Consequently, performing another study increasing the length of the treatment by adding additional lessons (e.g. a full unit or semester long program) may have impacted the results. Future research should include more than one lesson to determine if there is an effect to transfer or recall scores. Increasing the number of treatments, adding additional lessons, reinforcing concepts, and continuing to evaluate the content, could show a different result. Since the effect size was small it may take multiple lessons taught over a time to be large enough to be statistically significant. Additional, more in-depth information might yield a statistically significant result.

Furthermore, additional studies where the treatment is located in a longer, more in-depth lesson on safety as part of the student's wider curriculum would allow for a possible compounding effect. Additional studies where the treatment is placed within the context of the student's wider curriculum would allow for compound the learning. A study that followed a student group for a longer period of time where the hazard recognition training was part of the curriculum might yield different results than this study.

In this study the recall and transfer questions were separated and analyzed based on the treatment. An additional study analyzing the combined score of recall and transfer could yield different results. Furthermore, additional questions could have been added to the content assessment which would not have restricted the range of the dependent variable.

The results of this study may not be generalizable to a larger population of college students because the study population was not diverse in gender or race. Eighty-nine percent of the study participants were male, and 74% reported their race as white. A study with participants from a more diverse and national representative backgrounds (gender and race) may provide more generalizable results.

In addition, the participant ages showed a positively skewed distribution. People further along in their career may have seen the effects of not following safety rules and have more life experience, which could have influenced their assessment and motivation. A sample composed of traditional college age students without the work and life experience may have revealed different results.

Since the study participants were from a Community College in the Intermountain West a majority of the students were not new to the trades careers and; consequently, safety information. Seventy-six percent had worked in the trades and 74 percent had received hazard recognition training prior to this single lesson. In addition, this study did not measure their academic progress, some students may have been close to finishing the program and some students may have just been beginning. A future study that controls for prior knowledge with a pre-test to determine different levels of experience in trades, amount of safety training already received, and general questions to assess life experiences may reveal a correlation that is in line with the current CTML literature. Another study might only include students who are in their first semesters of their programs. A study of students who are just starting into their academic program, for example students who are in their first semester in the program, may yield results that more closely align with current literature.

As discussed previously a limitation of this study was how the experience and previous training questions were collected. They were part of the demographics questions. In order to ensure the data set were anonymized, the demographic data were separated from the treatments and only used to describe the participants. If the experience and training questions were collected in a way that connected them with the individual scores, additional analysis could have been conducted to see if there was a difference between prior hazard recognition training and working in the trades by the treatment. In addition, analysis of how life experiences and prior knowledge impacted the content assessment and motivation scores could have been conducted.

The relationship between segmentation and confidence are needed to be conducted in order to determine if participants were confused and overthinking the situation. Additional studies are needed to examine this possible conclusion.

Recommendations for Future Practice

These results are in disagreement with prior studies (Boucheix & Schneider, 2009; Clark & Mayer, 2011; Doolittle, Bryant, & Chittum, 2015; Ginns, Martin, & Marsh, 2013; Hasler, Kersten, & Sweller, 2007; Hassanabadi, Robatjazi, & Savoji, 2011; Kartal, 2010; Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009; Mayer, 2008, 2014a, b; Mayer, Dow, & Mayer, 2003; Mayer & Chandler, 2001; Mayer, Fennell, Farmer & Campbell, 2004; McLaren, DeLeeuw, & Mayer, 2011; Moreno & Mayer, 2000; Schneider, Nebel, Pradel, & Rey, 2015; Spanjers, Spanjers, Van Gog, & Van Merrienboer, 2012; Stiller, Freitag, Zinnbauer, & Freitag, 2009; Wang, et al., 2008; Wouters, Van Gog, & Van Merrienboer, 2011). Although the findings did seem to support Spanjers, et al. (2011) and McLaren et al. (2011) in regards to students with higher knowledge not getting assistance from personalization and segmentation in their learning. However, since this study did not find any main or interaction effects regarding personalization and segmentation, many studies have found the principles to positively benefit students learning and cognitive development. Consequently, instructional designers should not disregard the personalization and segmentation principles until enough additional studies can be conducted to confirm or refute this study's results.

As discussed by Keller (2017) understanding and analyzing the audience of the learning material is very important in ensuring that students are engaged. Understanding the audience of the materials including the amount of prior knowledge should be assessed prior to the instruction to ensure the students are motivated and able to sustain student's attention. Keller stated that it is important to fulfill the learners' requirements to find satisfaction in being able to complete the task, maintain attention so that the learner is willing to devote the necessary energy to understand, ensure students see how the material impacts their life and goals and finally feels confidence that they are able to succeed (Keller, 2010). Depending on the amount of prior knowledge instructional designers may wish to give students an option to "test out" of certain background material in order to maintain the aspects of motivation.

The personalization and no segmentation (ps) showed a higher confidence than the no personalization with segmentation group (pS). Instructional designers, who have chosen to use segmentation, should not immediately stop applying the segmentation principle. Instead, instructional designers may wish to vary how the segmentation principle is applied. As an example, instead of always using a next button that the student had to click and select to move on, requiring them to answer a question and providing feedback before they move on can be used.

Summary

This study analyzed two multimedia principle's effects - personalization and segmentation - of the cognitive theory of multimedia learning (CTML) on both learning and motivation. The subject matter of the learning material was hazard recognition; the participants were community college students. The data were collected with a researcher created summative assessment that measured both recall and transfer and Keller's IMMS as a measure of motivation. A MANOVA was used to analyze the effects of the four combinations of personalization and segmentation on three dependent variables (recall scores, transfer scores, and IMMS scores). The results of this study indicated neither personalization nor segmentation, nor the interaction between the two CTML principles, affected recall scores, transfer scores or motivation as measured by the IMMS scores. Additional analysis of the individual subscales measured by the IMMS (attention, relevance, confidence, and satisfaction), confidence showed a statistically significant difference between the ps and the pS groups. There are several possible reasons why this study did not find the same results as numerous other studies including: small effect size, variability in scores reduced the power, brevity of treatment, the individual lesson not being included in larger unit, lack of diversity in gender and race, diversity in participant's age, and amount of prior experience and safety training. These results are in disagreement with prior published research, although the findings did seem to support Spanjers, et al. (2011) and McLaren et al. (2011) in regards to students with higher knowledge. Consequently, instructional designers should not disregard the personalization and segmentation principles until enough additional studies can be conducted to further analyze this study's findings.

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Appendix A

ARCS Motivational Design Process

Keller Steps in the ARCS Motivational Design Process

Step 1 – Obtain Course Information

- 20-30 minute presentation on safety hazard awareness
- Setting – computer lab in ATIC building with headphones to listen to audio
- Students who agree to participate are entered into a random sequence generator to determine the version they will participate in.
- Students will log into learning management system – only their version will be present as an option.

Step 2 – Obtain Audience Information

- Skill Level - Some students are in the first year of the program and some students are in the second year of the program. Some students have already worked (formally or informally) in industry for many years, and some students are completely new to the subject matter being presented. However, students are randomly assigned to the three different groups, so it is assumed that the previous knowledge would be randomized across the three groups and so not influence one group more than another.
- The course is not necessarily part of their regular curriculum – students learn about the safety matters of their trades – students will get a small amount of extra credit for participating in the study.
- Since it is a College course and not a K-12 educational course students have willingly applied and been accepted into the programs. Typically the student has an inherent motivation to learn or they would not have gone to College to learn a skill.

Step 3 – Analyze Audience

- Students will view the material with a more neutral feeling – not excited or necessarily enthused but also not alarmed or anxious.
- Best –Guess Method – Categories Low, Average, High
    - Attention – Average – not necessarily part of their grade and so the heightened sense of needing to memorize and get a good grade will be neutral.
    - Relevance – High – students understand in trades that safety is large focus – looking around and seeing what hazards are available and risk mitigation will be very relevant for their trades.
    - Confidence – Average – based on the objectives of the material students will feel relatively confident they can accomplish the goals
    - Satisfaction – Average – if the student is able to gain something from the material and do not get bored or confused they will feel it is useful

Step 4 – Analyze Existing Materials

- Currently no material specifically using multimedia principles or providing a general overview of hazard analysis exists. I have some material that I use for the OSHA 10 and

30 General Industry courses that I give to students. However, it is a checklist of hazards and then we go around the building and shop to point out the hazards. Not necessarily a general overview of why we conduct a hazard analysis of a work area. The instruction assumes students already have experience and general background in hazard recognition. In addition, that material is directly relevant to Food Manufacturing environment, not a general trades safety awareness.

<u>Step 5 – List Objectives and Assessments</u>

After a short 20 minute, presentation on personal safety hazard awareness students will gain an understanding of how relevant the topic is to their everyday life and work.

Assessment – Regarding motivation – students will complete the shortened version of the IMMS to self-report their ARCS feelings about the material. For cognitive measurement a quiz with short answer and multiple-choice questions. Understanding that a short quiz after a short presentation does not necessarily measure a change in behavior. That can only be measured by a long-term assessment and visual observation.

<u>Step 6 – List Potential Tactics</u>

Attention –

Perceptual Arousal – What can I do to capture their interest? – Humor, Unexpected change in environment - change in tone or voice,

Inquiry Arousal – How can I stimulate an attitude of inquiry? – Provide a problem to solve or questions to answer, environmental design strategies – change colors

Variability – How can I maintain their attention? – make relevant to

Relevance –

Goal Orientation – How can I best meet my learner's needs? - Clearly state the goals in the first few minutes and then meet those goals.

Motive Matching – How and when can I link my instruction to the learning styles and personal interests of the learners? – provide personal achievement opportunities, provide leadership responsibilities.

Familiarity – How can I tie the instruction to the learner's experiences? - Relating to own life – examples that are applicable to most of the audience (use of a tool and received an injury – most everyone has had a cut/scrap).

Confidence –

Learning Requirements – How can I assist in building a positive expectation for success? – letting students know what is expected of them with clearly defined learning objectives

Success Opportunities – How will the learning experience support or enhance the students' beliefs in their competence? – provide feedback, provide opportunities for competitions and skill exercises

Personal Control – How will the learners clearly know their success is based upon their efforts and abilities? - giving a short quiz after the presentation – reporting their success is based on their efforts, some short answer questions on the quiz instead of just multiple choice – showing that I am willing to hear different responses.

Satisfaction –

Natural consequences – How can I provide meaningful opportunities for learners to use their newly acquired knowledge/skill - students will be able to see the usefulness in their everyday life both at school and at home.

Positive consequences – What will provide reinforcement to the learner's success?

Equity – How can I assist the students in anchoring a positive feeling about their accomplishments? - All students will receive the same rewards.

<u>Step 7 – Select & Design Tactics</u>

Table 9.8 Worksheet 7 – Final Design

Throughout

Use a mixture of text and pictures (A)

Beginning

Statistics on injuries (A, R)

Clearly state goals (R)

During

Real-Life Scenarios (R)

End

Quiz (C)

In quiz, have short answer questions as well as multiple choice (S)

<u>Step 8 – Integrate with Instruction</u>

Students will not receive any additional instruction besides the material. Took all the elements discussed and created the narrated PowerPoint.

<u>Step 9 – Select & Develop Materials</u>

Created materials.

Step 10 – Evaluate & Revise

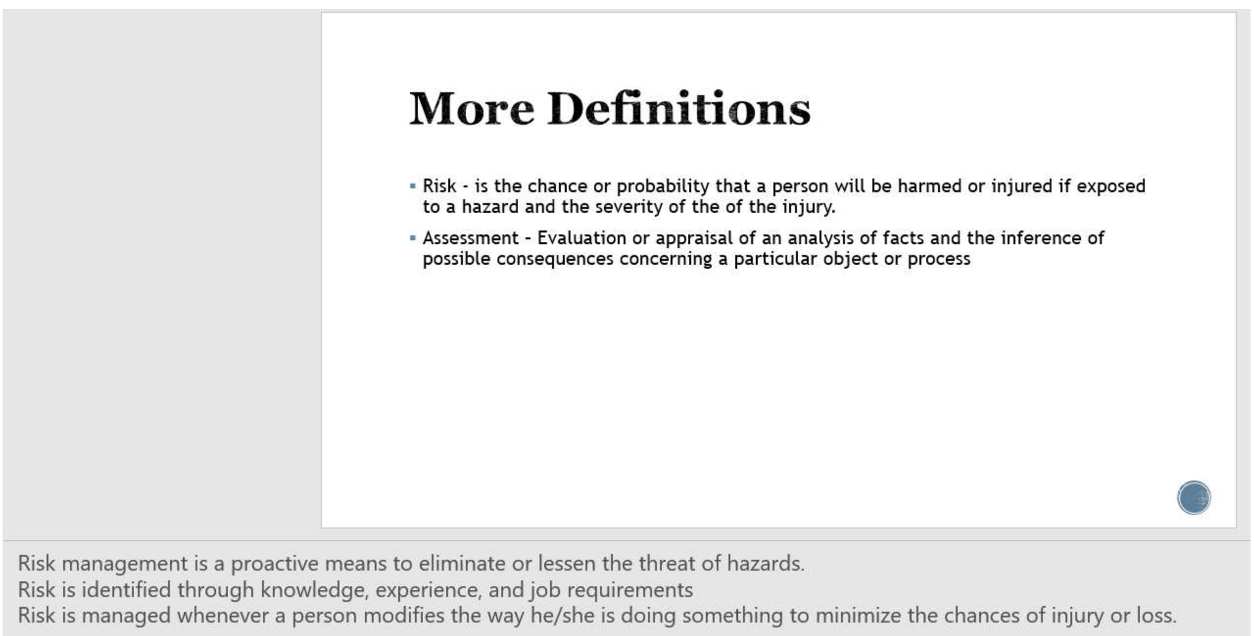
Materials were reviewed and revised based on comments from subject matter experts.

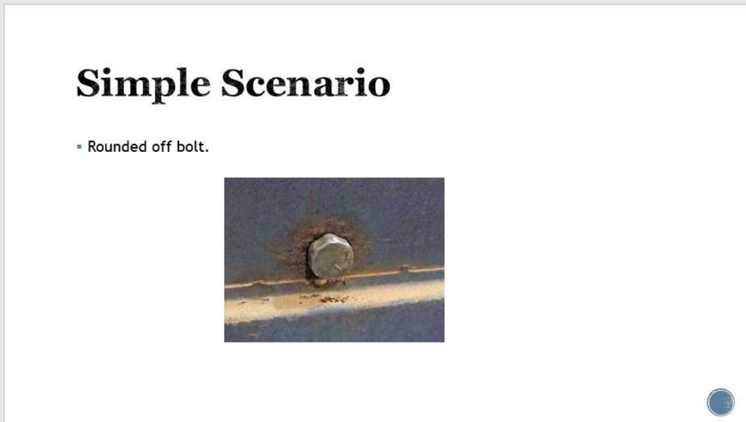
After revision material was reviewed again and found to be acceptable. Then the material was reviewed by a small test group to make sure there were no technology issues.

Appendix B

Screenshots of Instructional Material

Not Personalized or Segmented Version



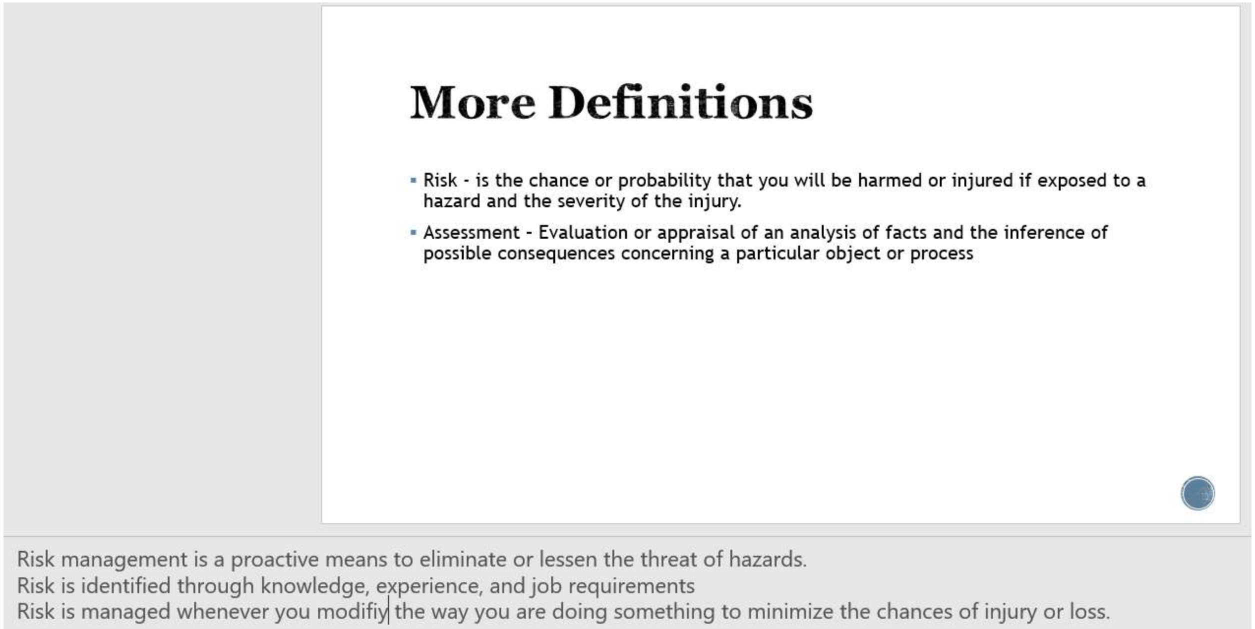


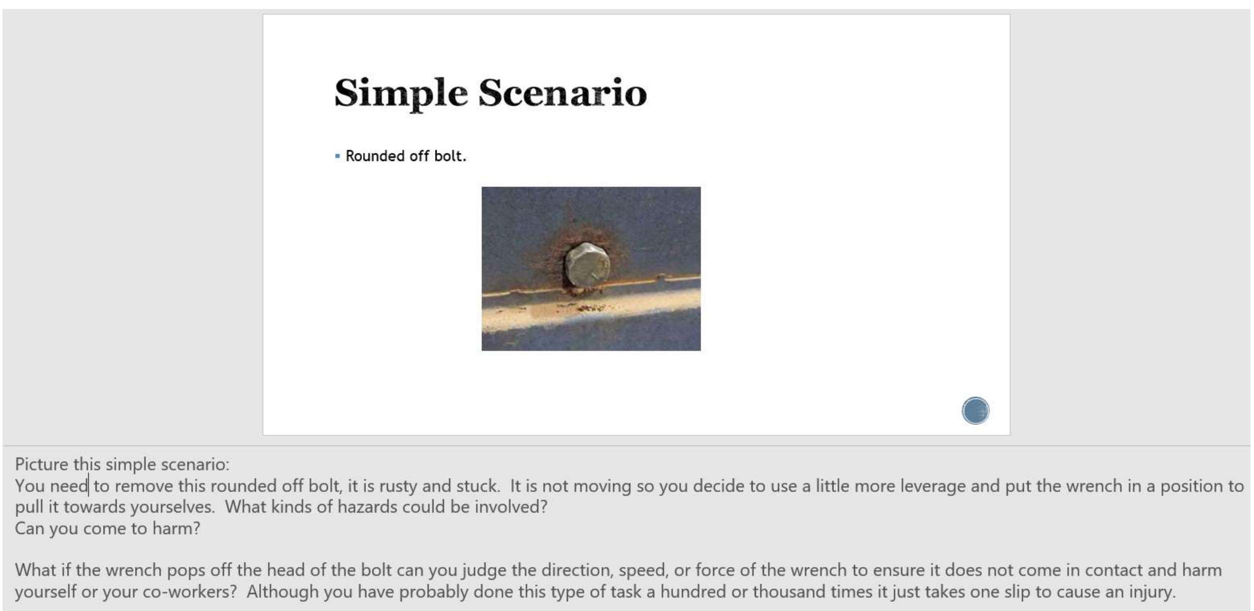
Picture this simple scenario:
A person needs to remove this rounded off bolt, it is rusty and stuck. It is not moving so the person decides to use a little more leverage and puts the wrench in a position to pull it towards themselves. What kinds of hazards could be involved?
Could the person come to harm?

What if the wrench pops off the head of the bolt can the person judge the direction, speed, or force of the wrench to ensure it does not come in contact and harm themselves or their co-workers? Although a person has probably done this type of task a hundred or thousand times it just takes one slip to cause an injury.

Personalized Version

This presentation will give you a general overview of some of the safety issues and things to pay attention to while you are working in the lab.
This presentation is not meant to be all the safety training you will get each semester. The Instructors and Lab Assistants will continually reinforce safety topics as you learn new concepts.





In the narrative *a person* was replaced with *you, or you're* in several locations.

Segmented version (not personalized)

Same slides but with a repeat and a next button.

Segmented and Personalized Version

Has both the informal speech with you and your also with the next button.

Appendix C

Keller's Instructional Materials Motivation Survey

The Instructional Materials Motivation Survey

Instructions: There are 36 statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear. Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.

Use the following values to indicate your response to each item.

1 = Not true 2 = Slightly true 3 = Moderately true 4 = Mostly true 5 = Very true

Write the number of your response by each question.

Questions:

_____ 1. When I first looked at this lesson, I had the impression that it would be easy for me.

_____ 2. There was something interesting at the beginning of this lesson that got my attention.

_____ 3. This material was more difficult to understand than I would like for it to be.

_____ 4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.

_____ 5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.

_____ 6. It is clear to me how the content of this material is related to things I already know.

_____ 7. Many of the pages had so much information that it was hard to pick out and remember the important points.

_____ 8. These materials are eye-catching.

_____ 9. There were stories, pictures, or examples that showed me how this material could be important to some people.

_____ 10. Completing this lesson successfully was important to me.

_____ 11. The quality of the writing helped to hold my attention.

_____ 12. This lesson is so abstract that it was hard to keep my attention on it.

_____ 13. As I worked on this lesson, I was confident that I could learn the content.

_____ 14. I enjoyed this lesson so much that I would like to know more about this topic.

_____ 15. The pages of this lesson look dry and unappealing.

_____ 16. The content of this material is relevant to my interests.

_____ 17. The way the information is arranged on the pages helped keep my attention.

_____ 18. There are explanations or examples of how people use the knowledge in this lesson.

_____ 19. The exercises in this lesson were too difficult.

_____ 20. This lesson has things that stimulated my curiosity.

_____ 21. I really enjoyed studying this lesson.

_____ 22. The amount of repetition in this lesson caused me to get bored sometimes.

_____ 23. The content and style of writing in this lesson convey the impression that its content is worth knowing.

_____ 24. I learned some things that were surprising or unexpected.

_____ 25. After working on this lesson for a while, I was confident that I would be able to pass a test on it.

_____ 26. This lesson was not relevant to my needs because I already knew most of it.

_____ 27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.

_____ 28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.

_____ 29. The style of writing is boring.

_____ 30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.

_____ 31. There are so many words on each page that it is irritating.

_____ 32. It felt good to successfully complete this lesson.

_____ 33. The content of this lesson will be useful to me.

_____ 34. I could not really understand quite a bit of the material in this lesson.

_____ 35. The good organization of the content helped me be confident that I would learn this material.

_____ 36. It was a pleasure to work on such a well-designed lesson.

Appendix D

Recall Summative Assessment

Course Goal/Learning Outcome:

Upon completion of this hazard recognition module, the student will be able to analyze situations to determine the hazards that are present in their work area.

Learning objectives:

Objective 1: The student will understand the different key words and their definitions associated with personal safety hazard analysis.

Objective 2: Given a picture or scenario, the student will be able to identify and apply the six types of hazard categories that could be present.

Objective 1.

R1 – Definition of risk

a. The probability that a person will be harmed
b. An impossible thing or situation
c. Has the potential to cause harm
a. Understanding something clearly and distinctly

R2 – Definition of Hazard

a. The act of rejecting something
b. Understanding something clearly and distinctly
c. An evaluation of the possible consequences
d. Has the potential to cause harm

R3 – Definition of Assessment

a. Certain to cause harm
b. An evaluation of the possible consequences
c. The probability that a person will be harmed
d. Understanding something clearly and distinctly

Objective 2:

R4. Touching a hot surface and getting burned is listed under which hazard classification?

a. Chemical and Dust
b. Biological
c. Ergonomic
d. Work Organization
e. Safety
f. Physical

R5. Mold in the air would be listed under which hazard category?

a. Chemical and Dust
b. Biological
c. Ergonomic
d. Work Organization
e. Safety
f. Physical

R6. The stress caused by working extra shifts would be listed under which hazard category?

a. Chemical and Dust
b. Biological
c. Ergonomic
d. Work Organization
e. Safety
f. Physical

R7. Helping a co-worker who has just cut their finger and is bleeding is an example of which hazard category?

a. Chemical and Dust
b. Biological
c. Ergonomic
d. Work Organization
e. Safety
f. Physical

R8. Manuel works on the packaging line, he repeatedly uses his arms and hands to make boxes. This gives a potential for what kind of hazard category?

a. Chemical and Dust
b. Biological
c. Ergonomic
d. Work Organization
e. Safety
f. Physical

Appendix E

Transfer Summative Questions

Course Goal/Learning Outcome:

Upon completion of this hazard recognition module, the student will be able to analyze situations to determine the hazards that are present in their work area.

Learning objectives:

Objective 1: The student will understand the different key words and their definitions associated with personal safety hazard analysis.

Objective 2: Given a picture or scenario, the student will be able to identify and apply the six types of hazard categories that could be present.

Objective 1.

T1. The presentation talked about a 3-step plan for developing a safe solution. Given the following scenario, what step is Katie working on?

Scenario: Katie needs to unload a flatbed trailer of new metal that has been ordered. She has completed the required forklift inspection documentation and has found the forklift is in good working order. She has climbed onto the forklift and is looking around to see if anyone is nearby the flatbed trailer.

a. Recognize
b. Evaluate
c. Control
d. Execute

T2. True or False – Cutting a finger on a sharp piece of metal is an example of harm.

T3. Jacob needs to check a unit to see if it has the correct amount of refrigerate. He must climb a ladder to get to the roof. He has determined that the weather and equipment is appropriate for the situation. What step in the risk assessment has Jacob just completed?

a. Recognize
b. Evaluate
c. Control

T4. Kurt works in the sanitation department. While inspecting the cleaning chemical room he has discovered a leak in the chlorine line. In the cleaning room there are caustics, acids, and chlorine. He knows that if acid comes in contact with chlorine that a harmful chlorine gas could be formed. What step in the risk assessment has Kurt completed?

a. Hazard Identification
b. Hazard Characterization
c. Exposure Assessment
d. Risk Characterization

Objective 2:

T5. Javier is just finishing working on a gearbox in the shop from a vehicle. He needs to lubricate one more item with his manual grease gun, however it ran out of grease and so he needs to replace the cartridge. While he is priming the new grease cartridge, some grease lands on the floor. As Javier is done, he slips on the spilled grease. Which of the following category potentially contributed to his injury?

a. Chemical & Dust
b. Biological
c. Ergonomic
d. Safety
e. Physical

T6. Scenario: Emilio needs to replace the air filters on the HVAC unit, the filter bank is 2 feet from the top of the roof. It is approximately 2:30pm in the afternoon. The HVAC unit is on the roof of the building, the building is 44 feet tall with an attached enclosed ladder on the south side. The weather is sunny and warm (not hot). There is no ice or snow on the roof. There is a light breeze. Emilio is about 6 feet tall.

T2a. Given this scenario, is there a potential biological hazard?
g. Yes
h. No

T2b. Given this scenario, is there a potential physical hazard?
i. Yes
j. No

T7. Given the following scenario what are some of the elements that are affecting this person's decision? List two factors that could be affecting John's judgement.

Scenario: John works on a shift from 6am to 6pm at a local manufacturing facility. John works on the packaging equipment. At 5:30 pm and the last day of Johns' long week, the packaging machine's pneumatically controlled arm loses a container lid inside the equipment. John does not lock out the equipment, although that is the appropriate procedure, because it will take longer to fix the jam. Instead, he quickly removes the guard and attempts to grasp the dropped container lid, the machine actuates and crushes John's arm.

T8. Look at the following picture of a transmission assembly line

T4a. Is there a potential for hazards in the ergo category?

a. Yes
b. No

T4b. Is there a potential for hazards in the chemical and dust hazard category?

c. Yes
d. No

T9. Which of the following risks is not found in this image of a person using a Tig welder to weld pipes together?

a. Chemical and Dust
b. Work Organization
c. Ergonomic
d. Physical

Appendix F

Demographic Questions

1. Ethnicity

Are you of Hispanic or Latino/a origin? Yes or No
If yes, choose one or more from the following list.
Cuban
Puerto Rican
Mexican, Mexican American, or Chicano/a
Other Hispanic or Latino/a
Prefer Not to Answer

2. Race

Choose one or more of the list below
African American or Black
American Indian or Alaska Native
Native Hawaiian/Pacific Islander
Asian
White
Other Race or Origin
Prefer Not to Answer

3. Gender

Choose one or more of the list below that describes your gender identity
Male
Female
Trans or Transgender
Nonbinary
A gender identity not listed here
Prefer Not to Answer

4. Age

Choose the age range that indicates your current age.
Less than 18
18-24
25-34
35-44
45-54
55 and over
Prefer Not to Answer

5. Work History

Have you worked in a trades environment prior to coming to school?
Yes
No
Prefer Not to Answer

Have you ever received workplace hazard recognition training before this presentation?
Yes
No
Prefer Not to Answer

Appendix G

Raw Data from IMMS and Summative Assessments

Subject #	Group #	Person	Seg	Recall Score	Transfer Score	tota l	IMM S Total Score	At t	Rel e	Con f	Sati s
1	1	0	0	6	7	13	131	34	37	42	18
2	1	0	0	8	8	16	138	47	32	43	16
3	1	0	0	6	8	14	150	51	36	41	22
4	1	0	0	8	7	15	136	42	38	41	15
5	1	0	0	4	5	9	117	43	26	34	14
6	1	0	0	8	8	16	155	51	40	40	24
7	1	0	0	5	7	12	119	28	31	44	16
8	1	0	0	6	6	12	105	35	25	38	7
9	1	0	0	5	9	14	159	52	41	44	22
10	1	0	0	6	9	15	116	36	26	40	14
11	1	0	0	6	4	10	122	40	35	33	14
12	1	0	0	3	7	10	119	41	24	40	14
13	1	0	0	7	7	14	167	57	44	43	23
14	1	0	0	7	9	16	124	37	32	37	18
15	1	0	0	5	9	14	142	47	39	37	19
16	1	0	0	7	7	14	130	39	36	37	18
17	1	0	0	8	10	18	139	41	40	43	15
18	1	0	0	5	5	10	113	37	30	37	9
20	1	0	0	8	8	16	131	42	35	39	15
21	1	0	0	6	7	13	129	43	31	44	11
22	1	0	0	6	6	12	129	37	34	40	18
23	1	0	0	3	7	10	129	45	33	35	16
24	1	0	0	6	6	12	130	45	30	39	16
25	1	0	0	8	8	16	129	40	34	38	17
26	1	0	0	6	5	11	129	40	32	38	19

Subject #	Group #	Person	Seg	Recall Score	Transfer Score	total	IMMS Total Score	Att	Rele	Conf	Satis
27	2	0	1	4	4	8	173	59	45	40	29
28	2	0	1	6	6	12	112	36	28	32	16
29	2	0	1	5	3	8	146	47	38	39	22
30	2	0	1	2	6	8	112	39	27	31	15
31	2	0	1	7	10	17	122	40	32	33	17
32	2	0	1	7	7	14	136	45	41	32	18
33	2	0	1	8	6	14	108	36	26	33	13
34	2	0	1	6	8	14	146	49	41	38	18
35	2	0	1	4	4	8	172	57	44	43	28
36	2	0	1	8	6	14	145	47	41	36	21
37	2	0	1	8	9	17	145	45	37	42	21
38	2	0	1	6	9	15	119	42	26	34	17
39	2	0	1	7	7	14	122	40	28	38	16
40	2	0	1	8	7	15	107	33	31	28	15
41	2	0	1	7	8	15	159	52	41	42	24
42	2	0	1	7	8	15	104	26	30	35	13
43	2	0	1	8	8	16	132	41	35	36	20
44	2	0	1	6	7	13	133	47	34	39	13
45	2	0	1	5	8	13	134	45	36	38	15
46	2	0	1	5	9	14	101	29	23	35	14
47	2	0	1	7	7	14	125	39	33	35	18
48	2	0	1	5	8	13	139	44	37	38	20
49	2	0	1	7	9	16	138	49	36	34	19
50	2	0	1	7	5	12	127	42	31	38	16
51	2	0	1	7	7	14	138	43	37	39	19

Subject Number	Group Number	Person	Segment	Recall Score	Transfer Score	total	IMMS Total Score	Att	Rele	Conf	Satis
52	3	1	0	4	7	11	156	48	41	43	24
53	3	1	0	4	7	11	121	37	32	43	9
54	3	1	0	8	9	17	91	22	24	35	10
55	3	1	0	7	5	12	148	46	45	35	22
56	3	1	0	8	6	14	108	29	32	34	13
57	3	1	0	8	8	16	122	39	30	35	18
58	3	1	0	6	9	15	105	37	23	32	13
59	3	1	0	6	6	12	140	39	36	42	23
60	3	1	0	5	7	12	147	49	34	39	25
61	3	1	0	7	7	14	163	55	42	43	23
62	3	1	0	8	9	17	119	40	30	33	16
63	3	1	0	5	5	10	121	41	32	32	16
64	3	1	0	3	7	10	139	47	36	40	16
65	3	1	0	8	8	16	161	53	42	43	23
66	3	1	0	8	9	17	146	47	36	40	23
67	3	1	0	8	6	14	138	44	35	39	20
68	3	1	0	4	6	10	130	39	37	41	13
69	3	1	0	5	8	13	139	43	35	40	21
70	3	1	0	2	7	9	158	50	40	43	25
71	3	1	0	5	5	10	130	40	35	37	18
72	3	1	0	6	6	12	141	44	38	39	20
73	3	1	0	5	8	13	131	44	36	34	17
74	3	1	0	6	7	13	130	41	34	38	17
75	3	1	0	7	6	13	136	41	34	41	20

Subject Number	Group Number	Person	Segment	Recall Score	Transfer Score	total	IMMS Total Score	Att	Rel	Conf	Satis
76	4	1	1	8	6	14	129	42	33	40	14
77	4	1	1	7	6	13	141	47	31	42	21
78	4	1	1	6	5	11	156	50	40	43	23
79	4	1	1	8	6	14	144	53	34	32	25
80	4	1	1	5	7	12	170	56	43	41	30
81	4	1	1	8	8	16	144	49	39	40	16
82	4	1	1	7	8	15	138	46	33	35	24
83	4	1	1	6	6	12	96	30	26	29	11
84	4	1	1	8	7	15	116	35	31	31	19
85	4	1	1	4	5	9	136	42	33	40	21
86	4	1	1	3	4	7	97	28	22	38	9
87	4	1	1	8	6	14	146	50	34	42	20
88	4	1	1	7	7	14	140	40	41	43	16
89	4	1	1	7	8	15	134	39	38	42	15
90	4	1	1	6	5	11	144	41	44	42	17
91	4	1	1	5	7	12	122	37	31	36	18
92	4	1	1	7	10	17	170	59	44	42	25
93	4	1	1	3	6	9	159	54	40	39	26
94	4	1	1	5	9	14	127	37	33	40	17
95	4	1	1	5	8	13	128	44	30	40	14
96	4	1	1	2	5	7	136	47	35	30	24
97	4	1	1	8	4	12	129	41	31	39	18
98	4	1	1	4	6	10	122	35	32	40	15
99	4	1	1	3	8	11	145	47	34	41	23
100	4	1	1	8	6	14	155	53	39	40	23
101	4	1	1	7	8	15	138	46	37	39	16
102	4	1	1	7	7	14	141	45	34	38	24