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Date ____________________________________

EXAMINING THE MULTIMEDIA REDUNDANCY EFFECT AMONG PRE-SERVICE TEACHERS: ASSESSING PEDAGOGICAL USABILITY OF MATERIAL

By

Sang Chan

A dissertation

submitted in partial fulfillment of the requirements

for the degree of Doctor of Philosophy in Instructional Design

College of Education

Idaho State University

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RE: Your application dated 10/3/2013 regarding study number 3960M: Examining the Multimedia Redundancy Effect among Pre-Service Teachers: Assessing Pedagogical Usability of Material

Dear Mr. Chan:

I have reviewed your application for revision of the study listed above. The requested revision involves changes to the protocol by slight question changes and addition to the Assessment Instrument.

You are granted permission to conduct your study as revised effective immediately. The study is considered Exempt and still not subject to renewal.

Please note that any further changes to the study must be promptly reported and approved. Contact Patricia Hunter (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

Dedication

To my late grandmother: MOUY LOA
To my grandparents: SROEU MIN & EUNG LEAN
To my parents: LIK TANN & SOPHA SROEU
To my wife: SOPHEANY SRY
To my siblings: SREY OUN TANN, SOPHEAKTRA TANN, & KOKCHHENG TANN
To other family and relatives

To those who have helped me grow personally, professionally, and intellectually

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Last but not least, I would like to thank my family: My parents, my wife, my siblings, and other relatives who have been supporting me on this long academic journey. I owe them everything.

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ABSTRACT

This study was to further examine the multimedia redundancy effect in learning a basic-level of Microsoft *Access* 2013 application. Two groups of teacher education majors were randomly assigned into one of the two 20-minute instructional modules: (a) graphics and narration and (b) graphics, narration, and text. The text was duplication with narration and was placed at the bottom of the screen. These two groups were compared on a performance-based posttest administered immediately after the treatment and once again after six weeks to measure long-term retention. A pedagogical usability survey was used to collect perceptions, which were also compared between the two groups. The study results indicated that there was no significant difference between the group that received graphics and narration and the group that received graphics, narration, and text on the posttest scores, delayed posttest scores, and pedagogical usability perceptions.

CHAPTER I

Introduction

Advanced technology permits the design of multimedia instruction that combines words and pictures to accommodate different learning needs (Clark & Mayer, 2011). According to Mayer (2009), multimedia instruction includes words and pictures, with words denoting printed text and spoken words and with pictures including graphics, photos, illustrations, and animations. However, Clark and Mayer warned that the use of cutting-edge technology without considering how humans processed information would result in ineffective instruction.

The efforts to understand how humans learn from words and pictures have resulted in many theories, such as working memory (Baddeley, 1986), dual-coding theory (Paivio, 2007), cognitive load theory (Sweller, 2010), and cognitive theory of multimedia learning (Mayer, 2009). Evidence has been accumulated to support that humans have two independent, but partially interconnected, systems to process verbal (auditory) and non-verbal (visual) information (Baddeley, 1986; Mayer & Anderson, 1991; Paivio, 1991; Mayer & Moreno, 1998; Schüler, Scheiter, & van Genuchten, 2011). People learn better when they have an opportunity to utilize both systems to process the information (Paivio, 1991).

Based on the knowledge, several multimedia design principles have been proposed and investigated through experimental studies to examine how people learn from words and pictures in different situations. These include coherence, signaling, redundancy, spatial contiguity, temporal contiguity, segmenting, pre-training, modality, multimedia, personalization, voice, and image principles (Clark & Mayer, 2011).

This study was centered on the redundancy principle, which was examined under the framework of cognitive load theory. According to Mayer (2009), the redundancy effect occurs when printed text is added to a graphic and narration presentation. The text, since it is duplicated with narration, becomes redundant. However, Sweller (2005) defined the redundancy effect in a broader sense, stating that the redundancy effect occurs when the inclusion of additional information (i.e., text or audio) has a negative effect on learning.

Many studies (i.e., Craig, Gholson, & Driscoll, 2002; Kalyuga, Chandler, & Sweller, 1999, 2000; Mayer, Heiser, & Lonn, 2001) have been conducted to examine the redundancy effect by comparing non-redundant materials (graphics and narration) with redundant materials (graphics, narration, and text). Mayer, Heiser, and Lonn (2001) found the retention and transfer test scores of students who received the 140-second instruction on lightening formation with animation, narration, and full text and of students who received the instruction with animation, narration, and summarized text were significantly lower than the test scores of those who received the same instruction with animation and narration only. Craig, Gholson, and Driscoll (2002) replicated Mayer, Heiser, and Lonn's study and found similar results. Group 1, which received a presentation with narration and animation, did not outperform Group 2, which received a presentation with narration, animation, and text, on the retention test but on the matching and transfer tests. However, Group 1 outperformed Group 3, which received a presentation with narration and text on the retention, matching, and transfer tests. Leahy, Chandler, and Sweller (2003) found the graph-reading test scores of fifth grade students who received graphics and audio were significantly higher than the scores of those who received the same materials with graphics, text, and audio.

These studies (i.e., Craig, Gholson, & Driscoll, 2002; Mayer, Heiser, & Lonn, 2001) found that text split learner's attention. With text being used simultaneously with narration and graphic, learners may have attempted to compare text with narration and paid more attention to text than to graphic, which was a more essential element for learning. Such use of limited cognitive resources to process the redundant element (text), instead of a more useful one (graphic), tends to have a negative impact on learning and retention.

However, the reviews of these studies (i.e., Craig, Gholson, & Driscoll, 2002; Mayer, Heiser, & Lonn, 2001) revealed that they used a short treatment time (i.e., 140 seconds), which was supported by a meta-analysis study indicating that many studies in the redundancy effect area used short treatment times of less than 15 minutes (Adesope & Nesbit, 2012). The above studies (i.e., Craig, Gholson, & Driscoll, 2002) measured only immediate learning and used a learning topic (i.e., lightening formation) that may not have been of particular interest to the research participants. When these factors were considered, other studies found different results. According to McNeill, Doolittle, and Hicks (2009), simultaneous use of text, narration, and graphic did not negatively affect learning. McNeill et al. found no significant differences in test scores as measured by a recall test and the immediate and delayed application posttests among pre-service teachers who received animation and narration material, those who received animation, text and narration material, and those who received animation and text material. Wu (2011) also found no significant differences in retention test scores among pre-service teachers who received image and narration material, those who received image, narration and full text material, those who received image, narration and short text material, those who received animation and narration material, those who received animation, narration and short text material, and those who received animation, narration and full text material, when controlling for spatial contiguity.

Therefore, there was a need for more research to further examine the redundancy effect with a focus on longer treatment times, longer-term retention (i.e., delayed posttest), and subject matter content that was part of a meaningful context (i.e., one unit within a 16-week course).

Problem Statement

The researcher of this dissertation contended that with a short treatment period and with students who had no specific interest in the learning content, as in Mayer, Heiser, and Lonn (2001), the results may have been compromised for real-world situations; further, the results may be different with a longer treatment period and with a meaningful, engaging, and relevant learning topic that was designed by following the instructional theory (i.e., Gagné's nine events of instruction). In content-driven settings, delivery of learning material usually requires longer time than the treatment time used in the cited, laboratory-based studies (i.e., Mayer, Heiser, & Lonn, 2001). This was also supported by de Jong (2010), who acknowledged that many studies under the cognitive load theory (CLT) framework used a very short study time when compared to the time required for learning in real-world situations.

While there were studies conducted in real-world training situations (i.e., Kalyuga, Chandler, & Sweller, 1999, 2000), only one study on the redundancy effect (i.e., McNeill, Doolittle, & Hicks, 2009) found by the researcher used a topic that was part of a formal semester-long, content-driven course. Therefore, there may be lack of research that informed the simultaneous use of text with graphics and narration to develop a longer and meaningful learning material that was more applicable to the academic settings.

The researcher of this study argued that evaluating learning immediately after the treatment provided useful information; however, such an assessment only addressed short-term learning. Within the existing literature on the redundancy effect, there was little delayed testing to determine if learning persisted over a longer time span. Mayer and his colleagues (i.e., Mayer, Heiser, & Lonn, 2001) only measured short-term learning through retention and transfer tests. This present study was intended to measure both short-term and long-term retention. However, interpretation of “long-term retention” has varied in the literature: Karpicke and Roediger (2007) considered a delay to be a few days post-treatment; Butler and Roediger (2007) considered a delay of one month; Sisson, Swartz, and Wolf (1992) used the barometer of three months. The researcher of this study argued that long-term retention could be standardized in an academic setting to be closely aligned with standard assessment points: midterm (six to eight weeks into a 16-week semester) or final examination (15^{th} to 16^{th} week of a semester). In this study, long-term retention was defined as six weeks post-treatment.

None of the previous studies (i.e., Craig, Gholson, & Driscoll, 2002; Leahy, Chandler, & Sweller, 2003; Mayer, Heiser, & Lonn, 2001; Mousavi, Low, & Sweller,

1995) discussed issues related to pedagogical usability of their learning materials. Pedagogical usability is the process undertaken to evaluate the pedagogical aspects of a learning module/material (Nokelainen, 2006; Silius, Tervakari, & Pohjolainen, 2003). Knowledge about pedagogical usability may further inform how to effectively design instruction that is engaging, appealing, and meaningful to learners. Therefore, this study used a survey to assess pedagogical usability of the two instructional modules that were built to examine the redundancy effect.

Purpose of Study

The purpose of this study was to further examine the redundancy effect by comparing the posttest scores, delayed posttest scores, and pedagogical usability perceptions of undergraduate education majors who received a non-redundant instructional module (graphics and narration) and of those who received a redundant instructional module (graphics, narration, and narration-duplicated text) on learning a basic level of the Microsoft *Access* 2013 application. The participants enrolled in an online technology course offered by the College of Education in fall 2013 at a public university in the intermountain western part of the U.S.

Research Questions and Hypotheses

This study was guided by the following research questions and hypotheses.

1. Is there a significant difference in posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by a researcher-designed instrument?

   Research hypotheses:

   H_{o1}: There is no significant difference in posttest scores between the non-redundant group and the redundant group ($\mu_{11} = \mu_{12}$).

H_{a1}: There is a significant difference in posttest scores between the non-redundant group and the redundant group ($\mu_{11} \pm \mu_{12}$)

2. Is there a significant difference in delayed posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by the same researcher-designed instrument?

   Research hypotheses:

   H_{o2}: There is no significant difference in delayed posttest scores between the non-redundant group and the redundant group ($\mu_{21} = \mu_{22}$)

   H_{a2}: There is a significant difference in delayed posttest scores between the non-redundant group and the redundant group ($\mu_{21} \pm \mu_{22}$)

3. Is there a significant difference in pedagogical usability perceptions of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text)?

   Research hypotheses:

   H_{o3}: There is no significant difference in usability perceptions between the non-redundant group and the redundant group ($\mu_{31} = \mu_{32}$)

   H_{a3}: There is a significant difference in usability perceptions between the non-redundant group and the redundant group ($\mu_{31} \pm \mu_{32}$)

Research Design

An experimental design was used in this study (see Figure 1). The research participants were randomly assigned into one of two instructional treatments. After the treatment, a four-point Likert scaled pedagogical usability survey (see Appendix A) was administered. Then, a performance-based posttest was administered and followed by the delayed posttest six weeks later. The posttest and delayed posttest was the same assessment.

Group	Treatment	Survey	Posttest	Delayed Posttest
T_1	X_1	O_2	O_6	O_{10}
T_2	X_2	O_4	O_8	O_{12}

T_1: Narration & graphics
T_2: Narration, graphics, & visible text

Note: O_2 and O_4 = usability perceptions; O_6 and O_8 = posttest; O_{10} and O_{12} = delayed posttest.

Figure 1: Research Design

Delimitations

This study was delimited to the multimedia redundancy effect. The learning content was the basic features in Microsoft *Access* 2013. The participants were pre-service teachers in the online EDUC 2215 course on *Preparing to Teach with Technology* offered in the fall 2013 semester by the College of Education at an intermountain regional university in the United States. The performance-based posttest and delayed posttest was used to measure short-term and long-term learning. A four-point Likert-scaled pedagogical usability survey, adapted from Nokelainen (2006), with the author's permission (see Appendix A-1), was used to measure perceptions about the quality of the instructional modules.

Isaac and Michael (1971) also listed four factors that may affect the external validity that should be carefully considered: (a) reactive or interaction effect of testing, (b) interaction effects of selection biases and experimental variable, (c) reactive effects of experimental environment, and (d) multiple treatments or interventions interference; each of these was discussed below.

Reactive or interaction effect of testing. While a pretest provides useful information about participants' prior knowledge and experiences, it also influences the research outcomes (Lana, 1959). However, in this study, pretest was not used; therefore, there was no influence of the pretest on the posttest and the delayed posttest. The time interval between the posttest and the delayed posttest was six weeks. The influence of the posttest on the delayed posttest scores may be minimal.

Interaction effects of selection biases and experimental variable. The instructor did not inform the participants about the treatment, survey, and assessments to try to prevent the interaction effects. Random assignment was also used to lessen the degree of interaction. However, some participants reported to have interacted with the learning material before the treatment and delayed posttest. Therefore, the results of this study may not be generalizable to other populations.

Reactive effects of experimental environment. The instructor proctored the study to prevent interaction among the participants during the treatment. To minimize the effect of the posttest on the delayed posttest, the instructor did not inform the participants that they had to take a delayed posttest to avoid revisit of the content. All hard copies of the posttests were collected from the participants after completion and were redistributed during the delayed posttest. However, some claimed to have prepared before the delayed posttest by other means.

Multiple treatments or interventions interference. Multiple treatments were not given to the participants in this study; therefore, the effect of one treatment on another treatment was not the case. However, this study administered multiple assessments.

Nonetheless, the time interval between the posttest and the delayed posttest was six weeks, which was believed to lessen a certain degree of influence.

Limitations

This study was limited to pre-service teachers who enrolled in the EDUC 2215 class in the College of Education at the targeted university; therefore, the results might not be generalizable to other students within the program or at other universities. Other factors that may be considered limitations to this research study were history, maturation, testing, instrumentation, statistical regression, selection, experimental mortality, and selection interactions (Gay, Mills, & Airasian, 2009). These potential limitations were addressed in the following subsections.

History. The treatments consisted of two modules, which had the same interface, length, and content, except the text element in the redundant module. To avoid any interaction with the content, the instructor informed the participants that the face-to-face class meetings were used to do some learning activities and to discuss other class issues. After the first computer lab meeting, the modules were not made available to participants for review. However, some participants claimed to have read the class textbook or watched an online video(s) on the topic before the first and second computer lab meetings. This threat to the internal validity was a concern.

Maturation. The targeted audience was adult learners. Any major physical and cognitive changes during the study period (six weeks) that may affect the posttest and delayed posttest scores were not expected; therefore, any threat due to maturation would be unlikely to affect the internal validity of this research.

Testing. There may be an effect of the posttest on the delayed posttest. However, it was believed that the effect was minimal after six weeks of delay. This may be inferred that a threat of testing to the internal validity of this research was minimal.

Instrumentation. The assessment instrument (posttest and delayed posttest) was validated by a Delphi survey among the subject matter experts to confirm its face and content validity. The administration of the assessment was conducted by the instructor using the same procedure. The survey and assessment was each field-tested with a small group of individuals to avoid the floor effect and/or ceiling effect in testing. Revisions were made based on the feedback before the actual implementation. Therefore, this threat to the internal validity of this research may be minimized.

Statistical regression. There was no selection of students based on prior performance or academic standing. The participants were not grouped based on their previous performance or test scores but were randomly assigned to one of the treatment groups; therefore, the regression to the mean should not be an issue.

Selection. The study used a convenience sampling, which may pose a serious threat to the internal validity. However, although the EDUC 2215 course was a required class for all education majors, students had an option to test themselves out of this class. Those who decided to enroll in the class tend to have similar characteristics, especially in terms of technology skills. In addition, the learner analysis indicated that the participants had very limited or no knowledge about the topic. Therefore, it appeared that selection may not present a serious threat to the internal validity.

Experimental mortality. Three participants (one from the redundant group and two from the non-redundant group) did not submit the posttests. One claimed that she felt lost after the treatment and did not want to attempt the assessment. One student had to leave for another class. The third person offered no reason.

Nine participants (four in the redundant group and five in the non-redundant group) dropped out during the delayed posttest because of various reasons. One participant had a corrupted database file, which could not be graded. One participant could not attend the session due to a conflicting schedule with the university's athletic commitment (on basketball competition tour). One participant claimed to be confused with the class meeting date. Two participants each had a family member who needed a serious medical treatment. Four participants came to the session but did not submit their delayed posttests. The reason was unknown. In addition to the missing test scores, there were also missing responses on the survey items. Therefore, mortality may be a serious threat to the internal validity in this study. However, the Little's *MCAR* tests to check the pattern of the missing data indicated that the missing data did not seem to deviate from randomness (see the data analysis in Chapter III for more discussion).

Selection-maturation interaction. Participants in the two groups may naturally grow apart. However, the study period was short (only two classes within the period of six weeks); therefore, such major developmental changes were unexpected among the participants between the two groups. This threat to the internal validity should not be an issue.

Definitions of Terms

Redundancy Effect: According to Mayer (2009), the redundancy effect occurs when the printed text is added to a graphics and narration presentation. The text becomes redundant, which hampers learning.

Cognitive Load Theory: The theory that explains why learning is negatively affected when a learning task requires cognitive resources that exceed the capacity of working memory (de Jong, 2010).

Usability: The extent to which a product enables users to achieve specific goals. Usability is the ability of a product to effectively and efficiently fulfill the needs and specifications of users (Koohang, 2004).

Pedagogical Usability: Pedagogical usability is the process undertaken to evaluate the pedagogical aspects of learning material. The pedagogical aspects of the learning materials include learner control, learning activity, cooperative/collaborative learning, goal orientation, applicability, added value, motivation, value of previous knowledge, flexibility, and feedback (Nokelainen, 2006). This study adapted such categories as learner control, learning activity, goal orientation, applicability, added value, value of prior knowledge, and motivation (with the author's permission).

ADDIE Model: The instructional design model that consists of the Analyze, Design, Develop, Implement, and Evaluate phases (Gagné, Wager, Golas, & Keller, 2005) used to systematically design instruction.

Learning Object: Any digital resource, large or small, that can be reused to support learning (Wiley, 2000).

Delphi Method: A qualitative technique that draws upon the collective opinion of a panel of experts (Gupta & Clarke, 1996). However, for the purposes of this study, a modified version of the Delphi (see Chapter III) was incorporated in which panels of experts were asked to confirm their level of agreement with various tasks within ADDIE.

Multimedia Learning: Learning from words (spoken words or printed words) and pictures (photos, graphics, videos, animations, and illustrations) (Mayer, 2009).

Long-Term Retention: For the purpose of this proposed research investigation, the long-term retention test was defined as the delayed posttest administered six weeks post-treatment.

Pre-Service Teachers: In this proposed study, pre-service teachers were those who enrolled in the online EDUC 2215 course within the teacher education program at the targeted university.

Significance of Study

Overall, the results of the study may offer additional insights into the design and development of learning material (i.e., video tutorials) within academic settings, especially an issue related to how text may be used simultaneously as closed-captioning with graphics and narration. Although the results may not be definitive, the study seemed to point to the direction that text may have the potential to support both short-term and long-term learning when it was presented slightly ahead of narration, which was spoken slowly. The results from the pedagogical usability survey informed the designers of various pedagogical aspects that may be considered when designing and developing relevant and meaningful instructional material.

CHAPTER II

Review of the Literature

The literature review for this study addresses the following research areas: (a) redundancy effect, (b) cognitive load theory, (c) human-computer interaction (pedagogical usability), (d) ADDIE instructional design model, (e) development of learning objects (LOs); and (f) Delphi method.

Redundancy Effect

According to Mayer (2009), the redundancy effect occurs when printed text is included in a graphic and animation presentation. The text, since it is duplicated with narration, becomes redundant. As a result, learning decreases. However, Sweller (2005) defined the redundancy effect in a broader sense, stating that it occurs when the inclusion of additional information has a negative effect on learning. The additional information could be one of two variations: (a) the same information is presented using two different forms (i.e., graphics and text), or (b) the information is elaborated instead of being summarized (i.e., full text versus summarized text).

According to Sweller, van Merrienboer, and Paas (1998), the redundancy effect was previously discovered in Miller's (1937) but then appeared to be forgotten. Sweller et al. believed there may be two reasons for this: First, the effect was counterintuitive, and the second reason was the effect was not placed in a theoretical framework. However, the redundancy effect has been rediscovered and placed within the cognitive load theory framework. As a result, research interest has been revitalized and is summarized in the following paragraphs.

Mayer, Heiser, and Lonn (2001) recruited 109 undergraduate psychology students to examine the redundancy effect. They found the retention and transfer test scores on lightening formation of students who received the 140-second instruction with animation, narration, and full text (*n* = 36) and students who received the instruction with animation, narration, and summarized text (*n* = 37) were significantly lower than the scores of those (*n* = 36) who received the same instruction with animation and narration. Craig, Gholson, and Driscoll (2002) replicated Mayer, Heiser, and Lonn's study with 71 undergraduate psychology students using similar learning content and found slightly different results: Group 1 (*n* = 24), which received a presentation with narrated animation, did not outperform Group 2 (*n* = 24), which received a presentation with narrated animation and text on the retention test, but Group 1 outperformed Group 2 on the matching and transfer tests. However, Group 1 outperformed Group 3 (*n* = 23), which received a presentation with narrated text on the three tests.

Moreno and Mayer (2002) conducted a study with 69 psychology students using a 300-second treatment. On retention and transfer tests, the group (*n* = 18) that received the treatment with animation presented first followed by text and narration (A-TN) outperformed the group (*n* = 17) that received the same instruction, but with the animation first followed by narration (A-N). However, on both retention and transfer tests, the group (*n* = 16) that received simultaneous animation and narration (AN) outperformed the group (*n* = 18) which received simultaneous animation with text and narration (ATN). Overall, the study results indicated that a simultaneous presentation of text and animation had a negative impact on learning. However, this study used a shortened treatment time and the interval from the treatment to retention testing was considered immediate. These two factors will be purposefully altered in the proposed study to gather data on a longer treatment embedded in a course context and with retention testing measured six weeks post-treatment.

Leahy, Chandler, and Sweller (2003) compared the graph-reading test scores of fifth grade students who received graphics and audio interface components on learning low and high element interactivity materials (*n* = 15) with the scores of those who received the same materials with graphics, text, and audio components (*n* = 15). The results indicated the graphics and audio group outperformed the group that received graphics, text, and audio.

Kalyuga, Chandler, and Sweller (1999) found first-year electrical engineering students who received diagram and audio instruction (*n* = 11) on soldering outperformed those who received diagram, audio, and text instruction (*n* = 12) as well as those who received diagram with text instruction (*n* = 11) as measured by faultfinding and multiple-choice tests. The diagram and audio group reported to have lower cognitive load than did the other two groups. The instruction time was unclear, because it was self-paced. The assessments were taken immediately after the instruction.

Kalyuga, Chandler, and Sweller (2000) used a multiple-choice test to measure the achievement of trade apprentices from two manufacturing companies. Those who received graphics and audio instruction (*n* = 14) outperformed three other groups: Those who received the graphics, text, and audio instruction (*n* = 15), those who received graphics with text instruction (*n* = 15), and those who received graphics-only instruction (*n* = 15). The graphics and audio group reported to have lower mental load than the other groups. The treatment time was not clearly specified; however, it was at least a few hours extending over a two-week period. The assessments were taken immediately after the treatments.

However, other studies found different results. McNeill, Doolittle, and Hicks (2009) found no significant difference in test scores on strategy instruction as measured by a recall test and the immediate and delayed application posttests among undergraduate students in a teacher education program who received the animation and narration material (*n* = 19), those who received the animation, text, and narration material (*n* = 18), and those who received the animation and text material (*n* = 19). The McNeill's et al. study results did not support the findings of Mayer, Heiser, and Lonn (2001), Craig, Gholson, and Driscoll (2002), and Leahy, Chandler, and Sweller (2003). In the McNeill's et al. study, the students had control over the pace of instruction. The treatment was much longer (a few hours).

Wu (2011) also found no significant differences in retention test scores on oceanographic and earth science among pre-service teachers who received image and narration material (*n* = 24), those who received image, narration, and full text material (*n* = 22), those who received image, narration, and short text material (*n* = 22), those who received animation and narration material (*n* = 24), those who received animation, narration, and short text material (*n* = 24), and those who received animation, narration, and full text material (*n* = 26) when controlling for spatial contiguity. The spatial contiguity ability was assessed before the treatment. The treatment (seven videos on oceanographic and earth science topics) was delivered online via the Blackboard learning management system and lasted 27 minutes. The retention test and confidence-level survey were administered immediately after the treatment.

In conclusion, the redundancy effect appeared to be important to be considered by instructional designers (Sweller et al., 1998). Based on previous research, the instructional implications of the redundancy effect include: Exclude the redundant information and activity (Sweller, 2005), and exclude the printed text from a graphics and narration presentation (Mayer, 2009). However, Sweller (2005) reminded that the redundancy principle should not be applied as a universal rule and should be considered in relation to cognitive load theory. The redundancy principle, by itself, does not inform what information may or may not be redundant to a learner. Some information may be redundant to a group of learners but may be useful for another group. Therefore, decisions should be made from the learner’s perspective and the context in which instructional materials are embedded.

A review of previous research on the redundancy effect revealed that those studies used a short treatment time, were conducted in a laboratory setting, used content that may not be relevant to participants’ interests, and measured learning immediately after the treatment. The present proposed study extended the scope of investigation of the redundancy effect by using more relevant content, i.e., part of a semester-long course, with a longer treatment time (approximately 20 minutes). Moreover, learning was assessed both immediately after the treatment and six weeks post treatment.

Cognitive Load Theory (CLT)

Cognitive load theory (CLT) is concerned with the way in which cognitive resources are used during complex cognitive learning and problem solving (Chandler &

Sweller, 1991). Since its development, CLT has generated many instructional design effects/principles, such as the goal-free effect, worked-example effect, completion-problem effect, split-attention effect, expertise-reversal effect, and redundancy effect (van Merrienboer & Sweller, 2005).

CLT is derived from knowledge about working memory, long-term memory, and schema theory (Sweller, van Merrienboer, & Paas, 1998). Working memory (WM) is known to be limited in capacity (Miller, 1956) and in duration (Peterson & Peterson, 1959). Long-term memory (LTM) is known to have unlimited capacity and to interact with WM (Pass, van Gog, & Sweller, 2010). LTM stores previously learned information, which is organized as hierarchical schemas. An individual performance level is determined by the amount of knowledge stored in LTM.

According to Pass et al., WM processes either previously acquired information or new information not yet stored in LTM. The limitations of WM are not applicable to processing the LTM-stored information, only to processing novel information. Kalyuga, Chandler, and Sweller (2000) indicated that unlimited amount of information could be processed in WM in a form of organized schemas—specific knowledge structure in LTM—that allow learners to treat multiple elements into a single element. When dealing with novel information, WM is limited but could be extended when processing in organized schemas (van Merrienboer & Ayres, 2005). This point leads back to Sweller, van Merrienboer, and Paas (1998) who state that schema construction and automation reduces WM load if sufficient practice is utilized to lead to automation.

According to Pass, van Gog, and Sweller (2010), cognitive load theory (CLT) assumes that knowledge can be acquired from experience or “can be borrowed from other people” (p. 121). Based on this premise, CLT theorists are concerned with how to carefully structure and present new information to assist learning and to choose learning activity to engage learners. Understanding the characteristics of WM and LTM as well as their interaction informs these instructional decisions. The goal is to structure and present information that does not overload WM and to assist learners in acquiring information for LTM so that they are not bound to the limitations of WM when processing new information.

The early work on CLT was on two types of cognitive load—intrinsic and extrinsic (Chandler & Sweller, 1991; Sweller & Chandler, 1991). The third type—germane load—was introduced by Sweller, van Merrienboer, and Paas (1998). DeLeeuw and Mayer (2008) claimed to have found empirical evidence to support the three types of cognitive load and the disassociation among them.

The intrinsic load level relates to the number of interacting elements that need to be processed simultaneously in working memory (Sweller, van Merrienboer, & Paas, 1998). “An element is anything that needs to be or has been learned, such as a concept or a procedure” (Sweller, 2010, p. 124). An element may range from a letter(s), word(s), phrase(s), sentence(s), or combination of those depending on learner’s knowledge and the nature of information. When these elements interact, they create either low-element interactivity materials or high-element interactivity materials. Low-element interactivity materials allow sequential learning rather than simultaneous processing. In other words, the materials can be learned without holding many elements in working memory. An example of low-element interactive materials would be learning English language vocabulary: Each word can be learned separately without knowing other words. High-element interactivity materials, on the other hand, are far more complex. To learn such materials, learners need to process many elements simultaneously in working memory. Grammatical rules are an example of high-element interactivity tasks in which many interactive elements must be manipulated simultaneously to produce a correct grammatical syntax.

When learners interact with low-element interactivity tasks, their intrinsic cognitive load is low, because working memory required to process the tasks is less. In contrast, with high-element interactivity tasks, learners usually experience higher intrinsic cognitive load due to task complexity, which requires more cognitive resources in working memory to manipulate several interacting elements. The number of interacting elements at a specific level of expertise determines element interactivity of a task (van Merrienboer & Ayres, 2005). Therefore, Sweller et al. (1998) recommended that instructional designers consider both the nature of materials and the learner's level of expertise to determine the element interactivity. While these authors previously argued that intrinsic cognitive load could not be directly manipulated by instructional designers, in later work by van Merrienboer and Sweller (2005), they acknowledged that the intrinsic cognitive load could be artificially altered by instructional interventions, but at the expense of understanding; i.e., when the intrinsic load is decreased, understanding is reduced, as well.

For extrinsic cognitive load, Sweller et al. (1998) reported that this load could be entirely manipulated by instructional designers. To reduce extraneous cognitive load, Mayer (2009) presented the coherence principle suggesting that irrelevant words, pictures, sound, music, and symbols should be excluded from the learning material. This is not to be confused with the signaling principle, which suggests that useful cues draw the learner's attention and may increase achievement. However, providing multiple cues (i.e., text) may distract learner's attention. The redundancy principle suggests excluding text from a presentation that consists of narration and graphics. If text and graphic are used together, the spatial contiguity principle suggests that they be presented physically near each other. While the spatial contiguity principle focuses on the physical proximity, the temporal contiguity principle suggests presenting words (i.e., text or narration) and pictures simultaneously, not sequentially.

In addition to these principles, Sweller et al. (1998) recommended worked-example, goal-free, problem-completion, and modality effects to reduce extraneous cognitive load. The worked-example effect is concerned with providing a complete demonstration of problem solving. It directs learner's attention to only the problem states and its operators, necessary to solve the problem (Chandler & Sweller, 1991). The goal-free effect requires learners to focus attention to the problem state and the operators that are applicable to the state. The goal-free effect reduces extraneous load compared to the conventional method (means-ends analysis), in which learners need to process a lot of information at the same time such as the current problem state, goal state, relation between them, operators, and sub goals in working memory (Sweller et al., 1998). The problem-completion effect encourages learners to participate in learning by solving a problem that already has partial solutions. The effect helps reduce extraneous load because learners do not have to spend all cognitive resources to solve a problem from the beginning. The modality effect, also mentioned in Mayer (2009), is concerned with presenting information visually and aurally for better learning. Working memory can be sub divided into visual and auditory for more effective processing. The two processors are partially independent. The working memory capacity increases when both visual and auditory processors are used.

The third type of cognitive load is germane load (Sweller et al., 1998). An increase in germane load does not negatively affect but assists learning, instead. Germane load is associated with conscious effort directly relevant to schema construction and automation (van Merrienboer & Ayres, 2005). The assumption is that low intrinsic load and low extrinsic cognitive load results in unused working memory capacity. Learners can be encouraged to use the unused resources to construct schemas (Sweller et al., 1998). The problem variability effect is to assist learners in constructing schemas (van Merrienboer & Ayres, 2005). Variability in problem conditions teaches learners how to identify similar properties and to differentiate between the related and the unrelated ones. Learning from high variability of task situations increases germane cognitive load, yields better schema construction, and improves learning transfer (van Merrienboer & Ayres, 2005).

According to Sweller et al. (1998), intrinsic load is directly added to extraneous load. The total load was equal to the sum of intrinsic load, extrinsic load, and germane load. The total load needs to be within the capacity of working memory to make learning occur. With unused resources, learners can be directed to construct cognitive schemas. Therefore, proper design procedures are to reduce intrinsic load and extraneous load and to assist learners in cognitive processes directly related to schema construction and automation.

Cognitive load theory (CLT) has been criticized for its theoretical underpinnings and conceptual clarity (de Jong, 2010; Schnotz & Kürschner, 2007; Schüler, Scheiter, & van Genuchten, 2011). According to Schüler, Scheiter, and van Genuchten (2011), the theoretical foundation of cognitive load theory is based on the working memory model (Baddeley, 1986). The model posits that there are verbal and pictorial representation codes. The two subsystems are limited in resources for processing information in parallel. However, in CLT, cognitive resources are considered a unitary construct that are not associated to either visual or verbal code of representation but are allocated among intrinsic load, extraneous load, and germane load (Schüler, Scheiter, & van Genuchten, 2011). Schüler et al. (2011) argued that it was not clear how the CLT's assumptions fit into Baddeley's working memory model, which emphasizes that each visual and verbal subsystem has its own resources and is overloaded within the subsystem. Within the CLT framework, only the modality effect differentiates the two subsystems. In addition, CLT does not incorporate the assumption about the role of episodic buffer, addressed in Baddeley's model, as a temporary place for storing information from the two subsystems and for combining the multimodal information with each other and with existing information stored in long-term memory.

Schnotz and Kürschner (2007) offered criticism regarding CLT's conceptual issues. The traditional view of CLT assumes that intrinsic load cannot be altered by instructional interventions (Chandler & Sweller, 1991; Sweller & Chandler, 1991; Sweller et al., 1998). In their later work, van Merrienboer and Ayres (2005) acknowledged that intrinsic load can be manipulated, stating that "more and more recent research deals with manipulations of intrinsic and germane load, as well as interactions between instructional methods and the level of expertise of the learner" (p.13). According to Schnotz and Kürschner (2007), intrinsic load was only fixed for a particular task at a given level of learner's expertise. Intrinsic load can and should be manipulated by instructional design through adapting to the learner's expertise levels, and lowing intrinsic load is not always helpful. For some instance, intrinsic load should be increased, instead, to make the tasks more challenging enough to learner's capacities; otherwise, the cognitive resources are left unused. As a result, learning may be hampered. This criticism led to a conceptual change in Sweller (2010), stating that intrinsic load can be altered by "changing the nature of what is learned [learning tasks] or by the act of learning itself [knowledge levels]" (p. 124).

Different from Sweller's and his colleague's view on extraneous load, Schnotz and Kürschner (2007) argued that extraneous load is not only caused by processing unnecessary information but may be a result of several factors:

(a) Learning is too complex and learners do not receive adequate instructional interventions (zone of proximal development and scaffolding).

(b) Learners need to mentally integrate information from multiple sources presented in isolation (split-attention effect).

(c) Learners are forced to process irrelevant information because multiple sources are integrated together, which is difficult to ignore (redundancy effect).

(d) Learners waste time and effort processing un-useful information that does not challenge their capabilities and not add value to learning.

Regarding germane load, Sweller et al. (1998) proposed that this cognitive load is concerned with schema construction and automation. The process imposes cognitive load on learners because it requires cognitive resources in working memory. Schnotz and Kürschner (2007) argued that sometimes schema construction and automation does not require extra resources from working memory. Therefore, learning can occur without germane load, but learning can be further improved with germane load. Schnotz and Kürschner (2007) justified the claim by referring to the area of unconscious learning, especially the implicit learning.

Sweller et al. (1998) noted the relationship between germane load and learner's motivation to construct schemas but saw germane load as a separate process from intrinsic load and extraneous load. However, Schnotz and Kürschner (2007) proposed that germane load is constrained by intrinsic load and learner's willingness to invest the unused cognitive resources to construct schemas. de Jong (2010) also shared a similar view that intrinsic load interacted with germane load. The difference between the two kinds seems to be a matter of degree, or probably they are no difference. Different germane processes seem to depend on different types of tasks. In other words, the characteristics of tasks tend to play a mediating role in the germane processes.

de Jong (2010) also questioned the relationship between extraneous load and germane load, which has not been addressed in Sweller's CLT version. He asked a question: Would it be considered extraneous load or germane load when instructional design leads to building wrong schema? de Jong (2010) further argued that the difference between extraneous load and germane load, just like the difference between intrinsic load and germane load, seems to depend on learner's expertise level. de Jong (2010) also briefly addressed an unclear relationship between intrinsic load and extraneous load. He mentioned the work of DeLeeuw and Mayer (2008), finding that intrinsic load was managed by changing the complexity levels of learning tasks. As a result, extraneous load was more affected than intrinsic load was by the instructional manipulation.

Because the interrelationships among intrinsic load, extraneous load, and germane load have been called in questions by critics (de Jong, 2010; Schnotz & Kürschner, 2007), the statement that the total load is equal to the sum of intrinsic load, extraneous load, and germane load claimed in earlier works (e.g., Sweller et al., 1998; van Merrienboer & Ayres, 2005) might not be true (de Jong, 2010). de Jong further states that the total load cannot be simply obtained by adding up the three kinds of loads together. For example, if intrinsic load and germane load are perceived as two different ontological categories, it would not make sense to add them up. Instead, if they are seen as the members from the same category, they are likely to interact. In either case, the sum of all three types of cognitive load is not simply the total load.

Sweller et al. (1998) also discussed issues related to measuring cognitive load. Many methods can be used to measure the learner's cognitive load level while performing a task. The methods include: (a) subjective rating techniques, which learners introspect on the cognitive process and report the amount mental effort used; (b) physiological techniques, which physiological measures in heart rates, pupillary dilation, and brain activity are taken; (c) task- and performance-based method, which uses the primary task to measure learner's performance and uses the second task to measure the cognitive load level related to performing the primary task. Among these techniques, Sweller and his colleagues found the subjective rating to be sensitive, reliable, valid, and nonintrusive. However, the psycho-physiological measure was nonintrusive but unreliable, invalid, and only sensitive to relatively large differences in cognitive load levels. They concluded that the subjective rating measure was the most promising technique to measure cognitive load. However, Schnotz and Kürschner (2007) argued that the subjective ratings, physiological measure, and performance-based method were intended to measure the total load but were not to measure intrinsic load, extraneous, and germane load separately, and more recent work has attempted to measure cognitive load separately (see de Jong, 2010, for references). Schnotz and Kürschner (2007) had doubt that the subjective measure was reliable and valid. They were not sure if learners were capable of clearly differentiating different kinds of cognitive load by introspection. Schnotz and Kürschner (2007) called for a more reliable and valid instrument to assess cognitive load.

de Jong (2010) shared similar views regarding issues related to cognitive load assessment measures. de Jong (2010) continued that the lack of a suitable measure of cognitive load has placed cognitive load theory (CLT) in a situation, in which many studies conducted under the CLT framework "make rather speculative interpretations of what happened with cognitive load during learning on the basis of learning performances" (p. 125). Regarding the reliability and validity of the subjective rating measure, de Jong (2010) presented arguments that the instrument was not reliable and valid as claimed in Sweller et al. (1998) because of variations in scales (e.g., nine points, seven points, five points, etc.) used in different studies. Moreover, the anchor terms at the extremes of the scales have been used differently among questionnaires. Terminologies intended to measure similar perceptions have also varied among studies, such as very high mental effort, extremely difficult, very difficult, etc. The questions asked in the instruments also differed. Some questions asked about effort expended, and others asked learners to report the difficulty level of material. As a result, the study results might be significantly depending upon what questions were asked.

Regarding the physiological measure, de Jong (2010) argued that this measure has become a promising instrument to measure cognitive load. Another alternative instrument is the dual-task approach from experimental psychology (Brünken, Plass, & Leutner, 2003). Among other methods used to measure cognitive load they briefly reviewed, Brünken et al. (2003) proposed the dual-task approach as one of the direct, objective measures of cognitive load. In the dual-task approach, the primary task is used to measure performance whereas the secondary task is introduced alongside with the primary task to measure cognitive load induced by the primary task.

Because of the criticisms (i.e., Schnotz & Kürschner, 2007), Sweller (2010) proposed conceptual changes to cognitive load theory (CLT). Within this new framework, the element interactivity does not only impose intrinsic load but also imposes extraneous load. Which element interactivity causes intrinsic load or extraneous load depends on what needs to be learned. It would be extraneous load if element interactivity can be reduced by changing the instructional procedures. It would be intrinsic load if element interactivity can be reduced by altering the nature of the task.

Germane load is no longer viewed as an independent source of cognitive load, and it was irrelevant to the information presented (Sweller, 2010). Germane load only refers to the available cognitive resources to process the element interactivity imposed by intrinsic load, assuming that learning motivation is high. If intrinsic load is high and extraneous load is low, germane load is also high, because of a high demand for cognitive processing in learning the material. If extraneous load is high, less cognitive resources are available to process the learning material; thus, germane load is reduced, and so is learning. Germane load determines the levels of cognitive resources used to deal with element interactivity imposed by intrinsic load.

Sweller (2010) also proposed a way to identify intrinsic load and extraneous load during learning. Within this new CLT framework, learners are unlikely to differentiate between element interactivity caused by intrinsic load or by extraneous load during learning, which makes attempts to classify the two loads psychometrically impossible. Sweller suggested analyzing the learning material prior to an experiment to categorize the loads and manipulate one load category while keeping the other constant during the experiment.

Regarding the redundancy effect, this new CLT conceptualization does not change how study results in this research area are interpreted. Using element interactivity as an underlying source of extraneous load, cognitive load theory still provides a simple explanation that the textual element may be redundant to the narration element. These two elements do not need to interact to assist learning. However, when they are presented together, they interact with each other. Learners may try to process them simultaneously, which imposes a heavy cognitive load. As a result, learning may be affected.

Like other principles, the redundancy principle has been studied under the CLT framework (Kalyuga, Chandler, & Sweller, 1999, 2000). This present study was also conducted under the CLT framework. It intended to further examine the redundancy effect in a situation when the treatment time (approximately 20 minutes) was longer than that used in previous studies (i.e., Mayer, Heiser, & Lonn, 2001) and when the content was derived from a topic taught in a formal semester-long course. The current investigation focused on whether the inclusion of text with narration and graphics may affect learning, when it was measured by the posttest and delayed posttest (six weeks) after the treatment.

In conclusion, cognitive load theory (CLT) has evolved to become one of the influential theories in instructional design. CLT has generated many design principles aimed at reducing extraneous load. de Jong (2010) accurately summarized the role of CLT in instructional design, that the theory "has created unity in a diverse set of instructional design principles and that it has described a cognitive basis underlying these principles" (p. 126).

Human-Computer Interaction

According to Myers, Hollan, and Cruz et al. (1996), human-computer interaction emerged as a discipline when interface design extended beyond one for engineers into one for non-programmers. The foundations of human-computer interaction (HCI) were derived from various disciplines, such as computer science, artificial intelligence, anthropology, cognitive psychology, social psychology, perceptual psychology, and linguistics. In turn, HCI has become an important field to other disciplines that use computer technologies, among which is education, because it involves both the development and evaluation of various educational technologies, such as multimedia systems, interactive simulations, and computer-based instructional materials in support of lifelong learning.

Myers, Hollan and Cruz et al. (1996) defined HCI as "the study of how people design, implement, and use interactive computer systems and how computers affect individuals, organizations, and society" (p. 794). HCI also addresses the interaction techniques in how information is presented and requested; how computer tasks are controlled and monitored; what forms of assistance (e.g., documentation, technical assistance, training) should be made available; what tools are used to design, build, test, and evaluate user interfaces; and, what processes developers follow when creating interfaces.

According to Peslak (2005), there are two subcategories of HCI—process and people. ‘Process’ involves skills in analyzing, designing, developing, and evaluating software. ‘People’ is concerned with the human factors, such as cognitive processing when interacting with the interface. Myers and Rosson (1992) surveyed 74 programmers and found that approximately 48% of the code produced was dedicated to the user interface. The average amount of time spent on the user interface was 45% for design, 50% for implementation, and 37% for maintenance. In the past, developers believed that users were able to adapt to anything they built as long as training, instruction, and practice were incorporated to help the users learn the interface in a way that matched the system processing capabilities (Oviatt, 2006). This begs for consideration of the usability principles when designing user interfaces. According to Chalmers (2003), the term “digital divide” was used to describe inaccessibility and lack of usability. Because accessibility and usability are interrelated, it is argued that more useable technology makes it more accessible to a larger population.

The concept of usability was originally developed under the HCI discipline (Kukulska-Hulme & Shield, 2004). Two broad categories of usability exist in the literature—technical usability and pedagogical usability (Nokelainen, 2006). According to Nokelainen, ‘technical usability’ focuses on ease of learning to use the system functions, ease of actually using the functions, and efficiency of the functions. ‘Pedagogical usability’ is concerned with how to build a system whose functions facilitate learning of materials.

Because technical usability addresses issues related to design preferences; i.e., ease of use of a device, battery life, device weight, display technology, ergonomics, and highlighting features (Lim, Song, & Lee, 2012), it was not intended as the focus of this proposed study. Instead, pedagogical usability was the focus, because it integrates usability aspects and learning issues into the design of instruction; therefore, pedagogical usability issues were considered next.

Pedagogical usability. In the past, there was little evidence on the integration of usability with learning when evaluating educational software (Squires & Preece, 1996). The term “pedagogical usability” reflects the relationship between usability and learning (Ardito et al., 2006; Nokelainen, 2006; Silius, Tervakari, & Pohjolainen, 2003). The pedagogical usability criteria included learner control, learning activity, cooperative/collaborative learning, goal orientation, applicability, added value, motivation, value of previous knowledge, flexibility, and feedback (Nokelainen, 2006).

Squires and Preece (1996) cautioned that although an interface may be easy to use, it did not necessarily mean the interface was properly designed from an educational perspective. The relationship between usability and educational issue must be considered. The system needs to be pedagogically usable with the interface based on grounded pedagogical models and theories (Ardito et al., 2006). Silius, Tervakari, and Pojlolainen (2003) concurred that, in educational settings, evaluating technical usability alone is not enough; the pedagogical aspects of an interface must also be evaluated.

Although technical usability and pedagogical usability seem to be two separate categories, Silius, Tervakari, and Pohjolainen (2003) advised that the two complimented each other. According to Kukulska-Hulme and Shield (2004), a learning module with pedagogically sound content is of little use if learners struggle to learn within a poorly designed interface. An interface that is technically well designed and pedagogically grounded may not be useful if it is not easily and reliably accessible. Therefore, developers need to consider pedagogical usability, technical usability, and accessibility when designing an interface to facilitate learning.

Silius, Tervakari, and Pohjolainen (2003) developed a multidisciplinary usability evaluation framework for a web-based learning environment. The framework consisted of four major criteria—informational quality (reliability and presentation), accessibility (multimedia, device-independent access, dynamic web pages, Section 508 compatibility), technical usability (navigation, online reading ease, multimedia, error prevention and recovery, visual clarity), and pedagogical usability (learning and tutoring).

To determine the degree to which a specific criterion has been achieved, Silius, Tervakari, and Pohjolainen (2003) recommended using questions based on a six-point rating scale (1 = poor to 5 = excellent with NA = not applicable). A report was then written, which included the overall profile of the learning environment, a summary of well-designed features, and guidelines on how to improve informational quality, accessibility, technical usability, and pedagogical usability.

Nokelainen (2006) developed the Pedagogically Meaningful Learning Questionnaire (PMLQ) to assess pedagogical usability of digital learning materials. The survey consisted of 10 subscales—learner control, learner activity, cooperative/collaborative learning, goal orientation, applicability, added value, motivation, valuation of previous knowledge, flexibility, and feedback. The questionnaire consisted of 92 five-point Likert scaled items, with 43 items measuring technical and pedagogical usability of the learning system, 24 items measuring technical usability of the learning material, and 25 items for pedagogical usability of the learning material. Nokelainen empirically tested the instrument with 5th and 6th elementary school students (n = 66) and their teachers (n = 4). The results supported the 10 subscales and were used to revise the questionnaire. The second version of PMLQ consisted of only 56 items after five new items were included. This version was empirically evaluated with another group of 5th and 6th grade students (n = 74). The participants were asked to rate a learning system (n = 52) and two learning modules (n = 34) embedded within the system. Nokelainen found the reliability coefficients of the subscales for the mathematic learning module (decimal numbers) ranged from .75 to .87, and the reliability coefficients of the subscales for the English learning module (single or plural) ranged from .80 to .92. Nokelainen concluded that the results from two empirical tests supported "all theoretical dimensions of the pedagogical usability criteria. The PMLQ was able to capture differences in the pedagogical usability profiles of the learning modules" (p. 188).

The PMLQ has been used by Nordin, Zakaria, Mohamed, and Embi (2013), who evaluated pedagogical usability of a digital module built to teach mathematics. High school teachers (n = 34) were the study respondents and were asked to provide feedback to the pedagogical usability survey adapted from Nokelainen (2006). The results indicated the majority of the teachers felt positively about the usability aspect of the module and agreed that the module could be used in teaching and learning mathematics.

This proposed study adapted the PMLQ (with the author's permission, see Appendix A-1). It was to inform the design of and to assess pedagogical usability of the two instructional modules to examine the redundancy effect.

In conclusion, as long as the intertwined relationship between education and HCI continues to grow, usability evaluation (both technical and pedagogical usability) is crucial to the development of an effective interface of a system or a module that facilitates learning. The usability evaluation should be implemented along with other evaluation processes (e.g., formative and summative evaluations) during the design, development, and implementation phases. This leads to the critical integration of multimedia design principles, instructional design principles, cognitive load theory, and usability evaluation as considerations in the design process in order to create an effective interface for instructional materials.

ADDIE Model

According to Leigh (1999), the history of instructional design might be traced to the work of Aristotle, Socrates, and Plato on the cognitive process of learning and memory, which was expanded by St. Thomas Aquinas' work on teaching in terms of freewill and by John Locke's work on knowledge construction through experience. Then, John Dewey expanded these ideas by promoting the concept of learning by doing over rote memorization. Dick (1987) states that the use of instructional procedures to design instruction has been traced to World War II (as cited in Reiser, 2001). However, Crawford (2004) claimed the instructional design principles have been around for several hundred years and the instructional design models have just emerged for the last 100 years.

Many instructional models exist in the literature (Andrews & Goodson, 1980; Gustafson & Branch, 2002). Most of these models are based on the five phases of ADDIE—analysis, design, development, implementation, and evaluation (Gagné, Wager, Golas, & Keller, 2005). In an effort to identify the origins of ADDIE, Molenda (2003) reviewed encyclopedias and dictionaries of instructional technology, education and training, consulted previous and recent published works in instructional design and technology, and discussed with educators, authors, and practitioners in the field. None of which informed the origins of the ADDIE model. Therefore, Molenda (2003) concluded that:

> ... the ADDIE Model is merely a colloquial term used to describe a systematic approach to instructional development, virtually synonymous with instructional systems development (ISD). The label seems not to have a single author, but rather to have evolved informally through oral tradition. There is no original, fully elaborated model, just an umbrella term that refers to a family of models that share a common underlying structure. . . . The origin of the label itself is obscure, but the underlying concepts of ISD can be traced to the model developed for the U.S. armed forces in the mid 1970s. (p. 35)

Bichelmeyer (2005) also proposed that ADDIE should be considered a conceptual framework, not a model. The researcher argued that the way ADDIE was called mattered greatly to the instructional design field. Instructional designers have perceived ADDIE as a core element to the field; however, ADDIE was not considered an actual model (Molenda, 2003). As a consequence, the instructional designers have spent several years building knowledge about something (ADDIE) that does not represent reality (Bichelmeyer, 2005). This may explain why other professionals do not view instructional design as a legitimate field and why the instructional design community questions whether the field adds value.

However, ADDIE has influenced the field of instructional design, and the instructional designers tend to use the term “ADDIE” to represent the field (Bichelmeyer, 2005), including when building online courses. For example, Lorh (1998) used ADDIE to create web-based training to increase learner autonomy by including teacher functions in the graphical user interface. Shu, Wu, Wang, and Chen (2009) used ADDIE to design an online course to teach the Chinese language to Japanese technicians, including ordinary language, science and technology terms, and engineering concepts, so the Japanese technicians could train the Chinese employees. The study adopted ADDIE, because it had been widely used and had records of good results. Wang and Hsu (2009) used ADDIE to design virtual learning activities to strengthen social presence among online learners. In the virtual learning environment, learners interacted with one another via an avatar, which could be customized by the user. The adoption of ADDIE produced instruction that helped improve knowledge and skills in the use of a virtual 3D learning environment.

Shibley, Amaral, Shank, and Shibley (2011) reported their success in using ADDIE to redesign a face-to-face undergraduate Chemistry course into a blended course with both online support and face-to-face meetings (n = 1000). All five steps in ADDIE were followed to create online class guides, learning objects, pre-class assignments, collaborative base group, and multimedia resources. The results of their questionnaire indicated the majority (94%) of the students agreed or strongly agreed that the blended course was helpful.

In conclusion, instructional designers tend to view ADDIE as a core element of the field of instructional design. Although some educators have viewed ADDIE as a conceptual framework (i.e., Bichelmeyer, 2005; Molenda, 2003), others have considered it an instructional design model (i.e., Gagné et al., 2005). Regardless, there has been evidence that ADDIE has successfully guided effective design of instruction (i.e., Shibley, Amaral, Shank, & Shibley, 2011; Shu, Wu, Wang, & Chen, 2009). Therefore, in this study, ADDIE was used to develop the instructional modules to examine the redundancy effect. (The ADDIE steps were discussed in detail in the procedure section of Chapter III.)

Development of Learning Objects (LOs)

The existence of the Internet has created a major change in the way instructional materials have been designed, developed, and delivered to facilitate learning (Wiley, 2000). Learning objects (LOs) have become fundamental elements of a new model for content creation and distribution and changed the shape and form of learning (Hodgins, 2002). According to Hodgins, LOs have resulted in a high efficiency of content design, development, and delivery to increase and enhance the effectiveness of learning and performance. The basic idea of LOs is that instructional designers can create small computer-based instructional components that can be delivered online, accessed and used by people simultaneously, and reused in different learning contexts (Wiley, 2000).

Learning objects may be known as knowledge objects, pedagogical documents, educational software components, online learning materials, and resources (see Wiley, 2000 for references) or educational objects (Friesen, 2001). Although the concept of learning objects (LOs) has been widely adopted, its definition varies (Polsani, 2003). The IEEE Learning Technology Standards Committee (LTSC) defined LOs as "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning." Taylor, Stewart, and Dunn (2006) defined LOs, in a similar way, as

“A learning resources that is used to support enrich or extend learning in a chosen knowledge domain” (p. 133). However, Wiley (2000) restricted the definition of LOs to only “any digital resource [large or small] that can be reused to support learning” (p. 7). Examples of smaller LOs include digital images, live data feeds, live or prerecorded video or audio, small portion of text, animations, and smaller web-based applications (e.g., Java calculator). Examples of larger LOs are entire web pages that have text, images, and other media or applications. According to LTSC, examples of LOs include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology-supported learning.

Not all digital resources can be considered LOs. According to Polsani (2003), to be considered LOs, digital objects or media should be wrapped in a learning intention and be reusable. The learning intention can be achieved in two aspects. The digital object needs to be embedded in the context of learning (form) and through reasoned reorganization (relation). A digital object needs to be reusable a number of times in multiple contexts. Although LOs should be created based on sound pedagogical principles, they should not adhere strictly to any specific method or theory (Polsani, 2003). Polsani believed that a genuine reusability and optimal functionality of LOs could be attained only when they were created with a high level of abstraction.

Attributes of learning objects. Ally (2004) listed many LO attributes, such as reusability (the ability to be reused multiple times in different learning contexts), revisability (the ability to be revised without affecting other objects), customizability (the ability to revise LOs to meet individual learning needs), scalability (the ability to build on one another to create an instructional sequence), linkability (the ability to combine LOs to create a larger unit of instruction), durability (the ability to be used many times without becoming outdated), learnability (the ability to help learners acquire the content intended), and interoperability (the ability to work with different systems).

Types of learning objects. According to Wiley (2000), there are four types of learning objects (LOs)—fundamental, combined-closed, combined-open, generative-presentation, and generative-instructional. Fundamental LOs are an individual resource (e.g., a digital image, audio) that is not combined with other objects. Combined-closed LOs consist of a small number of digital resources combined together, whose constituent objects are not individually accessible for reuse. A video clip is an example of combined-closed because the images and audio cannot be used separately. Combined-open LOs are comprised of a large number of digital resources, whose objects are directly accessible for reuse. A web page is an example of a combined-open LO, because the image, video, text, media, and other applications are in a reusable format. Generative-presentation LOs can draw on network-accessible objects and combine them to create presentations for use in instruction, practice, or testing. The generative-presentation LOs have high intra contextual reusability (the ability to use over and over again in similar contexts) and lower inter contextual reusability (the ability to use in domain other than that in which they were designed). Generative-instructional LOs involves the logic and structure for combining learning objects (fundamental combined-closed, and generative-presentation) and evaluating student interactions with those combinations, which are created to support the instantiation of abstract instructional strategies. The generative-instructional LOs have high intra contextual and high inter contextual reusability.

Many institutions have used the LOs approach to solve teaching and learning problems and built a repository to store the learning objects for future use. The University of New South Wales in Australia collaborated with other 25 institutions around the world to build the Learning Resource Catalogue, LO repositories, to identify and share the reusable learning resources among members (Koppi, Bogle, & Bogle, 2005). Brigham Young University invested in the information technology infrastructure to solve the issue related to increased enrollment (South & Monson, 2000). The university's instructional design center produced reusable learning objects to solve instructional problems. They built a LO repository to store the individual LOs. As a result, long-term financial benefits were realized in terms of lower development costs and lower delivery costs. The faculty and students provided positive responses to the reusable learning objects. Weller (2004) also shared experience at the Open University regarding the use of LOs as a way to reduce costs. LOs helped reduced fixed costs of production through the reuse of LOs, increase in production speed, ease of update materials, and low cost pedagogy (e.g., rich and varied learning experience with low cost).

Martinez (2000) provided guidelines to create LOs for personalized instruction. Three types of learners were identified—transforming, performing, and conforming. The LO designed for transforming learners should be discovery-oriented, un-sequenced, and mentoring because these learners are self-motivated and self-managed. They want to be passionate, assertive, and challenged by complex learning problems. For performing learners, the LOs should consist of content that is task-oriented (or project-oriented), competitive, and interactive. The learning environments should have coaching, practice, and built-in feedback. For confirming learners, the content of LOs should be scaffolded, simple, structured, facilitated, and low risks. The researcher concluded that creating LOs for personalized learning that matched learning orientations was to meet the challenges in education and training.

Orrill (2000) employed the constructivist approach to build LOs to teach different subject areas in business within the MBA program. Each of the LOs combined a number of smaller pieces. Each MBA LO consisted of introductory text, video, case studies, war stories, supplemental reading lists, and self-assessment. The program faculty and professionals in the field wrote the content. Although including learning context might limit reusability, all LOs were built in context of real-world, authentic problems in mind to prepare the students to adapt to the work environment. The design of the LOs also utilizes the scaffolding approach to help students acquire basic business concepts and develop deeper understanding of the content. The LOs were built to support inquiry-based learning by providing materials in an easy to access format and can be reused within the MBA cohort.

Windle, McCormick, Dandrea, and Wharrad (2011) investigated the effectiveness of reusable learning objects (RLOs) when using in workshop or for self-study to teach nursing students chemistry. The RLOs were developed using the tutor-centered, community of practice approach which specific learning needs and pedagogical factors were considered. The results indicated that the use of RLOs had significant effect on examination attainment. The students rated RLOs as being easy to navigate. They also found RLOs facilitated learning of this kind of subject area, which they originally found difficult to learn. They also appreciated the value of printed text and narration included in the RLOs.

Cameron and Bennett (2013) examined primary school students' responses to the use of reusable learning objects (RLOs) and how the RLOs supported learning. The researchers collected data from classroom observations, learning artifacts, and focus-group interview to learn about students' perceptions and experience with learning objects. The results indicated RLOs had a positive effect on students. The students felt engaged and motivated when learning with LOs; however, they expressed negative opinions on some design aspects. The findings indicated that the learning objects should be carefully designed so that the lack of features of the learning objects would not hinder learning. This might beg for consideration of instructional design methodologies when designing learning objects. Learning objects that rely heavily on technical aspects but not on the instructional methods are not widely used although the LOs adopted advanced technology (Martinez, 2000). To increase usability of LOs, it is necessary to consider instructional requirements and factors that impede and facilitate learning. Taylor, Steward, and Dunn (2006) also recommended the development of learning objects based on the instructional design system. The first step is to determine a learning objective for an LO. Learner's prior knowledge is analyzed. The content, learning activities and work practice need to be determined, and feedback and assessment need to be incorporated.

In conclusion, learning objects revolutionize the way learning materials are created. To build effective LOs, instructional designers may need to consider sound instructional design methodologies. Although LOs have many attributes, reusability is the core to its existence. To examine the redundancy effect, the researcher of this study created learning objects that were reusable, learnable, and interoperable. The pedagogical usability criteria and Gagné's nine events of instruction was used to inform the construction of the instructional modules to teach Microsoft *Access* 2013. The instructional modules were categorized as a combined-closed RLO (Wiley, 2000).

Delphi Method

The Delphi method has been widely used in planning, policy analysis, and long-term forecasting in private and public sectors (Gupta & Clarke, 1996). The first Delphi method was conducted in 1948, and has become popular after Dalkey and Helmer published the first article in 1963. The method was used at the RAND Corporation to "apply expert opinion to the selection . . . of an optimal U. S. industrial target system and to the estimation of the number of A-bombs required to reduce the munitions output by a prescribed amount" (Dalkey & Helmer, 1963, p. 458).

An increased use of the Delphi method was as a result of the need to make effective decisions when there is conflicting or inadequate information (Hasson, Keeney, & McKenna, 2000). Organizations have employed the Delphi method to obtain collective knowledge and experience of experts in a specific field to improve decision-making and better predictions (Gupta & Clarke, 1996). Gupta and Clarke defined the Delphi method as "a qualitative, long range forecasting technique, that elicits, refines, and draws upon the collective opinion and expertise of a panel of experts" (p. 185). Okoli and Pawloski (2004) argued that the method was a superior methodology to the traditional survey to collect higher quality data from experts and stakeholders. However, some researchers did not consider the Delphi method as a stand-alone technique but as one that may be enhanced when used with other approaches (see Rowe & Wright, 2011 for references). For example, Kennedy (2004) used the Delphi method as a primary tool and used the narrative approach as a follow-up procedure to expand, enhance, and support the Delphi findings.

The Delphi method is used to obtain reliable, consensus opinion of a panel of experts, which can be achieved by "a series of intensive questionnaires interspersed with controlled opinion feedback" (Dalkey & Helmer, 1963, p. 458). To conduct the Delphi method, researchers first need to consider whether a given research problem can be investigated by the Delphi method (Hasson, Keeney, & McKenna, 2000). Understanding the nature of the research topic and logistical considerations related to the topic determines if the Delphi is an appropriate method.

Second, the researcher identifies a panel of experts (Hasson et al., 2000). The originators of the Delphi method tend not to advocate selecting a random sample of experts (Goodman, 1987). Instead, a purposive or criterion sampling method may be preferred to select a group of experts to apply their knowledge and experience to solve a specific problem under investigation (Hasson et al., 2000). However, determining who is considered an expert could be controversial. Powell (2003) noted that experts should be those who have appropriate knowledge, expertise, and credibility in the area under investigation. According to Goodman (1987), using the experts who have interest and knowledge related to the investigating area may enhance the content validity. The traditional approach seeks a consensus from the homogeneous groups of experts (Goodman, 1987). However, Murphy et al. (1998) supported the use of heterogeneous groups of experts to draw different perspectives on the problem.

The number of experts employed in the Delphi method also varies (Okoli & Pawlowski, 2004). The number of experts should be considered in terms of time, money, magnitude of the problem, and acceptability of answers (Powell, 2003). However, a more important issue is to obtain their commitment to complete the Delphi process. This can be achieved by looking for those who have interest and involvement with the topic being studied (Hasson et al., 2000).

After determining a research problem and a panel of experts, the next step in the Delphi method is to create a questionnaire to obtain anonymous responses from the experts (Hasson et al., 2000). Their responses are summarized and used to make revisions. The new version is sent back to the same experts for re-evaluation. The iterative process is performed until consensus of opinion, or a point of diminishing returns, has been reached. It is also important that researchers know when the consensus is obtained (McKenna, 1994). Previous studies recommended that the consensus was reached between 51% agreement (Loughlin & Moore, 1979) and 80% (Green, Jones, Hughes, & Williams, 1999). Other studies considered the number of rounds in determining consensus ranging from three rounds (Powell, 2003) to two or more rounds (Murphy et al., 1998).

Many studies have claimed that the Delphi method is reliable, valid (i.e., face, content, construct, and criterion), and trustworthy (see Hasson & Keeney, 2011 for references and discussions). However, the method has received criticism regarding "conceptual and methodological inadequacies, potential for sloppy execution, crudely designed questionnaires, poor choice of experts, unreliable result analysis, limited value of feedback and consensus, and instability of responses among consecutive Delphi rounds" (Gupta & Clarke, 1996, p. 187).

Despite of the criticism, Gupta and Clarke (1996) found that the method has been used many areas such as agriculture, economics, education, health care, tourism, training, and others to assess the quality of projects. Okoli and Pawlowski (2004) used the Delphi method to build a theory. First, researchers use Delphi to identify variables of interest and generate propositions. Then, the researchers generalize the resulting theory through collecting information from experts in the field to extend the empirical findings of the initial theory. The Delphi method can also be used to establish the construct validity associated with the theory.

In the field of instructional design, researchers have used the Delphi method to study future trends (Ritchie & Earnest, 1999), to identify competencies essential to effective project management (Brill, Bishop, & Walker, 2006), to construct and validate an instructional design model (Tracey & Richey, 2007), and to identify the important heuristics that instructional designers used to guide the design process (York & Ertmer, 2011). A modified version of the original Delphi method has been utilized to collect consensus opinions from instructional design experts (IDEs) and subject matter experts (SMEs) to improve the quality of RLOs (Wang, 2011; Huang, 2012). The modified version was used in the present study, which was discussed thoroughly in the procedure section of Chapter III.

CHAPTER III

Method

Purpose of Study

The purpose of this study was to further examine the redundancy effect by comparing the posttest scores, delayed posttest scores, and pedagogical usability perceptions of undergraduate education majors who received a non-redundant instructional module (graphics and narration) and of those who received a redundant instructional module (graphics, narration, and text) on learning basic Microsoft *Access* 2013. This chapter discusses participants, research design, instruments, procedure (with construction of the modules), data collection, and data analysis.

Participants

This study employed a convenience sampling method. The targeted participants enrolled in the EDUC 2215 course on "*Preparing to Teach with Technology*" offered by the College of Education in fall 2013 at an intermountain regional university in the western part of the United States. Although it was a required class, students had an option to test themselves out. Two sections of this online class were offered. One section was on the main campus, and the other section was on a distance campus. The two campuses were approximately 50 miles apart. Past experience indicated that, despite separate geographical areas, students who had enrolled in this class usually shared similar characteristics in terms of technology skills, attitudes toward learning, and motivation.

Among 52 students, 42 participated in this study. The study participants consisted of five males and 37 females. All of them were native English speakers. Ten participants were non-traditional students (two males and eight females). None of the participants reported to have learning disabilities. Some participants expressed strong enthusiasm and interests in learning Microsoft *Access* 2013, which they claimed to be useful for their work, personal business, and future teaching.

Research Design

This study employed an experimental design (see Figure 1). The research participants were randomly assigned into one of the two instructional treatments. After the treatment, the four-point Likert scaled, pedagogical usability survey was administered. Then, the posttest, which was a performance-based test, was administered followed by the delayed posttest six weeks later. The posttest and delayed posttest was the same.

Research Instruments

Instructional modules. The instructional modules were built using the Adobe *Captivate* 7.0 software to capture full screen and were published in a flash format to play on a web browser. The non-redundant module had graphics and narration. The redundant module had graphics, narration, and text. The font size of text was 24 points (largest). The font type was Times New Roman. On average, eight words were presented at a time and in one line. The narration was presented as approximately 120 words per minute.

The two modules had the same instructional length and covered the same learning content. The original modules only taught how to create a database file and a table using Microsoft *Access* 2013. The pilot test with three volunteers (two receiving the redundant module and one receiving the non-redundant module) indicated that the content was too short, and the posttest was easy. Therefore, more content was added—creating queries in Microsoft *Access* 2013. The revised modules lasted approximately 20 minutes. The subject matter experts also validated the new content during the Delphi process.

The modules informed the participants of prerequisite skills and learning objectives and explained how useful a database could be for business and teaching. A picture of a table and query in Microsoft *Access* 2013 was each presented along with an explanation of its purpose. The modules then began addressing each objective. Within each objective, a review of what to be learned was presented before showing the steps. At the end of each objective, the modules also reviewed what was learned before addressing the next objective.

No navigation buttons (e.g., pause, rewind, backward, forward) were provided in the modules to prevent learners from manipulating the pace of instruction. The participants only watched the modules from beginning to end. This type of module was also used in Mayer, Heiser, and Lonn's (2001) research to determine how much information the participants could retain when they had to continuously process information. The present study attempted a similar investigation but in a slightly different way (see problem statement and purpose).

Assessments. The researcher in consultation with the subject matter experts developed the posttest and delayed posttest (Appendix C-7). Originally, the test was to assess learning to create a database file and a table in Microsoft *Access* 2013. The pilot test was conducted with three available volunteers (traditional and non-traditional students), who had never used the software. The feedback indicated that the posttest was too easy. The participants spent around 20 minutes to complete the test, and all of them scored the maximum points. Therefore, the posttest was revised by including more items (i.e., creating two queries) to increase the difficulty level. One volunteer participated in the second pilot test. The feedback indicated that the length of the module was appropriate (not too long nor too short), and the posttest had an appropriate difficulty level. The volunteer spent around 45 minutes to complete the posttest and did not score the maximum points. Therefore, adding the query section into the test seemed to increase the difficulty level, which also helped increase the test discriminatory power. This revised posttest was further assessed for its face and content validity by a panel of experts through a Delphi survey.

To assess pedagogical usability of the instructional modules, the researcher adapted the Pedagogically Meaningful Learning Questionnaire (PMLQ) (Nokelainen, 2006, with author's permission) to collect the participants' perceptions. Two versions of the surveys were used, which corresponded to the two types of the instructional modules. The first survey version was completed by the group that received the non-redundant instructional module (narration and graphics). This version consisted of 24 questions on the four-point Likert-scale, which took about 5-10 minutes to complete. The second survey was completed by the group that received the redundant instructional module (narration, graphics, and text). This version consisted of 25 questions using the same scale. The two survey versions were in Appendix A.

The reliability (Cronbach's alpha, α) of each survey was calculated to determine the internal consistency among the question items. The Cronbach's alpha for the non-redundant survey was .88, which showed high internal consistency. The Cronbach's alpha for the redundant survey was .83, which also indicated high internal consistency among the items.

Table 1

Time Length for Procedure

	Time Length	**Note**
Instructional module	Approximately 20 minutes	
Pedagogical usability survey	5 – 10 minutes	
Posttest	60 minutes	
Delayed posttest	60 minutes	Six weeks after posttest

Procedure

Although the two class sections were delivered online via the Moodle learning management system, the study was conducted in two face-to-face computer lab meetings, which occurred on two separate campuses. The class instructor informed students at the beginning of the semester about the study and asked for their participation. The instructor informed the students that there would be no negative consequences if they refused to participate. Because the content (Microsoft *Access* 2013) used in this study was also part of the course content, those who chose not to participate in this study also had an opportunity to learn the same content on Moodle after the study. Since the targeted subject content was a non-sequential, stand-alone module, there was no hindrance to course progress for those who did not participate.

The instructor obtained the informed consents from the participants via emails. Among 52 students, 49 originally agreed to participate. They were randomly assigned into one of the two treatment groups—redundant and non-redundant—before the first meeting in the computer lab. Seven participants—five in the redundant group and two in the non-redundant group—did not show up during the first meeting without prior notice. As a result, only 42 actually participated in the study, with 19 participants in the redundant group (graphics, narration, & text) and 23 participants in the non-redundant group (graphics & narration).

The first meeting was to watch the instructional modules, to complete the pedagogical usability survey, and to take the posttest. The second meeting happened six weeks later to complete the delayed posttest to measure long-term retention. The same instructor proctored the two meetings to prevent any interactions among the participants and to standardize the study procedure.

During the first meeting, each computer lab was divided into two separate areas for the two treatment groups. The instructor informed the participants that the activities were individual and independent experiences. Any questions should be referred to the instructor. Immediately after watching the module, the participants were asked to complete the four-point Likert-scaled pedagogical usability survey. Afterwards, participants completed the posttest and submitted it on Moodle for grading. Six weeks later, the participants returned to the same computer lab to complete the delayed posttest to assess long-term retention. Their delayed posttests were also submitted on Moodle for grading. The instructor kept a record of each participant's assigned module, survey responses, posttest score, and delayed posttest score. Only the instructor had access to the information. No students' identifiers were included when the study results were reported.

Construction of the instructional modules. Two instructional modules were created to examine the redundancy effect on learning basic Microsoft *Access 2013*. The ADDIE ID model was used to build the modules. The nine events of instruction (Gagné, Briggs, & Wager, 1992) and pedagogical usability principles (Nokelainen, 2006) were applied in the design of the modules. Each phase in ADDIE was discussed in the following sections.

Analyze phase. This phase consisted of 10 tasks (Strickland, Moulton, Strickland, & White, 2013), which was divided into four domains—content, instruction, environment, and management (see Figure 2). The degree to which these tasks were met was validated through the modified Delphi surveys completed by the subject matter experts (SMEs) and instructional design experts (IDEs) to establish their face and content validity (Strickland, Moulton, Strickland, & White, 2013). The responses from the Delphi surveys were used to calculate mean, median, standard deviation, and semi interquartile range. The following sections addressed each task within the Analyze phase (see Figure 2).

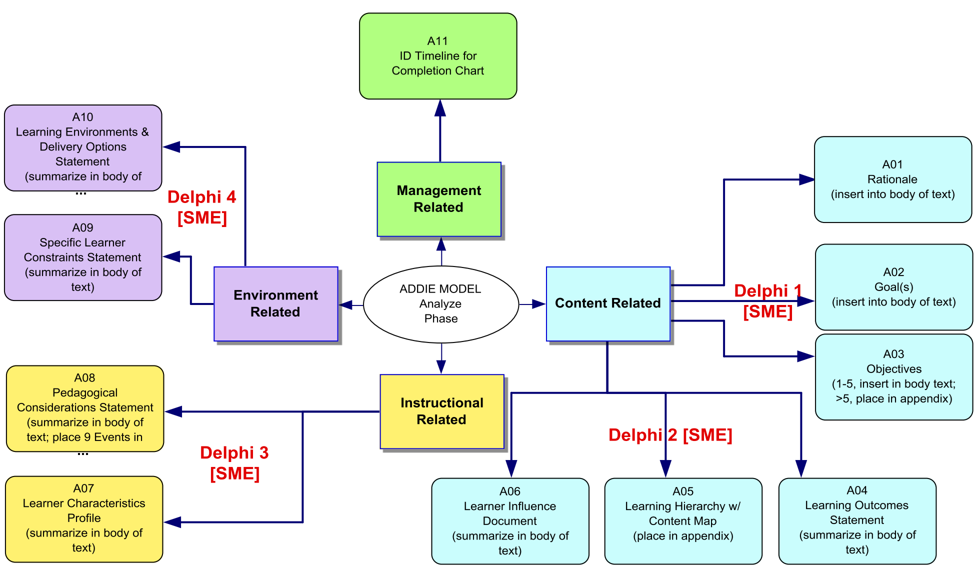

*Figure 2***:** Tasks of the Analyze Phase and Corresponding Delphis © 2013 A. Strickland, J. Strickland, Moulton, & White.

Task A01: Project Rationale. The project rationale provides justification for the project and directs the project goal and learning objectives:

> Two instructional modules were built based on the redundancy principle (Mayer, Heiser, & Lonn, 2001) and pedagogical usability (Nokelainen, 2006) to further examine the redundancy effect that may allow the researcher to identify which instructional module helped learners acquire skills in using Microsoft *Access* 2013 more effectively. The study results may inform a designer how to use multimedia elements when creating online modules to teach different technologies.
>
> Previous studies (i.e., Mayer, Heiser, & Lonn, 2001) in the redundancy effect were conducted in a laboratory setting, used a short treatment time (i.e., 140 seconds), and assessed only immediate learning. Using ADDIE, the researcher of this study built an instructional module that had graphics and narration and another instructional module that included graphics, narration, and text (duplication of narration) to further examine the multimedia redundancy effect within an academic setting, with a longer treatment time and with an assessment of long-term retention (delayed posttest). The research participants were teacher candidates who enrolled in the EDUC 2215 course on *Preparing to Teach with Technology* in the fall 2013 semester in the College of Education at an intermountain western university in the United States.

Task A02: Project Goal. According to Strickland, Moulton, Strickland, and White (2013), a goal needs to be specific, measurable, achievable, and significant. The project goal provides an overall guideline for the development of the modules:

> The goal of this project was to teach students how to use basic features in Microsoft *Access* 2013 to create a database file, a table, and queries through an instructional module with redundancy (graphics, narration, and text) and another module without redundancy (graphics and narration). The content was considered appropriate for the students in the EDUC 2215 class.

Task A03: Learning Objectives. The learning objectives followed Mager’s three components—performance, conditions, and standard (Mager, 1997). Performance indicates what tasks learners are able to perform at the end of the instruction; condition specifies circumstances under which learners perform the tasks; and, criterion indicates a standard that needs to be met when learners perform the tasks. To achieve the project rationale and goal, the following learning objectives were created to guide this project. The EDUC 2215 students were able to:

1. Create a database file with 100% accuracy as measured by a performance-based test according to instructor guidelines.
2. Create a table within the database with 100% accuracy as measured by a performance-based test according to instructor guidelines.
3. Create two queries in the database 100% accuracy as measured by a performance-based test according to instructor guidelines.

The project rationale, goal, and learning objectives were evaluated by the Delphi survey 01 (See Appendix B-1). The survey used a four-point Likert scale, with 1 as Strongly Disagree, 2 as Disagree, 3 as Agree, and 4 as Strongly Agree. The values of mean, standard deviation, median, and semi-interquartile range of all responses were computed to report the consensus from the subject matter experts (SMEs).

The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the 21 items of the Delphi survey 01 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 4. Table 2 listed the descriptive statistics of all responses from the SMEs.

Table 2

Delphi Survey 01: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 01: Analyze Phase (*Tasks A01-A03*)	21	3.75	.44	4	.25

Task A04: Learning Outcomes Statement. The learning outcomes statement is based on Gagné's conditions of learning (Gagné, 1985; Gagné et al., 1992). There are five types of learning capabilities—verbal information, intellectual skills, cognitive strategies, attitude, and motor skills. Verbal information is the ability to recall information (declarative knowledge). Intellectual skills are procedural knowledge, which allows learners to perform mental operations to discriminate concepts, define concepts, apply rules, or solve problems. Cognitive strategies are a self-regulatory process through which learners plan, control, and monitor their thinking and learning. Attitude is a predisposition that affects a personal choice of action. Motor skills are those that allow learners to physically perform a task.

The learning outcomes of this project were derived from the learning objectives and were categorized as intellectual and motor skills. Immediately after the treatment (short-term learning effect), the students were able to:

1. create a database file
2. create a table in the database
3. create two queries in the database

Six weeks later (long-term learning effect), the students were expected to recall how to create a database file, table, and queries. The students were also expected to apply the knowledge and skills in using Microsoft *Access* 2013 to create and manage a database to assist their future teaching-related tasks.

Task A05: Learning Hierarchy with Concept Map. A learning hierarchy is a graphical representation of learning objectives, tasks, and prerequisite skills that need to be accomplished to ensure the attainment of the project goal. The learning hierarchy was in Appendix B-2. According to the hierarchy, the participants were expected to have basic computer skills in using computer mouse and keyboard. During the modules, they learned how to create and save a database file, create a table, and create queries in this sequential order.

Task A06: Learning Influence Document. The learner influence document allows designers to discuss the use of instructional strategies (i.e., Gagné’s nine events of instruction) in the modules to facilitate learning. The strategies include gaining and maintaining attention, recalling prior knowledge, and enhancing recall of information. A detailed learner influence document for this project was in Appendix B-3.

The Delphi Survey 02 was used to assess the face and content validity of Tasks 04-06. The same panel of SMEs was asked to provide feedback on the four-point Likert-scaled items, with 1 indicating Strongly Disagree, 2 as Disagree, 3 as Agree, and 4 as Strongly Agree. The values of mean, standard deviation, median, and semi-interquartile range of all responses were calculated. The Delphi survey was in Appendix B-4.

The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the 20 items of the Delphi survey 02 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 3.67. Table 3 listed the descriptive statistics of all responses from the SMEs.

Table 3

Delphi Survey 02: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 02: Analyze Phase (*Tasks A04-A06*)	20	3.47	.50	3	.50

Task A07: Learner Characteristics Profile. The Learner Characteristics Profile was in Appendix B-5. It described the demographics of the research participants of the study (see the participants section).

Task A08: Pedagogical Considerations Statement. The pedagogical consideration statement of the project was as follows:

The instructional sequence followed the topical sequencing format (Reigeluth, 1999). In this format, a topic was completely taught before proceeding to the next one. Usually, the previous topic was prerequisite to the next topic, and each topic was taught only once. For example, the participants learned how to create a database file first before proceeding to learning how to create a table in Microsoft *Access* 2013. After they learned how to create a table, they learned how to create a query. The instruction was complete after these topics were addressed.

Regarding the instructional strategies, Gagné’s nine events of instruction (Gagné, et al., 1992; Gagné, et al., 2005) were used as a framework to design the modules. Because of the nature of the study, four events (gain attention, inform learning objectives, recall prior knowledge, and teach content) were applied to the modules. For example, the modules motivated the participants by discussing different scenarios that showed usefulness of Microsoft *Access* 2013. The modules recalled prior knowledge before attempting to teach the application. The participants were also informed about the learning objectives and its sub-objectives throughout the modules.

In addition, pedagogical usability (Nokelainen, 2006) was also used to inform the construction of the modules. The principle intended to address the student-centered approach for learning. For example, the modules were built to help the participants apply what was learned, to encourage active processing of information, and to motivate learning. Research in the area of multimedia learning suggested instruction that addressed multi modalities—visual and auditory channels (Mayer, 2009; Clark & Mayer, 2011). Both modules included graphics and narration to support different learning needs.

The Delphi survey 03 for Tasks A07 and A08 was conducted with the same panel of SMEs to evaluate face and content validity. (Appendix B-6 contained the survey template.) The mean, standard deviation, median, and semi-interquartile range were reported.

The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the 14 items of the Delphi survey 03 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 4. Table 4 listed the descriptive statistics of all responses from the SMEs.

Table 4

Delphi Survey 03: Descriptive Statistics of Responses

Survey	Number of Items	*M*	*SD*	*Mdn*	*SIR*
Delphi 03: Analyze Phase (*Tasks A07-A08*)	14	3.69	.47	4	.50

Task A09: Learner Constraints Statement. The statement described any difficulty the research participants may have during their interaction with the instructional module—graphics, narration or text. The learner constraints statement was as follows:

> It was expected that the majority of the participants had at least basic computer skills (i.e., using mouse and keyboard) and knew how to setup a headphone to the computer. The instructor would assist those who needed help. The participants may experience slight physical discomfort during the interaction with the instructional module. However, the module took about 20 minutes to complete. Therefore, this was not a major health concern. During the treatment, the participants were asked not to take notes or practice any activity but try to remember the content. As a result, some participants may feel lost and/or frustrated without any hands-on activities to help reinforce learning.
>
> Participants with disabilities—such as auditory, visual, or movement difficulties—were not the targeted audience because the focus of the research was on possible interference of multimedia elements (e.g., graphics, narration, & text). It was important to gather data from learners who could fully interact with the presented multimedia elements.
>
> All participants had access to a computer in the computer lab. They were also provided with a headphone. Prior to beginning the module, the instructor checked if all participants could view the content on their assigned computer.

Task A10: Learning Environment and Delivery Options Statement. In this study, the participants watched an assigned instructional module on computer, completed a paper-and-pencil survey, and completed the posttest and delayed posttest. Each activity was timed (see Table 1 above). Their posttest and delayed posttest assessments were submitted on the Moodle learning management system. Appendix B-7 contained the learning environment document and delivery options statements.

The Delphi survey 04 for Tasks A09 and A10 was conducted with the same panel of SMEs to evaluate face and content validity. Appendix B-8 contained the survey items. The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the 15 items of the Delphi survey 04 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 4. Table 5 listed the descriptive statistics of all responses from the SMEs.

Table 5

Delphi Survey 04: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 04: Analyze Phase (*Tasks A09-A10*)	15	3.78	.43	4	0

Design phase. This phase consisted of six tasks (see Figure 3) (Strickland, Moulton, Strickland, & White, 2013), four of which were sent to a panel of subject matter experts (SMEs) and instructional design experts (IDEs) to evaluate face and content validity.

The tasks included the task analysis, flowcharts with content, storyboards, assessment instruments, field-test of assessment instrument, and the prototype of a reusable learning object (RLO) for review. The following sections discussed each task and its corresponding Delphi survey in detail.

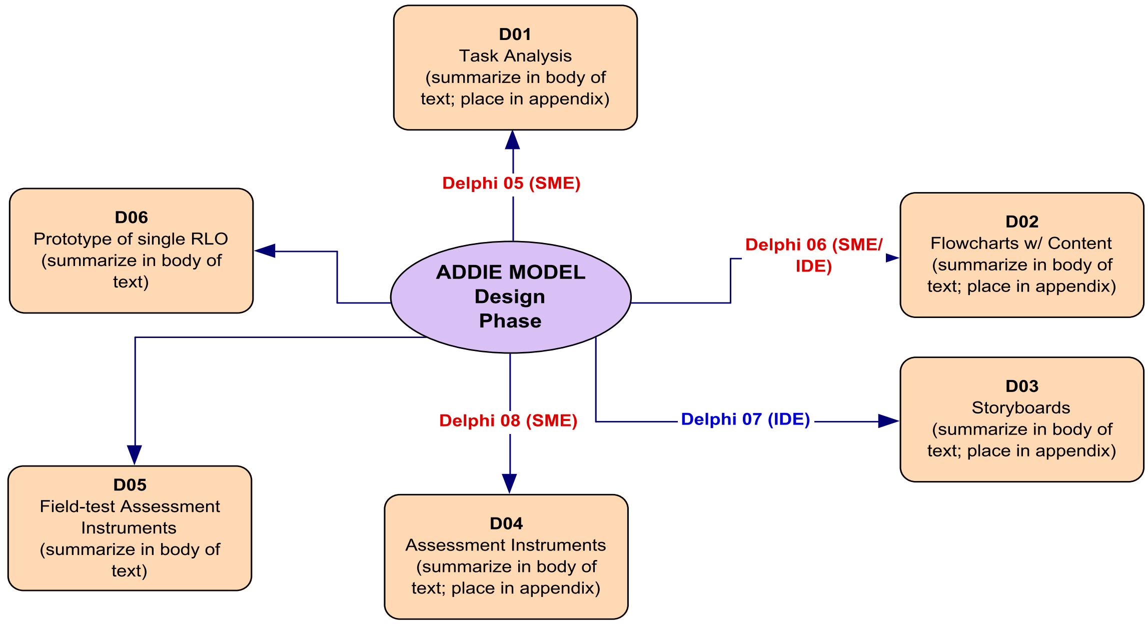

Figure 3: Tasks of the Design Phase and Corresponding Delphis ©2013 A. Strickland, J. Strickland, Moulton, & White.

Task D01: Task Analysis. According to Jonassen, Tessmer, and Hannum (1999), task analysis is “a process of analyzing and articulating the kind of learning that you expect the learners to know how to perform” (p. 3). Designers need to understand the nature of the tasks the learners will perform in order to design effective instruction to support learning.

In this project, tasks and subtasks that supported each learning objective were identified (see Appendix C-1). All tasks and subtasks were classified as procedural knowledge and were within the domain of motor skills. They had different levels of importance and difficulties, with no essential prerequisite skills required (see the Hierarchical Learning Map in Appendix B-2). The tasks and subtasks were evaluated by the SMEs via the Delphi survey 05 (see Appendix C-2).

The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the 15 items of the Delphi survey 05 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 3.67. Table 6 listed the descriptive statistics of all responses from the SMEs.

Table 6

Delphi Survey 05: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 05: Design Phase (*Task D01*)	15	3.53	.50	4	.50

Task D02: Flowcharts with Content. The flowcharts provide a visual representation of each step of the design process. Appendix C-3 contained the flowcharts for the modules; these were evaluated by the SMEs using Delphi 06, which is in Appendix C-4.

The panel of SMEs/IDEs responded positively to all of the five items of the Delphi survey 06 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean value for each individual item was 3.67. Table 8 listed the descriptive statistics of responses.

Table 7

Delphi Survey 06: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 06: Design Phase (*Task D02*)	5	3.67	.49	4	.50

Task D03: Storyboards. Storyboards were created to provide visual cues to assist the development of the modules. The storyboards contained specifications of text, graphics, narration, and navigation. The storyboards for the project were in Appendix C-5. Like other tasks, the storyboards were evaluated by the IDEs using the Delphi survey 07 (Appendix C-6) to establish face validity.

The instructional design experts (IDEs) responded positively (agree and strongly agree) to all of the 12 items of the Delphi survey 07 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean values for individual items ranged from 3.33 to 3.67. Table 8 listed the descriptive statistics of all responses.

Table 8

Delphi Survey 07: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 07: Design Phase (*Task D03*)	12	3.53	.51	4	.50

Task D04: Assessment Instruments. The researcher designed a performance-based posttest and delayed posttest to assess student learning. The posttest and delayed posttest was identical (see Appendix C-7). The test instrument was evaluated by the SMEs to confirm its face and content validity through the Delphi survey 08 (see Appendix C-8).

The subject matter experts (SMEs) responded positively (agree and strongly agree) to all of the six items of the Delphi survey 08 within the first round. The mean (*M*), standard deviation (*SD*), median (*Mdn*), and semi-interquartile range (*SIR*) of all responses were calculated. The mean value for each individual survey was 3.67. Table 9 listed the descriptive statistics of all responses from the SMEs.

Table 9

Delphi Survey 08: Descriptive Statistics of Responses

Survey	**Number of Items**	***M***	***SD***	***Mdn***	***SIR***
Delphi 08: Design Phase (*Task D04*)	6	3.67	.49	4	.50

Task D05: Field Test of Assessment Instruments. The assessment was also field-tested with four individuals with similar characteristics to those of the targeted learners to further confirm its clarity. Feedback was used to revise the instrument.

Task D06: Prototype of an RLO. The samples of instructional modules were built for the pilot test. The two modules had the same content and instructional time but were different in terms of multimedia element: One module consisted of graphics and narration; the other had graphics, narration, and text.

Develop phase. Adobe *Captivate* 7.0 was used to create the instructional modules. The modules were published in a *Flash*-based format. The modules did not include any navigation buttons (see the instructional modules section).

Implement phase. The modules were saved on computers in the computer labs. The participants watched their assigned module and completed the survey to assess the quality of the modules. Then, they completed the posttest and the delayed posttest.

Evaluate phase. A formative evaluation was conducted to assess the design process and the quality of the modules via Delphi surveys with SMEs and IDEs and pilot test. The feedback received was used to revise material, assessment, and other design elements. The students' responses to the pedagogical usability survey were collected to assess the quality of the modules for further revisions.

Data Collection

The pedagogical usability survey was administered immediately after the treatment and before the posttest. The survey was to capture participants' perceptions about the quality of the instructional modules. Forty-two participants completed the survey, with seven missing values. The reasons were unknown. This could be due to unclear questions.

The posttest and delayed posttest was used to measure short-term and long-term learning. The posttest was administered immediately after the survey. The delayed posttest was administered six weeks after the posttest. Among the 42 participants, three did not submit their posttests for grading, which resulted in only 39 scores (21 in the non-redundant group and 18 in the redundant group) available for data analysis. Nine of the 42 participants did not submit their delayed posttests due to family medical emergency, university's athletic commitment, and other unknown reasons. Only 33 delayed posttest scores (18 in the non-redundant group and 15 in the redundant group) were available for data analysis.

Data Analyses

This study suffered from loss of data on the survey responses and test scores, especially delayed posttest scores. An analysis of missing values was conducted to determine whether the data were missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). The result would inform an appropriate statistical test to analyze the data. If the data were missing completely at random or missing at random, this would warrant the use of conventional statistical tests; otherwise, a more robust test would be required.

The Missing Value Analysis using the expectation maximization method on *SPSS* was selected to examine the data pattern. The analysis was performed on the posttest scores, delayed posttest scores, and 25 survey questions (for the redundant group). The Little's *MCAR* test was not significant, χ^2 (252) = 263.08, p = .303. The analysis was also performed on the posttest scores, delayed posttest scores, and 24 survey questions (for the non-redundant group), the Little's *MCAR* test still maintained an insignificant result, χ^2 (147) = 167.96, p = .114. Any of these results suggested the probability that the missing pattern deviated from randomness was greater than .05 (Tabachnick & Fidell, 2007). This may infer MCAR or MAR, which warranted the use of a conventional statistical test to answer the research questions.

To answer the first and second research questions, Mann-Whitney *U*-tests were used separately to analyze the posttest and delayed posttest scores to compare the two treatment groups with the Bonnferroni's correction (.05/2 = .025). The choice of this nonparametric test over the independent *t*-tests or the mixed-design *ANOVA* test was based on the violation of the normality assumption required by the parametric tests. For posttest, the Shapiro-Wilk test of the non-redundant group was significant, $W(21) = .73$, $p = .000$, and that of the redundant group was also significant, $W(18) = .68$, $p = .000$. The results indicated deviation from normality. For delayed posttest, the Shapiro-Wilk test of the non-redundant group was significant, $W(18) = .88$, $p = .026$, and of the redundant group was not significant, $W(15) = .92$, $p = .202$. The Q-Q plots and histograms of both posttest and delayed posttest indicated deviations from normality. In addition, the equal variances assumption was also violated. The Levene's test of equality of posttest was not significant, *F*(1, 29) =. 44, *p* = .511. However, the Levene's test of equality of delayed posttest was significant, *F*(1, 29) = 9.01, *p* = .005. These mixed results also indicated a violation of the compound symmetry required by the mixed design *ANOVA*. Since the sample size of the study was small for both posttest and delayed posttest, a violation of the normality assumption was a major concern. Therefore, the nonparametric Mann-Whitney *U*-tests were considered more appropriate tests for both posttest and delayed posttest.

The boxplots of the posttest scores showed one outlier for the non-redundant group and two outliers for the redundant group. The boxplots of the delayed posttest scores did not show outlying points. Deleting these three outliers in the posttest scores improved normality of the non-redundant group, *W*(20) = .95, *p* = .413, but did not necessarily improve normality of the redundant group, *W*(16) = .85, *p* = .012. The histograms still indicated negatively skewed distributions for both groups. The Box's *M* test was also significant, *F*(3, 226349.78) = 3.129, *p* = .025, indicating a violation of the equal variance and covariance assumption in the mixed-design *ANOVA*. These assumption violations (i.e., normality, equal variances, and equal variance-covariance) after the outliers were deleted still did not warrant the use of the mixed design-*ANOVA* and the independent *t*-tests for posttest and delayed posttest. In addition, with or without the outliers, the study results were similar between the parametric tests (i.e., *t*-tests and mixed *ANOVA*) and the nonparametric test (Mann-Whitney *U*-tests). Therefore, the outliers were included back in the data analysis to keep a larger sample size, and the Mann-Whitney *U*-tests were used to compare the posttest scores and delayed posttest scores between the two groups.

According to Gravetter and Wallnau (2007), the Mann-Whitney *U*-test required the data to be independent and continuous. These two conditions were likely to be met. Myers, Well, and Lorch (2010) mentioned another assumption required by this test that the population distributions should have the same shape between the two groups. “If they do not, significant test results may reflect differences in variance, or in shape parameters, even though the averages are the same” (p. 136). This assumption was not met; however, the study results were less likely to be affected by its violation.

The independent *t*-test was used to compare the participants’ usability perceptions between the two treatment groups. The comparison was based on the average scores, instead of the total scores, considering the missing values and the difference in the number of question items (24 items in the non-redundant survey and 25 items in the redundant survey) between the two groups. Questions 6 and 15 were reversed in the calculation of the average scores. The independent *t*-test assumptions were met to warrant the use of this parametric test on perceptions. The normality assumption was met. The Shapiro-Wilk tests for the non-redundant group and redundant group were not significant, $W(23) = .95$, $p = .360$ and $W(19) = .98$, $p = .923$, respectively. The Q-Q plots and histograms did not indicate deviation from normality. The Levene’s test was not significant, $F(1,40) = .37$, $p = .838$. The observations were considered independent.

CHAPTER IV

Results

The purpose of this study was to further examine the redundancy effect by comparing the posttest scores, delayed posttest scores, and pedagogical usability perceptions of undergraduate education majors who received a non-redundant instructional module (graphics and narration) and of those who received a redundant instructional module (graphics, narration, and narration-duplicated text) for learning basic-level information on Microsoft *Access* 2013.

Research Question 1

Is there a significant difference in posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by a researcher-designed instrument?

Research hypotheses ($\alpha = .025$):

H_{o1}: There is no significant difference in posttest scores between the non-redundant group and the redundant group. The ranks in the non-redundant group were not systematically higher or lower than the ranks in the redundant group. ($\mu_{11} = \mu_{12}$)

H_{a1}: There is a significant difference in posttest scores between the non-redundant group and the redundant group. The ranks in the non-redundant group were systematically higher or lower than the ranks in the redundant group. ($\mu_{11} \pm \mu_{12}$)

Among the 42 participants, three did not submit their posttests for grading, which resulted in 39 scores available for data analysis. These scores were rank-ordered, and the Mann-Whitney *U*-test was conducted to compare the ranks for the non-redundant group

(n = 21) with the ranks for the redundant group (n = 18). The result indicated no significant difference between the two treatments, $U = 164.50$, $p = .489$, with the sum of ranks equal to 395.50 for the non-redundant group and 384.50 for the redundant group. The median for the redundant group was 80.44, and the median for the non-redundant group was 80.33. The estimated effect size was small, $r = Z/\sqrt{n} = .11$ (Field, 2009; Fritz, Morris, & Richler, 2012). According to a meta-analysis study in the redundancy effect, a small effect size was likely to be found in studies conducted in a classroom (part of a formal course) compared to a medium effect size of those conducted in laboratory settings, but both effect sizes should be statistically detectable (Adesope & Nesbit, 2012). However, the study did not find a significant result. It failed to reject the null hypothesis ($\mu_{11} = \mu_{12}$), meaning that the ranks in the non-redundant group were not systematically higher or lower than the ranks in the redundant group. In this study, text did not appear to negatively affect the immediate learning. However, because of a threat to the internal validity and confounding factors, the cause and effect interpretation of the study result must be done with cautions. The discussion of the results was provided in Chapter V.

Research Question 2

Is there a significant difference in delayed posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by the same researcher-designed instrument?

Research hypotheses (α = .025):

H_{o2}: There is no significant difference in delayed posttest scores between the non-redundant group and the redundant group. The ranks in the non-redundant group were not systematically higher or lower than the ranks in the redundant group. ($\mu_{21} = \mu_{22}$)

H_{a2}: There is a significant difference in delayed posttest scores between the non-redundant group and the redundant group. The ranks in the non-redundant group were systematically higher or lower than the ranks in the redundant group. ($\mu_{21} \pm \mu_{22}$)

Because of the missing values, only 33 delayed posttest scores were available for data analysis. These scores were rank-ordered, and the Mann-Whitney *U*-test was conducted to compare the ranks for the non-redundant group (n = 18) with the ranks for the redundant group (n = 15). The result indicated no significant difference between the two treatments, U = 118, p = .538, with the sum of ranks equal to 289 for the non-redundant group and 272 for the redundant group. The median for the redundant group was 74, and the median for the non-redundant group was 60.22. The estimated effect size was also small, r = .11. The result failed to reject the null hypothesis ($\mu_{21} = \mu_{22}$), meaning that the ranks in the non-redundant group were not systematically higher or lower than the ranks in the redundant group. In this study, text did not appear to have a negative effect on long-term learning.

Although the study did not find any significant difference in the posttest and delayed posttest scores between the two groups, the result from the Wilcoxon signed-ranks test indicated there was a significant difference between the posttest scores and the delayed posttest scores, Z = -3.40, p = .001, with the median posttest score of 86 and the median delayed posttest score of 71. The result suggested that learning decreased over time, which was supported by previous studies (i.e., Butler & Roediger, 2007; Karpicke & Roediger, 2007; Sisson, Swartz, & Wolf, 1992).

Research Question 3

Is there a significant difference in pedagogical usability perceptions of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text)?

Research hypotheses (α = .05):

H_{o3}: There is no significant difference in usability perceptions between the non-redundant group and the redundant group ($\mu_{31} = \mu_{32}$)
H_{a3}: There is a significant difference in usability perceptions between the non-redundant group and the redundant group ($\mu_{31} \pm \mu_{32}$)

All 42 participants completed the pedagogical usability survey although there were some missing values in those responses. The descriptive statistics of the responses were calculated for the two groups and were shown in Table 10.

Table 10

Descriptive Statistics of the Usability Survey Responses

Group	***n***	***M***	***SD***
Non-redundant (*Graphics & narration*)	23	3.32	.33
Redundant (*Graphics, narration, & text*)	19	3.26	.32

The independent *t*-test was performed to compare the participants' pedagogical usability perceptions about the instructional modules. The result indicated that there was no significant difference in perceptions between the non-redundant group and the redundant group, $t(40) = .60$, $p = .549$. The effect size was small, $d = .18$. The post-hoc power analysis indicated a very low power (9%).

To revise the existing survey used in this study, the Exploratory Factor Analysis (EFA) and reliability tests were performed to examine reliability and validity of the survey. A preliminary EFA analysis indicated six subscales (factors) within the survey. Each subscale had the eigenvalue of larger than 1. The six subscales accounted for

75.63% of the total variance. However, one of the subscales consisted of three questions, which had low bivariate correlations among one another. In addition, it seemed to address a similar aspect of another subscale. One subscale formed an unstable factor (only two questions). Attempts were made to reduce to only five subscales. As a result, questions 4, 5, 6, 14, and 15 were excluded based on statistical and conceptual reasons. (Question 25 for the redundant group survey was also excluded, because only one group completed the survey. When this question was included, the matrix determinant was equal to zero.)

The exclusion of the above questions slightly increased the overall reliability (α = .89). The five subscales accounted for 74.82% of the total variance, which was considered sufficient. Each subscale addressed a unique pedagogical aspect. These five subscales were not conceptually overlapping. To justify these subscales, the statistical assumptions of factor analysis were checked. However, it is noted that the study sample was still considered small for this type of analysis.

The Kaiser-Meyer-Olkin (KMO) was .71 (larger than .70). The Bartlett's test of Sphericity was significant, χ^2 (171) = 466.23, p = .000. The diagonal values of the anti-image correlation matrix were larger than .50, except for question 11. Many correlation coefficients in the correlation matrix were larger than .30. These conditions justified factorability, which indicated that the data were suitable for factor analysis (Leech, Barrett, & Morgan, 2008; Tabachnick & Fidell, 2007). The distributions of the question items, except questions 9 and 10, were not skewed. This indicated sufficient normality. However, there were outliers presented in questions 12, 17, 18, and 21. The determinant of the correlation matrix was much smaller than .0001, which may indicate a problem of collinearity (Leech, Barrett, & Morgan, 2008). Given the collinearity and outlier problems, the results should be interpreted with caution.

As mentioned earlier, the five subscales represented approximately 75% of the total variance and had the reliability coefficient of .89. Each of the five subscales consisted of different questions. Each question had a factor loading larger than .50, except question 11 (see Table 11). However, all items had communality equal to 1, which seemed to indicate that the survey may lack discriminatory power to capture different perceptions. The five subscales were listed, as follows:

The first subscale consisted of questions 20, 8, 1, 2, 3, and 16. These questions addressed the instructional design aspects of the instructional modules. Therefore, the subscale was named “Design Consideration” subscale. The reliability (Cronbach’s alpha) of this subscale was .84, which indicated high internal consistency among the items.

The second subscale consisted of questions 24, 23, and 22. These questions addressed the participants’ confidence in performing the tasks after watching the instructional modules. The subscale was named “Learning Confidence” subscale. The reliability of this subscale was .96.

The third subscale consisted of questions 17, 12, and 21. These questions addressed the participants’ learning preference with the instructional modules over the instructor-led, traditional environment. The subscale was named “Learning Format” subscale. The reliability of this subscale was .86.

The fourth subscale consisted of questions 13, 18, 19, and 7. These questions mainly addressed the participants’ interest and motivation in learning the content from the instructional modules. The subscale was named “Learning Motivation” subscale. The reliability of this subscale was .87.

The fifth subscale consisted of questions 9, 10, and 11. These questions addressed the role of multimedia elements (narration, graphics, and image) in learning the targeted content (Microsoft *Access* 2013). The subscale was named “Multimedia Element” subscale. The reliability of this subscale was .78.

This new survey excluded questions 4, 5, 6, 14, 15, and 25 from the original version (Appendix A-3). It was in Appendix A-4.

In conclusion, the study results indicated that text did not appear to have a negative effect on short-term and long-term learning of Microsoft *Access* 2013. The result also indicated no significant difference in pedagogical usability perceptions between the redundant group and non-redundant group. The pedagogical usability survey was revised using the exploratory factor analysis and reliability tests. The revised version had high reliability and consisted of 19 questions, which were divided into five main subscales—design consideration, learning confidence, learning format, learning motivation, and multimedia element—each of which had high reliability.

Table 11

Factor Loadings and Communality of the Survey Subscales

	Factor Loading					Communality
	1	2	3	4	5	
Q20: The time allotted for completing this tutorial was adequate for me.	.79					1
Q8: The difficulty level in this tutorial was appropriate for me.	.75					1
Q1: Dividing this content into sections assisted me in learning the concepts.	.65					1
Q2: The objectives informed me of what was expected for me to learn.	.65					1
Q3: The overview of what I would be learning in this module assisted me.	.56					1
Q16: The sequencing (order) of the materials helped me to learn this content.	.53					1
Q24: I understand how to create a Query after completing this tutorial.		.96				1
Q23: I understand how to create a Table after completing this tutorial.		.94				1
Q22: I will be able to create a database after completing this tutorial.		.88				1
Q17: I learned this material more quickly using this computer-based tutorial than I would in a traditional (face-to-face) format.			.95			1
Q12: It was more useful for me to learn the content in this format than in an instructor-led, traditional classroom.			.78			1
Q21: The tutorial was an adequate alternative to having an instructor lead me in learning this material			.74			1
Q13: I was interested in the topic of this tutorial.				.81		1
Q18: I felt motivated to learn the content from this tutorial.				.71		1
Q19: I would like to learn other technologies using this type of computer-based tutorial.				.65		1
Q7: This tutorial was designed for my needs as a future educator.				.65		1
Q9: The images in this tutorial helped me to learn the content.					.87	1
Q10: The audio narration in this tutorial helped me to learn the content.					.86	1
Q11: The animations in this tutorial helped me to learn the content.					.49	1

CHAPTER V

Summary, Discussions, Conclusion, and Recommendations

The purpose of this study was to further examine the redundancy effect by comparing the posttest scores, delayed posttest scores, and pedagogical usability perceptions of undergraduate education majors who received a non-redundant instructional module (graphics and narration) and of those who received a redundant instructional module (graphics, narration, and narration-duplicated text) for learning basic Microsoft *Access* 2013. This chapter addresses summary, discussions, conclusion, implications, and recommendations.

Summary

The study participants were education majors who enrolled in an online introductory technology course (EDUC 2215), which was offered in the fall 2013 semester by the College of Education at a public university in the intermountain western part of the U.S. The course consisted of two sections to accommodate students who lived in two geographic areas.

The students were asked to voluntarily participate in the study, which required two face-to-face meetings in the computer labs at their site. Due to mortality, 42 participated in the study, with 19 receiving the redundant instructional module (graphics, narration, & text), and 23 participants receiving the non-redundant instructional module (graphics & narration). The two modules taught the participants how to create a database file, table, and queries using Microsoft *Access* 2013. The modules had the same instructional length (approximately 20 minutes) and content but different multimedia elements—with text or without text.

During the first face-to-face meeting, the participants watched the assigned module, completed the pedagogical usability survey, and took the performance-based posttest. The second face-to-face meeting occurred six weeks later when they came to the same computer lab to complete the delayed posttest to measure long-term retention. These two meetings suffered from mortality (see the data collection section). As a result, there were 39 posttest scores (21 in the non-redundant group and 18 in the redundant group) and 33 delayed posttest scores (18 in the non-redundant group and 15 in the redundant group) available for data analysis.

Due to the missing values in posttest, delayed posttest, and survey responses, the Little's *MCAR* tests were conducted to check the missing pattern (see the data analysis section). The results suggested that the missing pattern did not appear to deviate from randomness, which warranted the use of a conventional statistical test (e.g., *ANOVA*, independent *t*-test, Mann-Whitney *U*-test) to address the research questions.

To answer the first and second research questions, the researcher used two separate Mann-Whitney *U*-tests to compare the two groups (redundant and non-redundant) on the posttest scores and delayed posttest scores. The mixed-design *ANOVA* was not used, because of violations of normality, homogeneity of variance, and compound symmetry assumptions. The independent *t*-tests were not selected, because of violations of normality and homogeneity of variance assumptions.

However, the assumptions of the independent *t*-test were met for the survey response data. Therefore, the researcher performed this test to compare the participants' usability perceptions between the two groups in order to answer the third research question. The survey responses were averaged instead of totaled, because of the missing responses and of different survey versions completed by the two groups.

Findings and Discussions

Research question 1. Is there a significant difference in posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by a researcher-designed instrument?

The result of the Mann-Whitney *U*-test indicated no significant difference in the posttest scores between the group that received the redundant module (graphics, narration, and text) and the group that received the non-redundant module (graphics and narration). The result was not consistent with the results in previous studies (i.e., Craig, Gholson, & Driscoll, 2002; Jamet & Bohec, 2007; Leahy, Chandler, & Sweller, 2003; Kalyuga, Chandler, & Sweller, 1999, 2000; Mayer, Heiser, & Lonn, 2001), which found that the non-redundant group outperformed the redundant group.

Based on cognitive load theory (e.g., Sweller, van Merrienboer, & Paas, 1998), the non-redundant group should perform better than the redundant group (as in Kalyuga, Chandler, & Sweller, 1999, 2000; Mayer, Heiser, & Lonn, 2001), because the former group did not have to process the redundant text that may be competing with the graphic for limited cognitive resources in working memory. On the other hand, the redundant group that received all three multimedia elements—graphic, narration, and text—could be distracted by the presence of text, because they may attempt to compare text with narration and may pay less attention to a more essential element, which was the graphic.

Kalyuga, Chandler, and Sweller (1999) found that having redundant text presented along with the graphic reduced the benefits of the dual-mode presentation. As a result, learning may be negatively affected.

However, the results of this study did not support the prediction made by cognitive load theory. This study found that text did not appear to have a detrimental effect on learning. The result of this present research was consistent with studies by McNeill, Doolittle, and Hicks (2009) and Wu (2011), which found no significant difference in immediate learning between the non-redundant group and the redundant group. Yue, Bjork, and Bjork (2013) also found a similar result, that is the non-redundant group marginally outperformed the redundant group on a recall test on the life cycle of a star (p = .06), but did not outperform the redundant group on a transfer test.

A possible explanation for the finding in the present study was that the participants may not consider text to be redundant with narration but see it as reinforcement. Sweller (2005) states that the redundancy principle, by itself, does not inform what information may or may not be redundant to a learner. Some information may be redundant to a group of learners but may be useful for another group. Therefore, decisions should be made from the learner’s perspective and the context in which instructional materials are embedded.

In the modules used in this study, each line of text that appeared on the screen was short—eight words on average—and was kept to one line each time. The font size was 24 points, which was the largest font size for closed-captioning for the Adobe *Captivate* 7.0 version. During the modules, text seemed to be available on the screen a little before (one second or less) narration, which was spoken at the speed of 120 words per minute, on average. Based on these design features, many participants reported that they could finish reading the text and then attend to the narration and graphics while these two elements were still playing. Moreover, the text may not have competed with the graphics for limited cognitive resources in working memory, but played a supportive role. During the demonstration of the software in the modules, narration played and finished, but text was still available on the screen until the next demonstration was shown. The participants could still read the text and look at the graphics. In this case, text may help keep the participants on track with the software demonstration. Moreover, the additional amount of time students had to process text during the demonstration may affect the redundancy effect.

The participants' responses to the survey questions helped confirm the usefulness of text. All of the 19 participants who received text "agreed" and "strongly agreed" that text was useful to their learning.

One participant wrote, "*The text was so helpful in understanding the content. I have never used access* [*sic*] *before &* [*sic*] *I think it can be helpful.*"

Another wrote, ". . . *The visuals were great and i* [*sic*] *appreciate having the subtitles to keep me on track.*"

A third participant wrote "*Seeing you perform the task but also having the words on the bottom helped reinforce the idea.*"

Still another participant said "*I really liked the reading at the bottom of* [the] *screen so I could follow along with the speaker.*"

All participants in the redundant group reported to have read from the closed-captioning (on-screen text) and claimed that text reinforced the narration. The amount of text was said to be the “right amount.” Fourteen participants reported their processing order of the three multimedia elements. Three participants reported that they were able to process the three multimedia elements (graphics, narration, and text) simultaneously. One reported to process the graphics, narration, and text in that sequential order. One claimed to process the graphics and text simultaneously and then the narration. One reported to process narration first and then process graphics and text simultaneously. Four reported to process graphics and narration simultaneously and then text. Two claimed that they attended to narration and text simultaneously before the graphics. Two reported to process the text first and then the graphics and narration simultaneously. These processing orders of the three multimedia elements claimed by the study participants may suggest a variety of impromptu strategies to overcome the redundancy effect.

When text was claimed to be processed as one of the first elements (n = 7) (either before graphics and/or narration, simultaneously with graphics and/or narration, or all simultaneously), the average posttest score was 86.86. On the other hand, when text was processed as one of the last elements (n = 6) (either after graphics and/or narration or simultaneously with graphics or narration but after one of the latter elements), the average posttest score was 69.17. Because text appeared slightly faster than narration, which was spoken slowly, those who attended to text first seemed to have a slight advantage, on average, over those who processed text as the last element in their processing order. This advantage still occurred, but with a smaller difference, in the average delayed posttest score when text was processed first (M = 76.84) compared to when it was processed last (M = 76.25).

The usefulness of text seemed to be reflected in a higher mean score (80.44) and median score (87.50) of the redundant group than a mean score (80.33) and median score (84) of the non-redundant group during the posttest, even much higher during the delayed posttest (see Table 12). Some studies found the redundant group outperformed the non-redundant group on test scores. For example, Toh, Munassa, and Yahaya (2010) found the gain scores of college students in Yemen who received redundant material to be significantly higher than the scores of those who received non-redundant material on English language learning when learners had control over the pace of instruction. Samur (2012) also found Turkish undergraduate students who were in the redundant group (*n* = 11) significantly outperformed those in the non-redundant group (*n* = 11) on retaining English vocabulary words.

Table 12

Descriptive Statistics of Posttest and Delayed Posttest Scores

	Posttest	**Delayed Posttest**
Non-Redundant group *(Graphics & narration)*	*M* = 80.33, *SD* = 15.15 *Mdn* = 84, *IQ* = 15	*M* = 60.22, *SD* = 29.58 *Mdn* = 67.50, *IQ* = 45
Redundant group (*Graphics, narration & text*)	*M* = 80.44, *SD* =19 *Mdn* = 87.50, *IQ* = 19	*M* = 71.20, *SD* = 13.41 *Mdn* = 74, *IQ* = 22

Note: M = Mean; SD = Standard Deviation; Mdn = Median; IQ = Interquartile Range

Although the mean and median of the posttest scores of the redundant group in this study appeared to be higher than those in the non-redundant group, the difference was not statistically significant. The insignificant result was likely due to low statistical power as a result of a small sample size and to high variability, which tends to hide the treatment effect, if there was any, from being detected. The high variability in the data may also suggest low motivation to participate in the study. A further analysis on some participants' submissions seemed to support that. Those subjects did not appear to put more effort into completing the posttest, which resulted in lower scores. These scores were not likely to reflect how much they learned from the modules. On the other hand, other participants made more serious attempts to complete the posttest, which resulted in higher scores. This motivation issue may have contributed to high variability in the data and was considered a confounding factor in this study.

The cause-and-effect interpretation of the study result should be received with caution due to another possible confounding factor. Although the instructor informed the participants that the class meetings were to do learning activities and to discuss class issues in order to prevent any interaction with the content, some subjects claimed to have prepared before the first meeting. Among the 18 participants who responded to the question, seven reported to have read the class textbook or watched a video(s) on the topic before the treatment. However, a further analysis on their posttest scores questioned the degree of influence the preparation had on the posttest scores. Those who claimed to have prepared (i.e., read textbook chapters or watched online videos on Microsoft *Access* 2013) before the first meeting received posttest scores in the range of 70 and lower—17 points, 24 points, and 53 points, which were considered outliers in the boxplots (see discussion of the data analysis in Chapter IV). Only two participants received 81 and 89. On the other hand, the majority of those who claimed that they did not prepare in advance scored higher, in the range of 80 and 90. The participants who claimed to have prepared before the posttest were considered technology competent, based on the scores they received on other class assignments. If they were really prepared, their posttest scores on

Microsoft *Access* 2013 should have been more comparable or even higher than the scores of those who did not prepare. It appeared that the scores did not reflect a serious preparation, which brings into question how much the preparation influenced the posttest scores.

Research question 2. Is there a significant difference in delayed posttest scores of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text) as measured by the same researcher-designed instrument?

The result of the Mann-Whitney *U*-test also indicated no significant difference in the delayed posttest scores between the group that received the redundant module (graphics, narration, and text) and the group that received the non-redundant module (graphics and narration). The result was consistent with the McNeill, Doolittle, and Hicks (2009) study, which found no significant difference in the delayed posttest (one week after treatment) between the non-redundant group and the redundant group. Previous research (i.e., Craig, Gholson, & Driscoll, 2002; Kalyuga, Chandler, & Sweller, 1999, 2000; Mayer, Heiser, & Lonn, 2001) did not measure long-term learning, and cannot be used to further discuss the results in the present study. The researcher has found there was a lack of research in the redundancy effect that examined the influence of text on long-term learning (i.e., weeks or months post treatment). Future studies should consider the investigation of redundancy on long-term retention.

In this study, the usefulness of text seemed to be present in the delayed posttest. The mean (71.20) and median (74) of the redundant group (15 participants) were much higher than the mean (60.22) and median (67.50) of the non-redundant group (18 participants) (see Table 12). This huge difference seemed to suggest the practical significance that text may have the potential to support long-term learning. However, the difference was not statistically significant. Once again, this insignificant result may be due to a small sample size and high variability in the data. In the delayed posttest scores, motivation was a lesser issue. Those who did not appear to put effort in completing the posttest assessment tried harder during their delayed posttest assessment. This variance in the delayed posttest scores between the two groups may be due to an actual significant decrease in learning over time. After six weeks, two participants received only 5 out of 95 points on the delayed posttest. These individuals were observed to have expended a great deal of effort during the completion of the delayed posttest assessment.

Although this study did not find any evidence to support that text had a negative effect on long-term learning, a cause-and-effect interpretation should be made with caution due to confounding factors. Once again, some participants (10 out of 18 participants who responded to the question) claimed to have prepared before the delayed posttest in a similar manner prior to the first computer lab meeting, but the analysis did not seem to reflect their efforts. Four participants received scores between 40 and 50. Three scores were between 60 and 70. Two participants received only 5 out of the possible 95 points. On the other hand, those who indicated they did not prepare before the delayed posttest received higher scores (in the range of 70, 80, and 90). This raised the question of the degree of influence the preparation had on the delayed posttest scores. It could be that their preparation may not be as effective in influencing their delayed posttest score.

The higher mean and median scores of the redundant group on both posttest and delayed posttest seemed to indicate that text may have the potential to support learning, especially long-term retention (at least six weeks post treatment). This may indicate another way to effectively use text in multimedia design: Presenting short bits of text early (1 or 2 seconds) than narration (120 words per minute) and keeping the text available on the screen along with the graphics during learning may have a positive effect on immediate and long-term learning for novice learners. The text, however, should be short and of sufficient size to easily see. However, this argument was not empirically supported by the data in this study and should be considered in future research for further examination.

Research question 3. Is there a significant difference in pedagogical usability perceptions of pre-service teachers who received an instructional module on Microsoft *Access* 2013 with no redundancy (narration and graphics) and those who received the same instructional module with redundancy (narration, graphics, and visible text)?

The independent *t*-test that compared the participants' pedagogical usability perceptions on the instructional modules was not statistically significant between the non-redundant group and the redundant group. However, the survey responses indicated the participants felt positive about the modules. (See the instructional modules section in Chapter III for a description of the modules.)

The majority of the participants highly rated the survey items. Among 42 respondents, only eight respondents each gave an average rating below 3. These ratings ranged from 2.54 to 2.96. The rest of the ratings were from 3.17 to 3.84. The open comments indicated aspects the respondents found useful in the modules.

- Review of learned material:

  "I think a quick review of the main points at the end of the tutorial would have helped to solidify the information in my memory."

  "... Reviewing after each topic helped reinforce the concepts."

"I really liked knowing what I was going to learn and having the reinforcement of the review after each objective was met…."

"I like how there were brief review [sic] *of each section at the end of the section."*

- Content with clear instruction and logical sequence:

"I really liked how it was broken into the three objectives and how those objectives built on top of one another. Having the tutorial in a step by step process really helped me understand the program and how to use it again."

"It was simple and straight forward in the directions."

"It presented how to do the process one step at a time and only included a few things that I could practice and master before moving on to other steps. It did not provide so much information as to be overwhelming."

"It is useful that the objectives built on one another. I also thought it was helpful to see what the end product would look like."

"…The tutorial followed a very logical sequence, so it made sense and I could easily see ways to apply the software to my teaching."

- Benefits of multimedia elements (graphics, narration, & text):

"…The visuals were great and i [sic] *appreciate having the subtitles to keep me on track."*

"Seeing you perform the task but also having the words on the bottom helped reinforce the idea."

"I really liked the reading at the bottom of screen so I could follow along with the speaker."

"The video and audio step-by-step how to do everything was helpful."

"It showed us how to do it in real time, as opposed to being interrupted in class with questions from the students/peers."

"Spoke in easy to understand terms. Did the steps along with [the] *tutorial- This helps me as a visual, hands on learner to better grasp the concept. Easier to see the arrow clicking on a tab than for someone over my shoulder telling me what to click on while I search the screen for it. Very useful & impressive!"*

"I liked how you showed us what to do as you talked about it."

"I've never used ms [*sic*] *access* [*sic*] *before, but watching how to create a table and a query from a table, makes me very excited to use Access."*

"Seeing and listening to the information made things more clear."

The benefits of the dual-mode presentation for visual and auditory processing have been supported by previous research. Baddeley's (1986) model of working memory and Pavio's dual coding theory (1991, 2007) recommended presenting materials that allowed multi-modality processing in the visual and auditory channels for better retention and retrieval. In addition, many experimental studies have provided extensive evidence to support the benefit of this dual-mode presentation (Clark & Mayer, 2011; Mayer, 2009). Reviewing learned concepts and creating a logical sequence of learning the content has been encouraged in the practice of instructional design (i.e., Gagné et al., 1992; Reigeluth, 1999) by both behaviorist and cognitive learning theories (i.e., Driscoll, 2005), and in the area of brain-based learning (i.e., Jensen & Dabney, 2000; Jensen & Johnson, 1994) to reinforce and assist learning. Presenting concise instruction was also supported by the coherence principle of multimedia learning (Mayer, 2009) as an effective presentation method.

The study respondents also provided other feedback on the modules. The comments indicated a few areas for future considerations. A few expressed their learning preference in a face-to-face environment over a computer-based presentation:

"… I guess I do not enjoy learning solely on a computer. … [I] *don't look forward to learning only via online classes. With that said- they are (videos) very effective + even as they are, are* [*sic*] *a great learning tool. I just prefer a classroom.*"

Another respondent added, "*This tutorial was a great reference guide to help create your own table & query but personally I would rather have a face to face setting with these tutorials as supplements within the classroom.*"

Another said, "*I think this would be an effective alternative to* [a] *classroom, but only if face-to-face was not an option. Again, the delivery was clear and direct.*"

One person also mentioned, "*... I have never liked online classes,* [*sic*] *they confuse me as to knowing what is due for share* [*sic*] *and when. I did learn from this though and I liked it.*"

Other important comments related to the need for hands-on activities as part of the learning process, instead of just watching the videos. One respondent said, "*I would have liked to do the work as the tutorial was going.*"

Another wrote, "*For my level of comfort, covering one topic ie* [*sic*] *table, then having the ability to practice, I think would be better. Covering 3 topics before being able to practice is slightly intimidating.*"

The third person also wrote, "*… was useful to watch this but I don't know that I can go straight to* [*sic*] *and make my own just yet. I am a slow learner so I think practice would help.*"

The effectiveness of the hands-on learning approach has been supported by various studies (i.e., Bilgin, 2006; Canfield, Ghafoor, & Abdelrahman, 2012; Guha, 2010; Satterthwait, 2010) to assist student learning in the fields of science and computers. Due to the nature of this study, the participants were not provided with an opportunity to practice using Microsoft *Access* 2013 along with the modules. In real-world learning situations, this hands-on activity should be allowed and encouraged for more active learning.

Conclusion

This study did not find any significant difference in posttest scores and delayed posttest scores between the redundant group, which received graphics, narration, and text, and the non-redundant group, which received graphics and narration. (However, the study found there was a significant difference in learning between the posttest and delayed posttest with learning decreased after six weeks.) The insignificant results may be due to the lack of statistical power to detect the difference due to the small sample size and high variability in the data.

Despite insignificant results, the mean and median scores of the redundant group were higher than the mean and median scores of the non-redundant group on both the posttest and delayed posttest scores. The anecdotal evidence seemed to suggest that the participants in the redundant group benefitted from the on-screen text. The usefulness of text was observed to last six weeks from posttest to delayed posttest. However, this was not empirically supported by the data and should not be interpreted as cause and effect.

The survey responses indicated the majority of the participants felt positive about the two instructional modules with a rating of 3 given by the majority to the survey items. The useful aspects of the modules specified by the respondents included a review of learned concepts, a logical sequence of content, use of different multimedia elements (graphics, narration and text), and concise instruction. Some respondents said the modules could be used to substitute for the face-to-face meetings, but others preferred the latter approach and recommended using the modules as supplemental materials to the classroom instruction. Some participants would appreciate an opportunity to practice along with the modules.

Implications. The study results offered insight for instructional design practice. First, although the results were not statistically significant, the data anecdotally showed that, overall, the redundant group may benefit from text when it was presented on the screen slightly faster than narration and when text was kept on the screen after narration to support graphics during learning. Instructional designers may consider the arrangement of text in this manner and further observe its impact on learning to use software.

Second, if on-screen text is used, the instructional designer should keep it to one line (i.e., eight words) at a time with a large font size and easy-to-read font type. The narration should be at a normal or slightly slower speed (i.e., 120 words per minute) to allow time for processing multiple elements; this technique may reinforce rather than becoming redundant or distracting. The main idea is to use text in a way to support and reinforce narration, not to make it redundant.

Third, when creating learning material, instructional designers may consider including introductory information to motivate learning; presenting objectives to guide learning; sequencing content in a logical manner; and, allowing the review of the learned materials to assist encoding. Gagné’s nine events of instruction (Gagné et al., 1992), which was used in designing the content and its chunking, provided a useful guideline, as supported by the survey responses in this study.

Recommendations

Future studies may attempt to further investigate the effect of text on learning when it is presented slightly faster than narration. Text should be short, large, easy to read, and constantly available despite the absence of narration. (The position of text may be irrelevant in this case.) This recommendation is based on the anecdotal evidence found in this study; that the group that received text had higher mean and median scores on the posttest and delayed posttest.

Future research should attempt to explore other ways to use text as a supporting and reinforcing multimedia element, instead of seeing text as only redundant to narration or graphic, since text is one of the important elements in accommodating the needs of some diverse learners. Future research may consider providing text as an option and allow students to select if they want to use it or to add it after the narration. In addition, different narration speeds may also be provided for students to match their reading speeds. Pictures may be worth a thousand words, but certain pictures may not be easily comprehensible without textual explanation. A harmonious use of graphics, narration, and text may greatly benefit certain categories of learners.

Different processing orders of the three multimedia elements (graphics, narration, and text) reported above by the study participants may suggest a variety of impromptu strategies to overcome the redundancy effect and may be investigated in future studies. Although there was no evidence to support this, the participants seemed to benefit from text when they had time to attend to it first rather than last. Future research may provide students with options to select whether text should be presented before or after other elements. More importantly, the design should allow time to process the textual element.

A large sample size should also be acquired for future studies. In this study, the mean delayed posttest score of the redundant group was much larger than the mean of the non-redundant group. This huge difference seemed to suggest practical significance that text may have the potential to support long-term learning. However, the difference was not statistically significant due to low statistical power; therefore, a larger sample size is recommended for future investigations.

Designing and/or using a more reliable assessment instruments should also be considered in future research to reduce variability in the data, which, in turn, allows the effect of treatment, if any, to be detected. Finally, future studies should take motivation as a serious consideration: Low motivation may contribute to high variability in the data. Motivation is a difficult factor to control, but an important one to consider when designing a research study.

In conclusion, the study results did not appear to support cognitive load theory, predicting that the non-redundant group should outperform the redundant group on learning basic Microsoft *Access* 2013, because those in the redundant group may be distracted by the presence of text. In this study, text did not appear to have a negative effect on short-term and long-term learning. However, the study results were confounded by extraneous variables. A cause and effect relationship could not be drawn. The respondents' comments revealed that text was not perceived as a distracting element but assisted learning. In this study, text was presented in short bits earlier than narration, which was spoken slowly. The participants reported that they had time to process the text and then attended to graphics and narration without losing any essential information. However, due to low statistical power and high variability in the data, the results were not statistically significant. Although the results may be anecdotal, this study provided directions and insights worthy of consideration by instructional designers and researchers in the design and development of meaningful and relevant instruction that integrates multimedia elements.

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APPENDIX A:

Pedagogical Usability Survey Instruments

APPENDIX A-1:

Author's Permission

Petri Nokelainen <Petri.Nokelainen@uta.fi>
To Chan Sang chansang82@yahoo.com
May 24, 2013

Dear Sang,

yes, that is all right by me. Please let me know about the results!

Petri

Lainaus Chan Sang <chansang82@yahoo.com>:

Dr. Nokelainen,

I would like to make sure if you also allow me to adapt your work by revising, excluding, and/or adding the items to your original questionnaire to suit my dissertation topic.

Thank you!

Best regards,

Sang

From: Petri Nokelainen <Petri.Nokelainen@uta.fi>
To: "Chan Sang" <chansang82@yahoo.com>
Date: Thursday, May 23, 2013, 12:49 PM

Dear Chan,

thank you for asking, feel free to use the PMLQ. You might also be interested in a recent paper by Sung & Mayer (attached).

Best wishes,

Petri Nokelainen
Professor
School of Education
University of Tampere, Finland
Http://www.uta.fi/~petri.nokelainen
Tel. +358 40 557 4994
Room 501, Virta-building
Åkerlundinkatu 5
33014 Tampere

Chan Sang <chansang82@yahoo.com> kirjoitti 23.5.2013 kello 19.28:

Dr. Nokelainen,

I am a graduate student working on a Ph. D in Instructional Design at Idaho State University. I am writing my dissertation and would like to ask for your permission to adopt and adapt the questions in the Pedagogically Meaningful Learning Questionnaire (PMLQ) published in the following article:

Nokelainen, P. (2006). An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students. Educational Technology & Society, 9 (2), 178-197.

I have found your work to be relevant to mine and was wondering if you allow me to do so. I would like to include Pedagogical Usability in my dissertation to assess the usefulness of the instructional modules that I am creating.

I would like to ask if you may have any suggestions regarding to other research articles and instruments in this particular area.

Thank you!

Best regards,

Sang

APPENDIX A-2:

Non-Redundant Survey

(Graphics & Narration)

Name:
Section (Pocatello or Idaho Falls):

Tutorial Quality Assessment Survey

(Non-Redundant)

Dear Respondent,

My name is Sang Chan. I am a Ph. D student in the Instructional Design program of the College of Education at Idaho State University. I would like to invite your participation in completing this "Tutorial Quality Assessment" survey. The purpose of the survey is to learn your perceptions regarding the quality of the tutorial. The survey will take approximately 5 to 10 minutes. The data from the survey will NOT include any personal identity; all reporting of data will be anonymous. The data obtained from the survey will be stored on a password-protected computer.

Your participation is voluntary. There will be no consequences toward your grade if you do not participate. If you have any questions, please contact me via email: chansang@isu.edu.

Please respond by placing an "X" in the appropriate column for each item: ***SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree***

Thank you very much for your participation!

Item	**Rating**			
	SD	**D**	**A**	**SA**
1. Dividing this content into sections assisted me in learning the concepts.				
2. The objectives informed me of what was expected for me to learn.				
3. The overview of what I would be learning in this module assisted me.				
4. This tutorial taught me skills I will need in the future.				
5. I will be able to use the skills targeted in this tutorial.				
6. This tutorial was challenging to me as a basic user of the Microsoft Access 2013 software.				
7. This tutorial was designed for my needs as a future educator.				
8. The difficulty level in this tutorial was appropriate for me.				
9. The images in this tutorial helped me to learn the content.				
10. The audio narration in this tutorial helped me to learn the content.				
11. The animations in this tutorial helped me to learn the content.				
12. It was more useful for me to learn the content in this format than in an instructor-led, traditional classroom.				
13. I was interested in the topic of this tutorial.				

14. The design of these materials made it easy for me, as a beginner, to learn this content.				
15. There was too much material to learn in the time allocated for this content.				
16. The sequencing (order) of the materials helped me to learn this content.				
17. I learned this material more quickly using this computer-based tutorial than I would in a traditional (face-to-face) format.				
18. I felt motivated to learn the content from this tutorial.				
19. I would like to learn other technologies using this type of computer-based tutorial.				
20. The time allotted for completing this tutorial was adequate for me.				
21. The tutorial was an adequate alternative to having an instructor lead me in learning this material				
22. I will be able to create a database after completing this tutorial.				
23. I understand how to create a Table after completing this tutorial.				
24. I understand how to create a Query after completing this tutorial.				

What was/were the useful aspect/aspects of this tutorial?

Other comment:

Adopted and adapted with author's permission (Nokelainen, 2006)

APPENDIX A-3:

Redundant Survey

(Graphics, Narration, & Text)

Name:
Section (Pocatello or Idaho Falls):

Tutorial Quality Assessment Survey

(Redundant)

Dear Respondent,

My name is Sang Chan. I am a Ph. D student in the Instructional Design program of the College of Education at Idaho State University. I would like to invite your participation in completing this "Tutorial Quality Assessment" survey. The purpose of the survey is to learn your perceptions regarding the quality of the tutorial. The survey will take approximately 5 to 10 minutes. The data from the survey will NOT include any personal identity; all reporting of data will be anonymous. The data obtained from the survey will be stored on a password-protected computer.

Your participation is voluntary. There will be no consequences toward your grade if you do not participate. If you have any questions, please contact me via email: chansang@isu.edu.

Please respond by placing an "X" in the appropriate column for each item: ***SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree***

Thank you very much for your participation!

Item	**Rating**			
	SD	**D**	**A**	**SA**
1. Dividing this content into sections assisted me in learning the concepts.				
2. The objectives informed me of what was expected for me to learn.				
3. The overview of what I would be learning in this module assisted me.				
4. This tutorial taught me skills I will need in the future.				
5. I will be able to use the skills targeted in this tutorial.				
6. This tutorial was challenging to me as a basic user of the Microsoft Access 2013 software.				
7. This tutorial was designed for my needs as a future educator.				
8. The difficulty level in this tutorial was appropriate for me.				
9. The images in this tutorial helped me to learn the content.				
10. The audio narration in this tutorial helped me to learn the content.				
11. The animations in this tutorial helped me to learn the content.				
12. It was more useful for me to learn the content in this format than in an instructor-led, traditional classroom.				
13. I was interested in the topic of this tutorial.				
14. The design of these materials made it easy for me, as a beginner, to learn this content.				
15. There was too much material to learn in the time allocated for this content.				
16. The sequencing (order) of the materials helped me to learn this content.				

17. I learned this material more quickly using this computer-based tutorial than I would in a traditional (face-to-face) format.				
18. I felt motivated to learn the content from this tutorial.				
19. I would like to learn other technologies using this type of computer-based tutorial.				
20. The time allotted for completing this tutorial was adequate for me.				
21. The tutorial was an adequate alternative to having an instructor lead me in learning this material				
22. I will be able to create a database after completing this tutorial.				
23. I understand how to create a Table after completing this tutorial.				
24. I understand how to create a Query after completing this tutorial.				
25. The closed captioning included in this tutorial helped me to learn the content.				

What was/were the useful aspect/aspects of this tutorial?

Other comment:

Adopted and adapted with author's permission (Nokelainen, 2006)

Did you read from the closed-captioning? □ Yes □ No

How much did you read from the closed-captioning throughout the tutorial?
□ All the time □ A lot □ Half □ Little □ Not at all

Did you read the closed-captioning first before you attended to the narration?
□ Yes □ No

If yes, please answer the following questions:

Did the closed-captioning make the narration clearer? □ Yes □ No
Did the closed-captioning reinforce what was said in the narration? □ Yes □ No

In what order did you process the closed-captioning, narration, and graphics? (For example: closed-captioning first, then narration and graphics simultaneously or all of them simultaneously, etc.)

<u>*Please specify*</u>:

The amount of closed-captioning presented each time was:
□ Too long □ Long □ Right amount □ Short □ Too short

APPENDIX A-4:

Revised Pedagogical Usability Survey

Revised Pedagogical Usability Survey

Item	Rating			
	SD	D	A	SA
Dividing this content into sections assisted me in learning the concepts.				
The learning objectives clearly informed what I was expected to learn in this tutorial.				
The overview of what I would be learning in this tutorial assisted me.				
This tutorial was designed for my needs as a future educator.				
The difficulty level in this tutorial was appropriate for me.				
The images in this tutorial helped me to learn the content.				
The narration in this tutorial helped me to learn the content.				
The animations in this tutorial helped me to learn the content.				
The text in this tutorial helped me to learn the content.				
It was easier for me to learn the content in this format than in an instructor-led, traditional classroom.				
I was interested in learning the content from this tutorial.				
The sequencing of the materials helped me to learn this content.				
I learned this material more quickly using this computer-based tutorial than I would in a face-to-face format.				
I felt motivated to learn the content from this tutorial.				
I would like to learn other technologies using this type of computer-based tutorial.				
The time allotted for completing this tutorial was adequate for me.				
The tutorial was an adequate alternative to having an instructor lead me in learning this material				
I felt confident in creating a database after completing this tutorial.				
I felt confident in creating a table after completing this tutorial.				
I felt confident in creating a query after completing this tutorial.				

Please describe the useful aspect(s) of the tutorial?

Please provide other comments:

APPENDIX B:

ADDIE Analyze Phase

Appendix B-1

ADDIE Analyze Phase
Task A01 – A03: Rationale/Goal/Objectives
Delphi Survey 01

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached related to the project's rationale, the goal, and the objectives.
2. Mark the rating that most represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

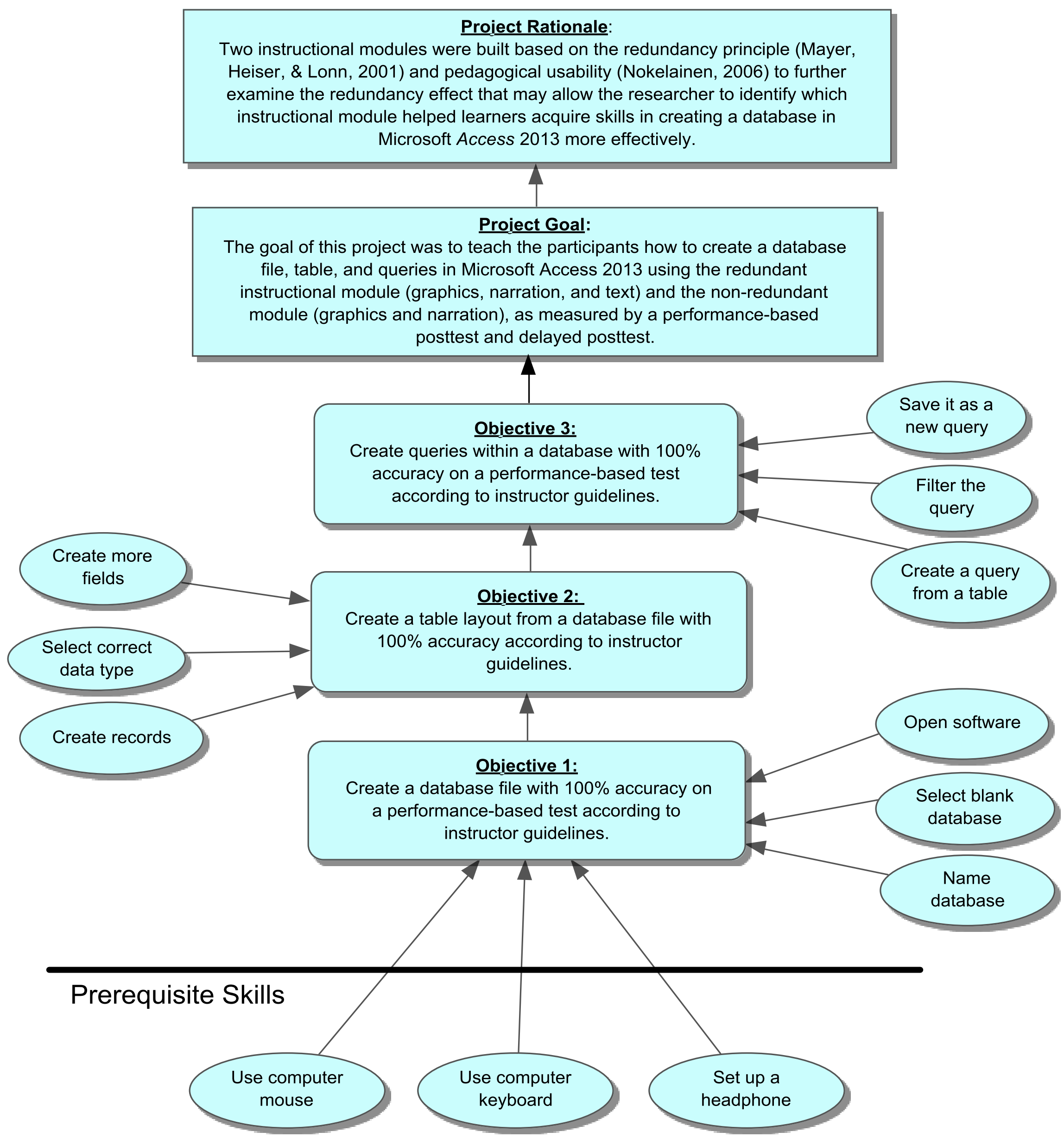
Item	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
Project Rationale (Task A01):				
1. The benefit of this project to the institution or organization is clearly stated.				
2. The benefit of this project to the targeted learners is clearly stated.				
3. The need for this project is clearly stated.				
4. The geographical scope for this project is clearly stated.				
5. The project's subject matter is clearly stated.				
6. The project's approach to the problem is clearly stated.				
7. The project's expected outcome is clearly stated.				
Project Goal (Task A02):				
8. The goal of this project is clearly stated.				
9. The goal of this project states what the project is to accomplish.				
10. The goal of this project clearly indicates how the success will be indicated.				
11. The goal of this project appears to be achievable.				
12. The goal of this project appears to be significant to the field of knowledge indicated by the rationale.				
13. The goal of this project appears to be measurable.				
14. Considering the target population, the goal of this project appears to be realistic.				
15. The outcomes of the project appear to be obtainable.				
Project Objectives (Task A03):				
16. Each objective of this project module is aligned to the goal statement.				
17. Each objective of this project module contains a behavior/action verb that is measureable.				

Item	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
18. Each objective of this project module has an identified audience.				
19. Each objective of this project module contains a degree/constraint that is clearly stated.				
20. Each objective of this project module contains a condition/situation that is clearly stated.				
21. Each objective of this project is aligned to the identified audience.				

APPENDIX B-2

TASK A05: LEARNING HIERARCHY WITH CONCEPT MAP

Learning Hierarchy with Concept Map
Task A05



APPENDIX B-3

TASK A06: LEARNING INFLUENCE DOCUMENT

Learning Influence Document
Task A06

Item/Event	Strategies
1. What events will the instructional designer utilize to gain the learner's attention?	At the beginning of the module, learners are informed of the project goal and learning objectives. An introduction to what a database is and its purpose is also presented in the module.
2. What techniques will the instructional designer use to maintain the learner's attention?	Examples are given throughout the module to inform the participants of circumstances when creating a database may help with their teaching-related tasks. For instance, a teacher may want to create a table in the database to keep student's information and grades and use to table to identify those who perform poorly in class for remediation purposes.
3. What events will the instructional designer provide to stimulate recall of prerequisite knowledge?	The module will inform the participants that no prior knowledge is necessary to learn the content because it is designed for beginners.
4. How will the instructional designer communicate the learner's responsibility?	The learner responsibilities will be informed verbally by the class instructor at the beginning of the study. The responsibilities include: watch the assigned module, avoid any interaction, complete a survey, and take the assessment tests.
5. What techniques will the instructional designer use to inform the learner of expected instructional outcomes?	The instructional outcomes are presented in the module after the participants watch the introduction as a reinforcement to the learning objectives.
6. What techniques will the instructional designer employ to produce inquiry?	A scenario will be presented in the module to stimulate the interest while learning the concept. For example, filter the table or create a query to present specific information.
7. How will the instructional designer enhance the learner's recall of the material (i.e., short-term memory)?	The use of graphics and narration allows learners to process information visually and aurally to enhance memory. Linking the learning concept to a real-world situation improves recall of the material. At the end of each learning objective, the module reviews what was just discussed.
8. How will the instructional designer elicit learner participation?	No activities are included in the module. The learners will participate after they watch the module. For example, they will complete a survey and take the assessments.

Item/Event	Strategies
9. How will the instructional designer utilize feedback gathered from the instructional and the practice materials?	A pilot test will be conducted to evaluate the module before an actual implementation. The results will be used to revise the module. After the actual implementation, the participants will be asked to complete a survey to assess the quality of the module. Their responses will be used to inform the design practice to develop future modules.
10. What learner capabilities will the instructional designer develop as an outcome?	The learners will gain motor and intellectual skills in creating a database file, table, and query using Microsoft *Access*2013.
11. How has the instructional designer responded to any particular learning trait?	The use of multimedia elements such as graphics, narration, and text supports learning of the visual and auditory learners.
12. How will the instructional designer assess learner satisfaction with the instruction?	The pedagogical usability survey will be used to collect learners' perceptions on the quality of the module.
13. How will the instructional designer accommodate any learner disability (psychomotor, cognitive, and emotional)?	Different multimedia elements (e.g., closed-captioning, graphics, and narration) are included to accommodate various learners. The Section 508 guidelines may be followed when creating the module within the limitations of the multimedia components being tested. However, participants who have learning disabilities as identified by the instructor will be accommodated. Data from such individuals may be excluded from analysis if the design features being tested within the treatment are compromised due to disability. To avoid any disruption in acquiring the content (even if the individual is excluded from the data analysis), alternative methods for acquiring the knowledge will be initiated by the instructor.

Appendix B-4

ADDIE Analyze Phase
Task A04 – A06: Learning Outcomes Statement/Learning Hierarchy w/ Content Map/Learning Influence Document
Delphi Survey 02

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached related to the project's concept map, learning influences, expected learning outcomes, and learning hierarchy.
2. Mark the rating that <u>most</u> represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
Learning Outcomes Statement (Task A04):				
1. There is an accurate description of the <u>short-term</u> learning effect for each of the objectives for each RLO/Module.				
2. There is an accurate description of the <u>long-term</u> learning effect for each of the objectives for each RLO/Module.				
3. There is an accurate description of how the learner is expected to change as a result of each objective.				
4. There is an accurate description of what is expected to change as a result of the instruction.				
Learning Hierarchy w/ Content Map (Task A05):				
5. It appears the concept map accurately presents each goal of the project. (Refer to Task A02 for the goal(s), if needed.)				
6. It appears the concept map accurately presents each of the primary objectives. (Refer to Task A03 for the objectives, if needed.)				
7. Using the project goal(s) and the project objectives [Task A02 and Task A03] as references, it appears the concept map accurately links each goal with its corresponding primary objective(s).				
8. Using the project objectives as reference, it appears the concept map accurately presents each of the secondary objectives.				
9. Using the project objectives as reference, it appears the concept map accurately links each of the secondary objectives to its corresponding primary objective.				
10. The total concept map presents an accurate depiction of the project.				
11. The total concept map displays appropriate linkages among all elements.				
12. The essential prerequisite learner knowledge/skills to achieve the objectives are identified.				

Item	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
13. The hierarchal map provides accurate graphical representation of the prerequisite knowledge/skills the learner is to achieve before commencing work on this project's objectives.				
Learner Influence Document (Task A06):				
14. There is an accurate description for gaining the learner's attention within each RLO/Module.				
15. There is an accurate description for maintaining the learner's attention within each RLO/Module.				
16. There is an accurate description for assessing the learner's satisfaction within the instruction for each RLO/Module.				
17. There is an accurate description of how each RLO/Module will include a focus on specific learner capabilities.				
18. There is an accurate description of how each RLO/Module will stimulate the learner's prerequisite knowledge (or skills).				
19. There is an accurate description of how each RLO/Module will accommodate identified learner disabilities.				
20. There is an accurate description of how each RLO/Module will respond to a participant's particular learning traits.				

APPENDIX B-5

TASK A07: LEARNER CHARACTERISTICS PROFILE

Learner Characteristics Profile
Task A07

GENERAL INFORMATION

	Data Collected	Resources Used
1.0 General Characteristics of the Target Population	The targeted students are those who enroll in the EDUC 2215 class in the College of Education in the Fall 2013 semester. Most of them are a pre-education major, classified as traditional students (18 – 25 year old) and as non-traditional students (over 25 year old). Most of them are females, English-speaking Caucasians.	School records
1.1 Age Range	The age ranges are from 21 to 25 year old. In some cases, some students may be in their thirties, forties, or fifties.	School records
1.2 Gender Distribution	The targeted students tend to be more females than males. Female students may represent up to 80% of the class.	School records
1.3 Special Needs	In the class sections taught by the instructor during the Fall 2012 and Spring 2013 semesters, no student reported to have special needs. Therefore, students with special needs are not expected.	School records and past experience
1.4 Ethnic/Cultural Background	A small percentage of Hispanic and Native American students attended this class in the past semesters. However, the majority have been English-speaking, Caucasian students.	School records
1.5 Language Distribution	Some students may speak Spanish or their native language, in addition to English. All students have been a Native English speaker.	School records

ACADEMIC INFORMATION

	Data Collected	Resources Used
2.0 What entry behavior(s) is needed for learner success?	The targeted students are pre-education majors who have at least basic skills in operating the computer mouse and keyboard.	School records & past experience
2.1 What is the attitude toward target content material?	The students may have a positive attitude toward learning the material because it is part of the course content and has a higher grade allocation than other assignments.	Past experience
2.2 What is the learning preference(s) or modality?	Past students have been known to be visually-inclined, aurally-inclined, or both. The majority preferred a hands-on approach.	School records & past experience
2.3 Is it reasonable to expect that the material to be cognitively learned by these learners?	It is assumed that both traditional and non-traditional students have had exposure to the use of technology either at high school or at work place.	School records & past experience
2.4 What is a reasonable time frame for the targeted content to be mastered?	It is expected that the modules take approximately 20 minutes to cover the targeted content.	Departmental requirements
2.5 What is the motivation for the learner to complete this targeted content?	Two factors should motivate students to learn this material. It is part of the course content, and it has a higher grade allocation than many other assignments.	School records & past experience

PRIOR INFORMATION NEEDED

	Data Collected	Resources Used
3.**0** **What prior knowledge is needed for learner success?**	No general requirements for prior knowledge(*elaborated more in the following sections*)	Past experience
3.**1** **What prerequisite cognitive skills are needed for learner success?**	Understanding how Microsoft Excel works may be beneficial. However, it is not required because the module is built for beginners.	Past experience
3.**2** **What prerequisite motor skills are needed for learner success?**	They need basic computer skills in using the computer mouse and keyboard.	Past experience
3.**3** **What previous experience would the learner have that would inhibit success?**	The factors may include computer-use anxiety, absence of hands-on activity to practice steps, and physical and mental exhaustion and boredom.	Past experience

APPENDIX B-6

ADDIE Analyze Phase
Task A07 – A08: Learner Characteristics Profile/Pedagogical Considerations Statement
Delphi Survey 03

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached related to the project's targeted learner characteristics, audience, constraints, and pedagogical considerations.
2. Mark the rating that most represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
Learner Characteristics Profile (Task A07):				
1. It appears the general characteristics accurately describe the target population of the project.				
2. It appears the age range accurately represents target population of the project				
3. It appears the gender distribution accurately represents target population of the project				
4. It appears the ethnic/cultural distribution accurately represents target population of the project				
5. It appears the language distribution accurately represents target population of the project				
6. It appears the entry behavior is appropriate for target population of the project				
7. It appears the time frame for completion is reasonable for target population of the project				
8. It appears the list of prior knowledge needed for completion of the project is complete.				
9. It appears the statement of prerequisite cognitive skills for completion of the project is complete.				
10. It appears the statement of prerequisite motor skills for completion of the project is complete.				
Pedagogical Considerations Statement (Task A08):				
11. It appears that the Pedagogical Considerations Statement has addressed issues regarding instructional sequencing.				
12. It appears that the Pedagogical Considerations Statement has addressed issues regarding instructional motivation.				
13. It appears that the Pedagogical Considerations Statement has addressed issues student-centered learning.				
14. It appears that the Pedagogical Considerations Statement has addressed issues regarding use of an advance organizer or some system to clarify the instructional goals and objectives of the project/				

APPENDIX B-7

TASK A10: LEARNING ENVIRONMENT AND DELIVERY OPTIONS

Learning Environment and Delivery Options Statements
Task A10

Learning Environment Statement

Prompt	Response
1.0 What are the specific electronic hardware requirements for this project?	Participants will interact with computer mouse and keyboard during the treatment and assessments. They will be provided with a headphone to listen to narration.
2.0 What are the specific requirements in order to easily navigate the content materials (e.g., web–based items, 508-compliant resources, etc.)?	Due to the nature of this study, the participants will be asked to only watch the module, which will present the information in a sequential order. No navigation buttons (e.g., rewind, pause, forward, etc.) will be made available within any modules.
3.0 What are the specific software requirements needed for the learner to use the instructional materials?	The modules will be built using Adobe Captivate 7.0 version and will be published in a flash format, which is readily installed in many browsers (e.g., Firefox, Google Chrome). Therefore, the module content can be viewed on one of those browsers. The learners will use the Microsoft *Access* 2013 software to complete a posttest and a delayed posttest. Each computer in the computer labs has a copy of this software.
4.0 What are the specific learner requirements for successful use of the materials (e.g., sufficient time to complete assignments in one session, alternative formats, etc.)?	The participants are expected to know to how to use computer mouse and keyboard. The instructional module will teach them how to use Microsoft *Access* 2013. They should be able to complete the posttest and delayed posttest. Each activity (e.g., module, survey, assessment) gives sufficient time to the participants to complete.

5.0 Include any statements that may have been used to support Item #13 in Task A07: Learner Influence Document (LID).	Graphics, narration, and/or text are included in the modules to examine the interference effect of the multimedia elements and, at the same time, to accommodate different learners. Once again, the study will not include students who have learning disabilities. However, if any, they can still participate in the study sessions like other participants and can choose a type of module to watch. Those who have physical disabilities will be accommodated during the treatments. For example, they may choose a computer station in the computer lab and use a different type of headphone. Given the past experience, no students with English as a Second Language (ESL) enrolled in this class. However, ESL students should be able to learn the content from the modules, which are designed for beginners and use easy-to-understand vocabulary.

Delivery Options Statement

Prompt	Response
1.0 What is the delivery plan for the targeted content's assignments?	There will be no assignments for each module (See assessment plans below).
2.0 What is the delivery plan for the targeted content's activities?	No learning activities will be incorporated in the modules.

3.0	**What is the delivery plan for the targeted content's assessments?**	After the module, the participants will complete a paper-and-pencil survey. The instructor will collect the surveys. After that, the participants will take a posttest and eventually a delayed posttest (six weeks later). They will use Microsoft *Access* 2013 to create a database file, table, and query. The assessment instruction will be provided in a paper-based format delivered in the computer lab. They will submit both assessments (Microsoft *Access* databases) in the assigned submission boxes on the Moodle course page.
4.0	**What is the plan for learner self-directed materials (e.g. homework, out-of-class assignments)?**	There will be neither out-of-class assignments nor homework for this module.
5.0	**What is the plan for any remedial learning based on pre-test assessment feedback?**	The instructor will discuss the material on Microsoft *Access* 2013 again after the study for remedial purposes.
6.0	**What is the plan for the availability of auxiliary formats for materials (e.g., printed, podcast, Wiki, blog, twitter feeds, etc.)?**	The browsers have a built-in flash player. Therefore, the participants should be able to view the content, which will be produced in a flash format. The instructor will check to ensure that all participants can view the content with their assigned computer station. If necessary, the modules will be produced in a different format such as a video file.
7.0	**What is the plan for student-to-instructor communication and interactions (e.g., face-to-face, synchronous, asynchronous, etc.)?**	The participants can ask the instructor during the treatments in the computer labs about issues related to the study and technical aspects of the modules. They can also contact the instructor before and after the study via email or phone.

APPENDIX B-8

ADDIE Analyze Phase
Task A09 & A10: Specific Learner Constraints Statement/Learning Environment & Delivery Options
Delphi Survey 04

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached related to the project's learning environment and delivery options.
2. Mark the rating that most represents your expert evaluation for each item on the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
Learner Constraints Statement (Task A09):				
1. It appears the learner constraints (e.g. Time, budget, user preferences, organizational culture, and available technology) have been reasonably addressed for target population of the project.				
2. It appears the learner constraints regarding ADA considerations have been reasonably addressed for target population of the project.				
3. It appears the learner constraints regarding network software have been reasonably addressed for target population of the project.				
Learning Environment & Delivery Options Statement (Task A10):				
4. It appears the specific hardware requirements have been accurately described for the project.				
5. It appears the specific requirements to navigate the content materials have been accurately described for the project.				
6. It appears the specific software requirements have been accurately described for the project.				
7. It appears the specific learner requirements have been accurately described for the project.				
8. It appears the specific learner requirements for students with physical disabilities have been accurately described for the project.				
9. It appears the specific learner requirements for students with English as a second language have been accurately described for the project.				
10. It appears the specific learner requirements for students with cognitive disabilities have been accurately described for the project.				
11. It appears the specific delivery plan for content assignments has been accurately described for the project.				
12. It appears the specific delivery plan for content activities has been accurately described for the project.				

13. It appears the specific delivery plan for content assessments has been accurately described for the project.				
14. It appears the specific delivery plan for content assessment feedback has been accurately described for the project.				
15. It appears the specific delivery plan for student-to-instructor communication has been accurately described for the project.				

APPENDIX C:

ADDIE Design Phase

APPENDIX C-1

TASK D01: TASK ANALYSIS

Task Analysis Worksheet
Task D01

Task/Subtask	Knowledge Type (D, P, S)	Prerequisite (Y/N)	Environment Factors (T, E, M, P, L)	Domain Type (C, M, A, MO)	Importance (H, M, L)	Difficulty (H, M, L)
Objective 1: Create a database file with 100% accuracy according to instructor guidelines.						
- Open the database software program.	P	N	T, M, P, L	M	H	L
- Select the *blank* database option from the software menu.	P	N	T, M, P, L	M	H	L
- Name the database according to the instructor guidelines.	P	N	T, M, P, L	M	L	L
Objective 2: Create a Table from a database file with 100% accuracy according to instructor guidelines.						
- Create additional fields in the Table	P	N	T, M, P, L	M	H	L
- Select a correct data type for a field	P	N	T, M, P, L	M	H	M
- Create additional records in the Table	P	N	T, M, P, L	M	H	M
Objective 3: Create Queries within the database with 100% accuracy according to instructor guidelines.						
- Create a Query from the Table using "Query Design"	P	N	T, M, P, L	M	H	L
- Filter the Query	P	N	T, M, P, L	M	M	M
- Save it as a new Query	P	N	T, M, P, L	M	H	M

Explanation of Terms (Legend):

Column 2: Knowledge Type (**D, P, S**)

Instructions: Mark the column with D, P, or S (choose only one knowledge type)

According to Jonassen (1999), there are three types of knowledge for an Instructional Designer to consider: (1) Declarative (**D**), (2) Procedural (**P**), and (3) Structural (**S**).

Declarative Knowledge is defined as factual knowledge (e, g., the capital of Florida is Tallahassee), and may be thought of in at least two ways: episodic (knowledge is organized by where, when, who) and semantic knowledge (knowledge of the meaning of words, facts, geography, and things that are classified). Declarative knowledge may also include information about concepts.

Procedural Knowledge is defined as a listing of "how" something is done (e.g., driving a car or preparing a recipe). This knowledge type details activities required to perform a specific task. Procedural Knowledge transforms detail tasks into a habitual process (e.g., fire drill instructions, pre-flight check list).

Structural Knowledge is defined as the linking of one concept to another in order to solve a problem, generate a plan or a strategy by setting conditions for a set of procedures.

Column 3: Prerequisite

Instructions: Mark the column with **Y** (yes) or **N** (no) (choose only one)

If prerequisite knowledge or skills are required in order to complete the task (e.g., A student cannot add 3+2 unless the concept of the number 3 and 2 exist prior to the act of addition), then this should be identified in the worksheet.

Column 4: Environmental Factors (**T, E, M, P, L**)

Instructions: Mark the column with **T** (**T**ime), **E** (**E**nvironment), **M** (**M**edia), **P** (**P**hysical condition), or **L** (**L**earning environment) (multiple factors may apply; choose accordingly)

Time is the estimated time to complete the task. (You will use this estimate to compare actual student time to complete the task. The difference between these two quantities (e.g., estimated time 23 min, actual time 36 min, difference 13 minutes) may result in instructional changes to improve performance.

Environment: Examine the literature to see what environmental concerns are related to the specific task requirements. You may also need to consult with one, or more, instructional experts to gain insight.

Media: What is the best media that will assist in the targeted learners in completing the task? You may need to consider your response to the Environment issue (see above) since this may impose conditions on the media that is best given any environmental constraints.

Physical Condition: These are not the same as Environmental issues (see Watson, 1997: *Task Analysis: An Occupational Performance Approach*. Bethesda, MD: The American Occupational Therapy Association). You may wish to examine Card, Moran, and Newell (1983) in relation to GOMS (Goals, Operators, Methods, Selection) in job task analysis for business, industry, and government.

Learning environment: Considerations should include connectivity, type of hardware/software and peripherals, user interface designs for computer assisted Instruction and distance learning interfaces.

Column 5: Domain (**C, M, A, MO**)

Instructions: Mark the column with **C** (**C**ognitive), **M** (**M**otor), **A** (**A**ffective), or **MO** (**Mo**tivation) (choose only one)

The terms Cognitive, Motor, and Affective are related to Gagne's taxonomy of learning outcomes and are somewhat similar to Bloom's taxonomies of cognitive, affective, and psychomotor outcomes.

Motivation refers to Maslow's Hierarchy of Needs:
Self-Actualization (reaching one's maximum potential)
Esteem (respect from others, self-respect, recognition)
Belonging (affiliation, acceptance, being part of something)
Safety (physical safety, psychological security)
Physiological (hunger, thirst, rest)

Column 6: Importance (**H, M, L**)

Instructions: Mark the column with **H** (**H**igh), **M** (**M**edium), or **L** (**L**ow) (choose only one)

As an instructional designer you will want to determine if a specific task (or subtask) is highly important, of medium importance, or would actually be considered as being at a low level of importance.

Column 7: Difficulty (**H, M, L**)

Instructions: Mark the column with **H** (**H**igh), **M** (**M**edium), or **L** (**L**ow) (choose only one)

Similar to Importance, the instructional designer will want to determine the "weight" of the level of difficulty for the specific task. This my impact the amount of time, or placement, or degree of support needed within the instructional project in order to accomplish this task.

APPENDIX C-2

ADDIE Design Phase
Task D01: Task analysis
Delphi Survey 05

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached related to the project's tasks and subtasks (if included).
2. Mark the rating that most represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

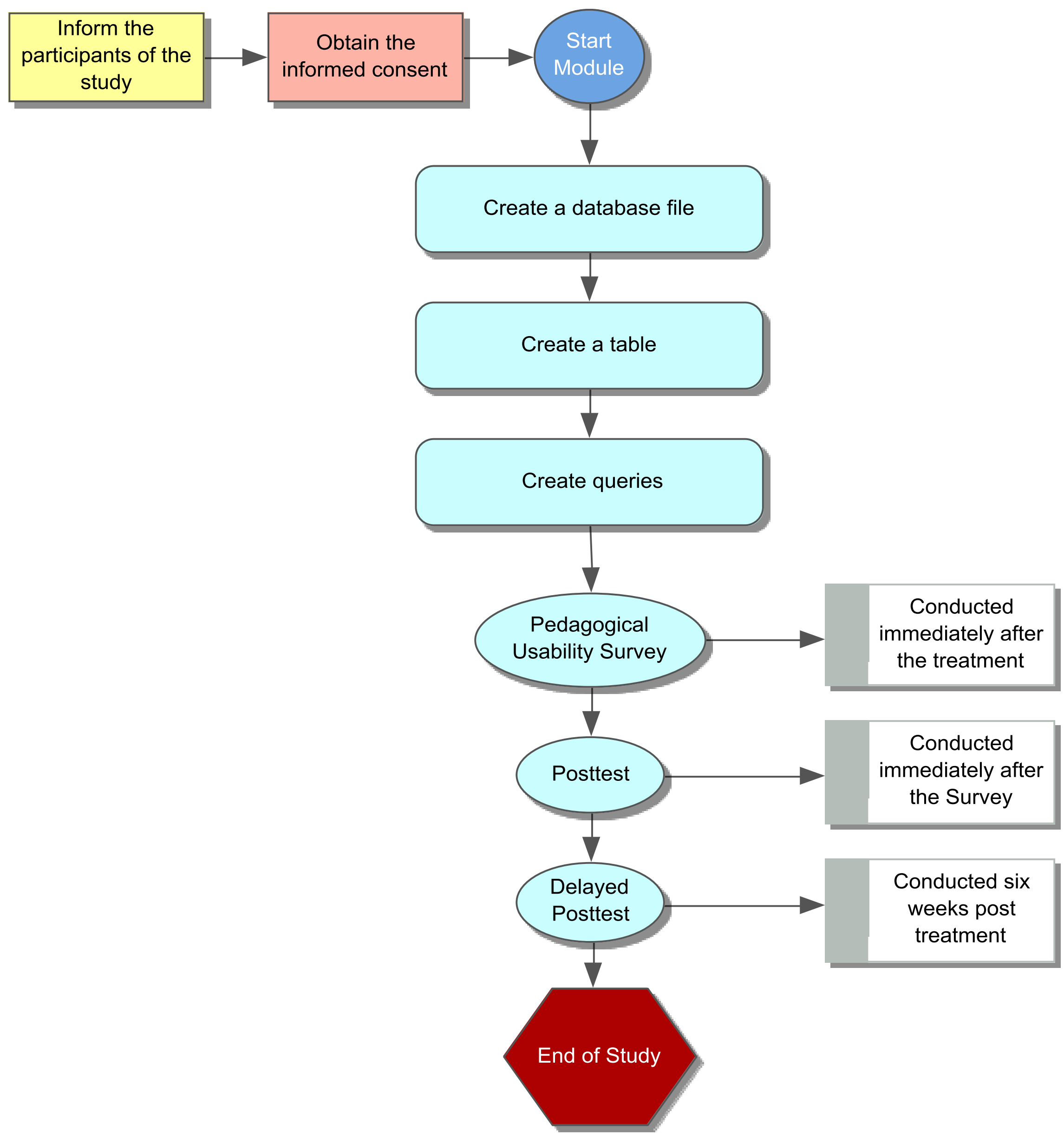
Item	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
1. The objectives for the tasks are clearly stated.				
Project Tasks:				
2. The listed tasks are aligned with each objective.				
3. The knowledge identification types are aligned with each task.				
4. The prerequisite decisions (Y/N) are aligned with each task.				
5. The environmental factors identified are aligned with each task.				
6. The domain types are aligned with each task.				
7. The importance levels are aligned with each task.				
8. The difficulty levels are aligned with each task.				
Project Subtasks:				
9. The listed sub-tasks appear to be aligned with the tasks.				
10. The knowledge identification types are aligned with each subtask.				
11. The prerequisite decisions (Y/N) are aligned with each subtask.				
12. The environmental factors are aligned with each subtask.				
13. The domain types are aligned with each subtask.				
14. The importance levels are aligned with each subtask.				
15. The difficulty levels are aligned with each subtask.				

APPENDIX C-3

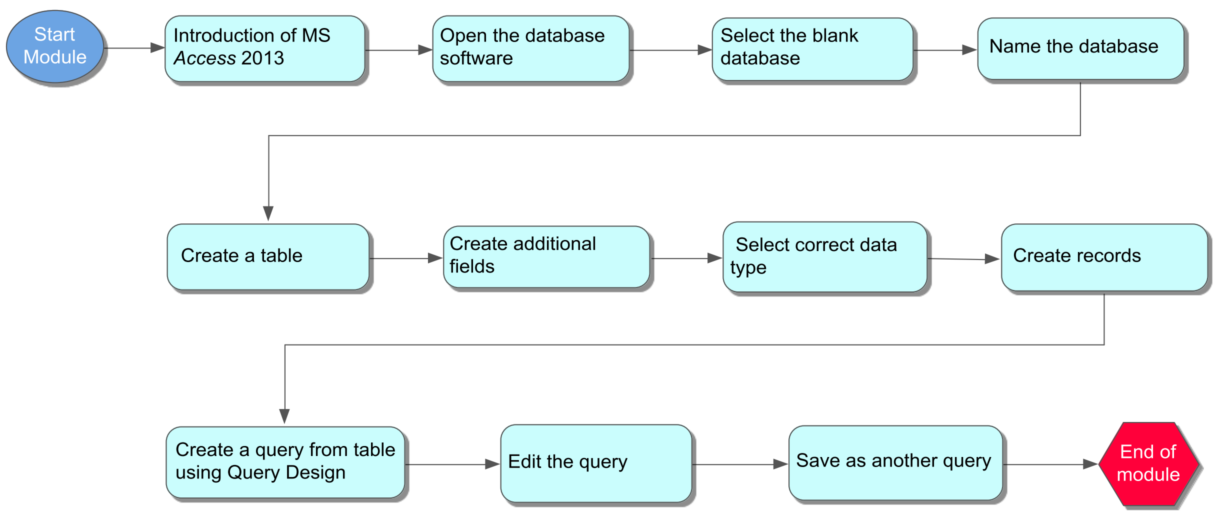
TASK D02: FLOWCHARTS WITH CONTENT

Overall Project Flowchart

Task D02



Flowcharts with Content



APPENDIX C-4

ADDIE Design Phase
Task D02: Flowcharts with Content
Delphi Survey 06

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached.
2. Mark the rating that <u>most</u> represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
1. Each objective for the module is represented in the flowchart.				
2. Appropriate content in support of each objective is represented in the flowchart.				
3. Assessments for each objective are represented in the flowchart.				
4. Appropriate decision points are represented in the flowchart.				
5. The content within the flowchart is appropriately sequenced for the module.				

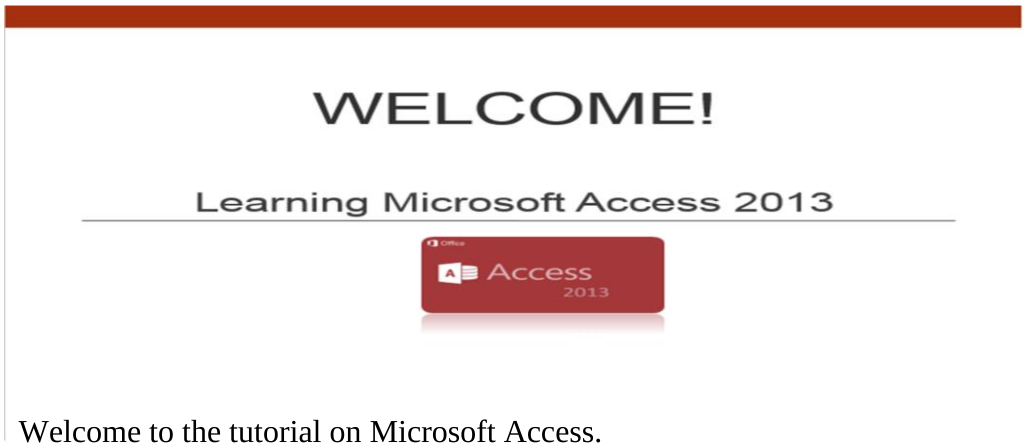
APPENDIX C-5

TASK D03: STORYBOARDS

Storyboards
Task D03

Introduction to Microsoft *Access* 2013

<u>Graphics</u>



<u>Narration:</u>

Welcome to the tutorial on Microsoft Access. The goal of this tutorial is to teach you how to create a database file, a Table, and Queries using Microsoft *Access 2013*. . . .

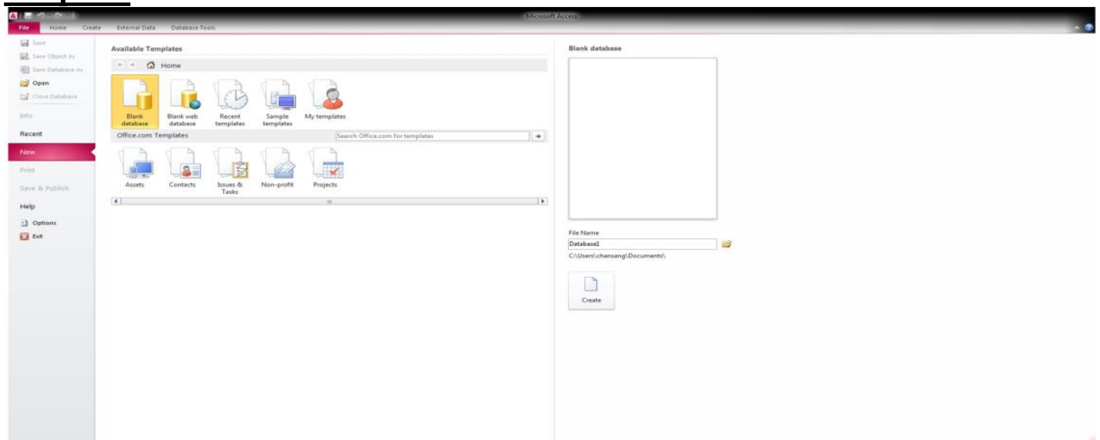
<u>Technical Specifications:</u>

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

<u>Note:</u>
This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

OBJECTIVE 1: Create a database file in MS Access 2013

Graphics



To build a new database, the first step is to select "*Blank desktop.*"

Narration:

To build a new database, the first step is to select "*Blank desktop database.*" Let's name the database file "Student Records" and save this file on the desktop for easy access. Then, click on the "*Create*" button to create a database file. . . .

Technical Specifications:

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

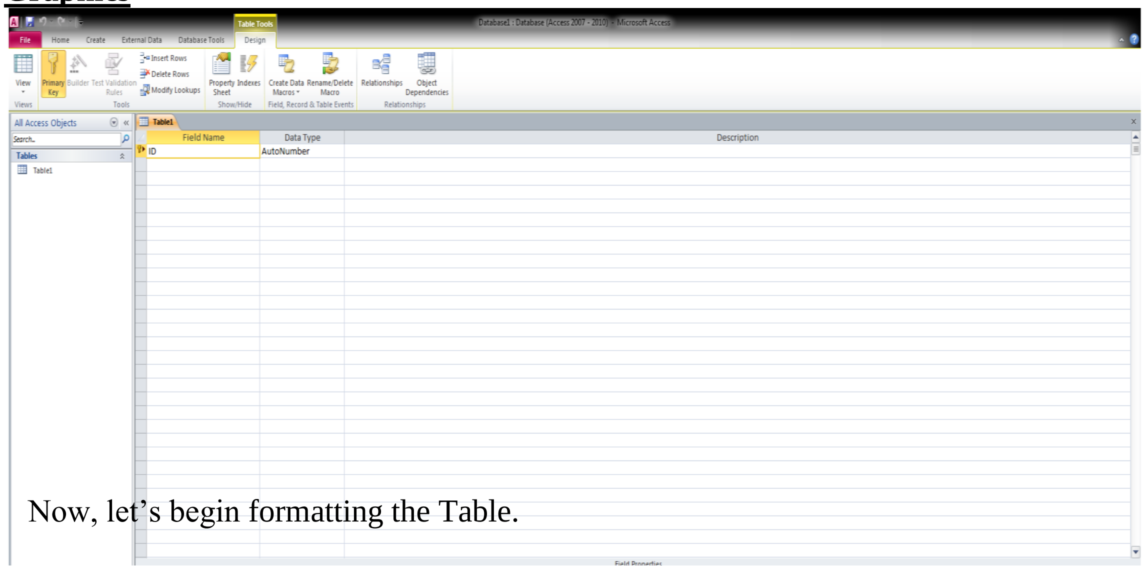
Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

OBJECTIVE 2: Create a table in the database

How to edit the table

Graphics



Narration:

Now, let's begin formatting the Table. By default, Microsoft *Access* creates and names the Table as *Table1*. This table has only one field called "ID". We need to create more fields for this Table. First, let's save this Table as *StudentT*. Then, go to the "*Home*" tab and select on the "*Design View*" button to format the Table.

……..

Technical Specifications:

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

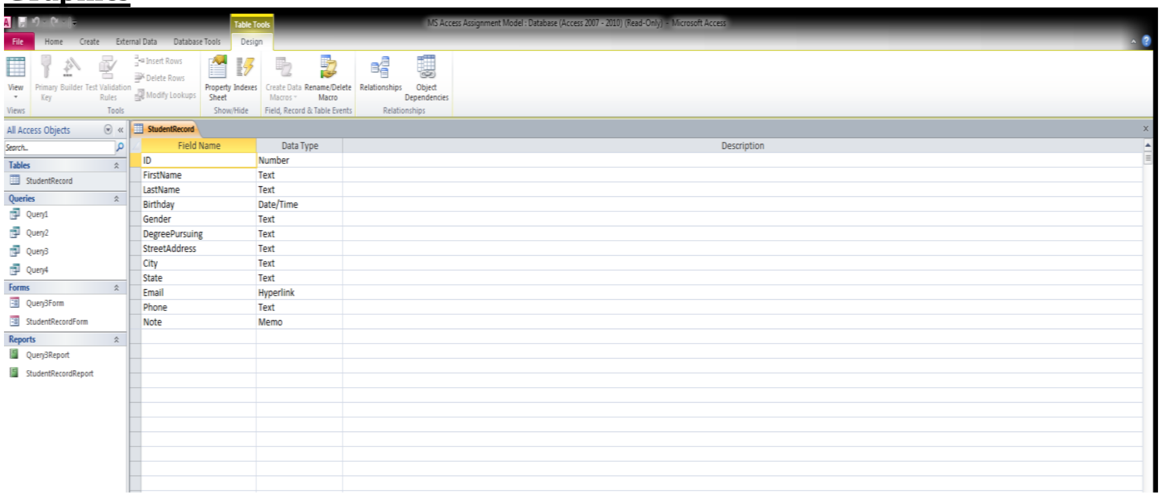
Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

Objective 2: Create a table in the database

Create additional fields in table

Graphics



For example, to create a field for last name, type the word in the row below "ID".

Narration:

For example, to create a field for last name, type the word in the row below "ID". By default, the data type is specified as "*Short Text*", which is correct because we want to enter text in this field. Change it to other data type if you wish.

……..

Technical Specifications:

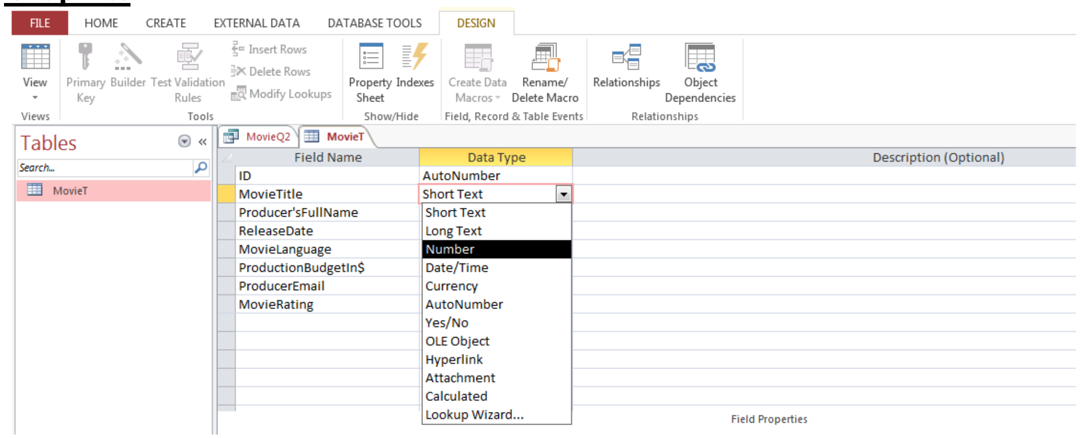
- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

Objective 2: Create a table in the database
Select correct data type

Graphics



By default, the data type is specified as "*Short Text*"

Narration:

By default, the data type is specified as "*Short Text*", which is correct because we want to enter text in this field. Change it to other data type if you wish.
……..

Technical Specifications:

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

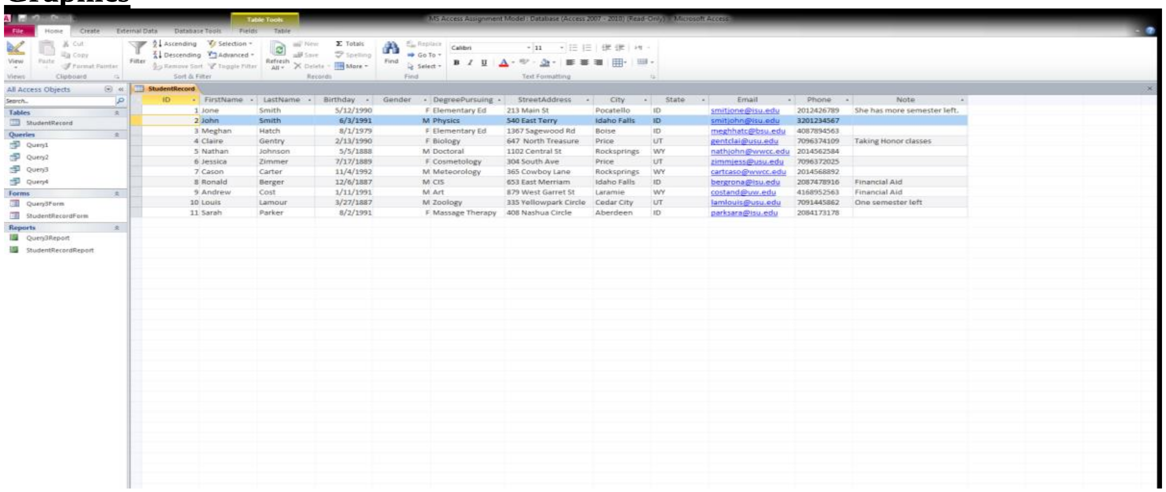
Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

Objective 2: Create a table in the database

Create records in table

Graphics



Let's begin adding records to the Table.

Narration:

Let's begin adding records to the Table. Once again, each record represents one student. To add a record, enter information in any field, except the ID field, which is an "*AutoNumber*" generated by *Access*. Proceed to the other fields by pressing the forward arrow key or clicking in the next field. For our first record, input the following information:

……..

Technical Specifications:

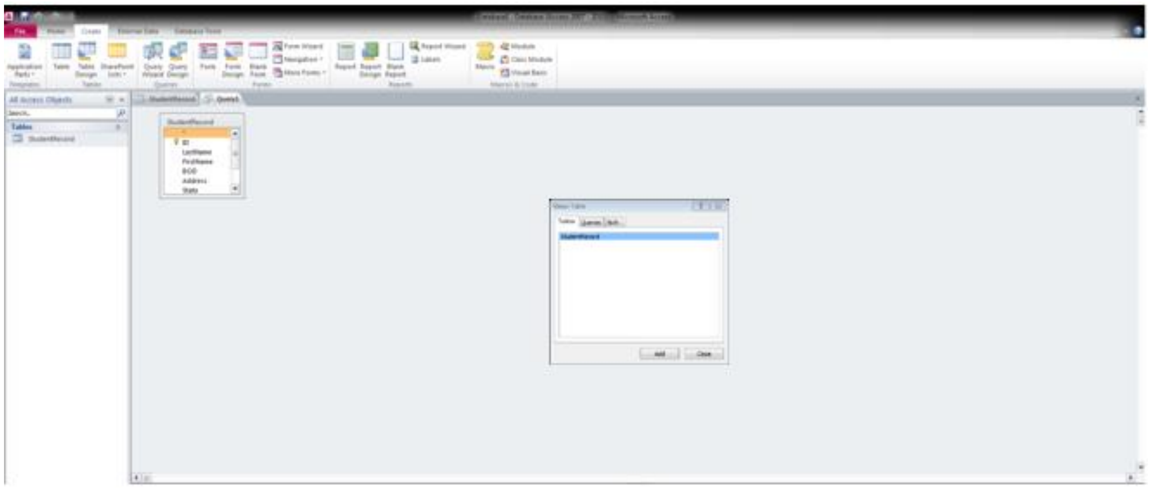
- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

OBJECTIVE 3: Create a query from the table using Query Design

Graphics



To create a Query, go to the “*Create*” tab and choose “*Query Design*”.

Narration:

To create a Query, go to the “*Create*” tab and choose “*Query Design*”. It will take you directly to the design view mode. A dialogue “*Show Table*” appears. Select a Table from which you want to create this query. Click “*Add*” and then click “*Close*” to close the dialogue. ……..

Technical Specifications:

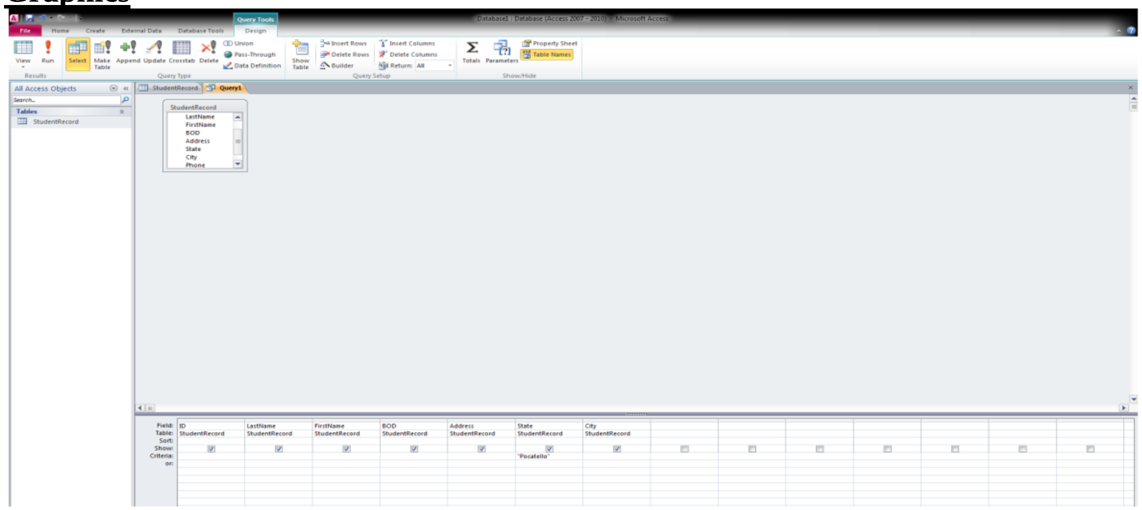
- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

Note:
This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

Objective 3: Create queries in the database

Filter the query

Graphics



You can also filter the Query based on one or more

Narration:

You can also filter the Query based on one or more fields to present even more specific information. For example, you may want to filter the Query by city to see only students from Pocatello and want to save it as a new Query so that the original Query stays intact………

Technical Specifications:

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

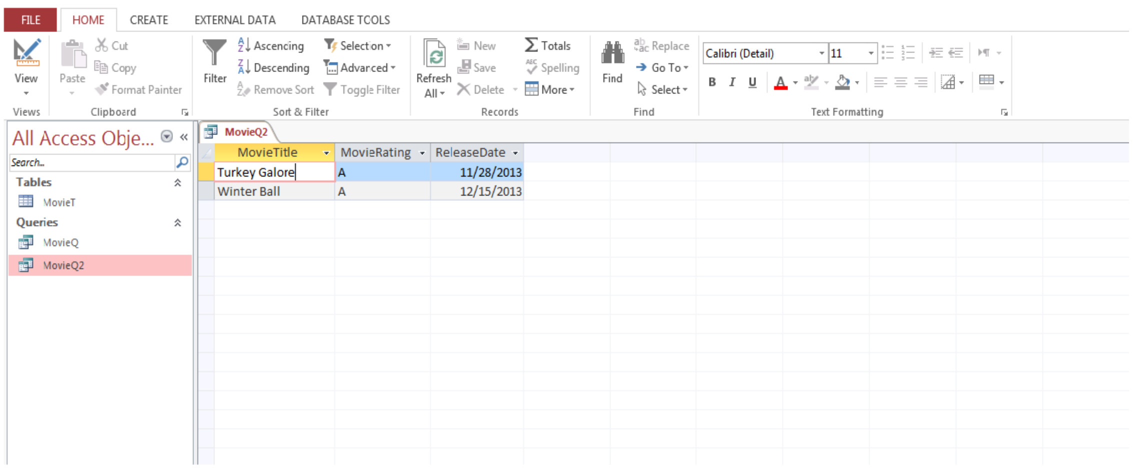
Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

Objective 3: Create queries in the database

Save a new query

Graphics



To save it as a separate Query, go to "*File*", click on "Save As".

Narration:

To save it as a separate Query, go to "*File*", click on "Save As". Then click on "*Save Object As*" and click on the "Save As" button to give it a name "StudentQ2". Two Queries have been created. The original Query still lists all students. The second Query lists only students from Pocatello.

……..

Technical Specifications:

- No navigation buttons (e.g., pause, play, rewind) were made available.
- Text (closed captioning) contained eight words or less on most screens.
- Text was displayed in one line at a time.
- Text size was 24 pt (largest) and text type was Times New Roman.
- Adobe Captivate 7.0 was used to capture the screen.
- Full screen was captured.

Note:

This module was for the redundant group (graphics, narration, and text). For the non-redundant group, the graphics and narration elements were the same, but there was no text included at the bottom of the screen.

APPENDIX C-6

ADDIE Design Phase
Task D03: Storyboards
Delphi Survey 07

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached.
2. Mark the rating that <u>most</u> represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
1. There is a series of storyboards aligned with the flowcharts (Task D02).				
2. The placement for graphical elements is included in the storyboards.				
3. The type of graphical elements is identified in the storyboards.				
4. The size parameters of graphical elements are identified in the storyboards.				
5. The placement for textual elements is included in the storyboards.				
6. The font style for textual elements is included in the storyboards.				
7. The font size for textual elements is included in the storyboards.				
8. Hypertext links (where needed) are indicated in the storyboards.				
9. The placement of hypertext links is indicated in the storyboards.				
10. Navigation buttons (where needed) are indicated in the storyboards.				
11. The placement of navigation buttons is indicated in the storyboards.				
12. The style of navigation buttons is indicated in the storyboards.				

APPENDIX C-7

TASK D04: ASSESSMENT INSTRUMENT

Assessment Instrument
Task D04

Posttest and Delayed Posttest Assessment

There is a maximum score possible on this assignment of **95 points**. You must work **INDEPENDENTLY**. You **CANNOT** talk to *anyone* or consult *any resources*. If you have questions, please ask the instructor.

Open the Microsoft *Access* 2013 application, and follow the instruction below to create a database for your favorite movies.

1. Create a database file and save it using the following protocol: *Your First Name_Last Name_Database* (For example: Sang_Chan_Database) (**3 points**)

Create a Table

2. Save the table as *MovieT*. (**1 point**)

3. Create the following fields for the *MovieT* table and specify an appropriate data type for each field: (**14 points**)

    - ID (NOTE: MS Access creates this field as an AutoNumber field; you do not need to alter it.)
    - Movie title
    - Producer's full name
    - Movie release date
    - Language used in the movie (e.g., English, French, etc.)
    - Production budget in dollars
    - Email address for the producer

    Note: The fields for the *MovieT* table must be **in the exact order**. **(1 point)**

    Each field name should consist of at least two words for clarity. For example: the field for movie title should have the words "movie" and "title" in it, **NOT** "movie" alone or "title" alone. (**7 points**)

4. Create **five** records (movies) in the *MovieT* table by entering information in each field (You can also use fictitious information.) (**40 points**)

At this point you should have the fields and records created for the *MovieT* table.

5. Adjust the size of any fields necessary in order to read the data that should be displayed. (**2 points**)

6. Below the email address field, create one more field for movie rating and specify an appropriate data type for this field. (**3 points**)

7. Move the field for movie rating to the right of the field for movie title. (**4 points**)

8. Rate the five movies (use A, B, or C as the identification for the movie rating; be sure you have at least one movie for each of these. Do not use + or – sign in a rating.) (**5 points**)

Create Queries

9. Create a Query that is for the following fields (**6 points**):

   - Movie title
   - Movie rating
   - Movie release date

10. Save this Query as *MovieQ* (**1 point**)

11. From the *MovieQ* query, create another Query to display only the movies that receive the A rating (**5 points**)

12. Save this new Query as *MovieQ2*. (**3 points**)

13. Save your work and submit it on Moodle.

End of Assessment!

APPENDIX C-8

ADDIE Design Phase
Task D04: Assessment Instruments
Delphi Survey 08

In order to best represent your feedback on the project, I ask that you proceed as follows:

1. Carefully and thoroughly review the documents attached.
2. Mark the rating that best represents your expert evaluation for each item in the survey.
3. Return your completed instrument via reply email as an attachment no later than **month day, year**.

Item	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
1. The questions in the performance-based posttest are related to the Objectives.				
2. The questions in the posttest are appropriate to assess if the Objectives are achieved.				
3. The questions in the posttest are formatted for readability.				
4. The assessment questions in the posttest are sufficient related to each Objective.				
5. The assessment questions in the posttest appear to have the face validity.				
6. The assessment questions in the posttest appear to have the content validity.				

APPENDIX E:

Delphi Survey Data

APPENDIX E-1:

Delphi Survey 01

Delphi Survey 01

Item	SME 1	SME 2	SME 3
1	3	3	4
2	4	3	4
3	4	3	4
4	4	4	4
5	4	4	4
6	3	3	4
7	4	4	4
8	4	4	4
9	4	4	4
10	4	3	4
11	4	4	4
12	4	3	4
13	4	3	4
14	4	4	4
15	4	4	4
16	4	3	4
17	4	3	4
18	4	3	4
19	4	3	4
20	4	3	4
21	3	3	4

APPENDIX E-2:

Delphi Survey 02

Delphi Survey 02

Item	SME 1	SME 2	SME 3
1	3	3	4
2	3	3	4
3	3	3	4
4	3	3	4
5	4	3	4
6	4	3	4
7	4	3	4
8	4	3	4
9	4	3	4
10	3	3	4
11	3	3	4
12	4	3	4
13	4	3	4
14	3	3	4
15	3	3	4
16	3	3	4
17	3	3	4
18	3	3	4
19	4	3	4
20	3	3	4

APPENDIX E-3:

Delphi Survey 03

Delphi Survey 03

Item	SME 1	SME 2	SME 3
1	4	4	4
2	4	4	4
3	4	4	4
4	4	4	4
5	4	4	4
6	3	3	4
7	3	3	4
8	3	3	4
9	3	3	4
10	3	4	4
11	3	4	4
12	3	4	4
13	3	4	4
14	3	4	4

APPENDIX E-4:

Delphi Survey 04

Delphi Survey 04

Item	SME 1	SME 2	SME 3
1	3	4	4
2	3	4	4
3	3	4	4
4	4	4	4
5	4	4	4
6	4	4	4
7	3	3	4
8	3	3	4
9	4	4	4
10	3	3	4
11	4	4	4
12	4	4	4
13	4	4	4
14	4	4	4
15	4	4	4

APPENDIX E-5:

Delphi Survey 05

Delphi Survey 05

Item	SME 1	SME 2	SME 3
1	3	3	4
2	3	3	4
3	3	3	4
4	3	3	4
5	3	3	4
6	3	4	4
7	3	3	4
8	3	3	4
9	3	3	4
10	3	3	4
11	3	3	4
12	3	3	4
13	3	3	4
14	3	3	4
15	3	3	4

APPENDIX E-6:

Delphi Survey 06

Delphi Survey 06

Item	SME 1	SME 2	SME 3
1	3	4	4
2	3	4	4
3	3	4	4
4	3	4	4
5	3	4	4

APPENDIX E-7:

Delphi Survey 07

Delphi Survey 07

Item	SME 1	SME 2	SME 3
1	3	4	4
2	3	3	4
3	3	3	4
4	3	4	4
5	3	4	4
6	3	3	4
7	3	4	4
8	3	3	4
9	3	4	4
10	3	4	4
11	3	3	4
12	3	4	4

APPENDIX E-8:

Delphi Survey 08

Delphi Survey 08

Item	SME 1	SME 2	SME 3
1	3	4	4
2	3	4	4
3	3	4	4
4	3	4	4
5	3	4	4
6	3	4	4

APPENDIX F:

Posttest and Delayed Posttest Data

Posttest and Delayed Posttest Data

No	Group	Posttest	Delayed Posttest
1	TNA	91	
2	TNA	88	62
3	TNA	87	89
4	TNA	82	52
5	TNA	74	74
6	TNA	91	83
7	TNA	91	80
8	TNA	80	74
9	TNA	93	85
10	TNA	93	
11	TNA	93	62
12	TNA	93	84
13	TNA	80	67
14	TNA	71	50
15	TNA	53	53
16	TNA	17	
17	TNA	93	
18	TNA		87
19	TNA	78	66
20	NA	84	
21	NA	86	86
22	NA	88	86
23	NA	73	5
24	NA		
25	NA	88	
26	NA	87	64
27	NA	82	43
28	NA	95	87
29	NA	87	18
30	NA	79	
31	NA	24	56
32	NA	81	51
33	NA	74	
34	NA	78	45
35	NA	74	86
36	NA	95	95
37	NA	89	71
38	NA	93	84
39	NA	91	87
40	NA		35
41	NA	68	80
42	NA	71	5

APPENDIX G:

Pedagogical Usability Survey Responses

Pedagogical Usability Survey Responses

No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25*
1	4	4	4	4	4	4	4	3	4	4	4	4	3	4	4	4	4	3	4	4	4	4	4	4	3
2	3	3	3	3	3	3	2	2	4	2		1	1	3	2	3	2	2	2	3	2	3	3	3	4
3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	2	3	3	3	2.5	2.5	2.5	3
4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	3	4	4	3	3	3	4	3	3	3	3
5	4	4	3	3	3	3	3	3	4	4	4	4	3	4	4	3	4	3	3	2	4	2.5	2.5	2.5	4
6	4	4	3	3	4	4	3	3	4	4	4	3	3	3	4	4	3	3	3	4	4	3	3	3	3
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21	4	4	4	4	3	1	4	3	4	4	4	3	3	4	3	3	3	3	3	3	3	2.5	2.5	2.5	

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23	3	4	4	4	4	2	3	3	4	4	4		3	3	4	4	2	3	3	4	4	4	4	4
24	4	4	4	4	4	2	4	4	4	4	4	2	3	3	1	4	2	3	3		3	3	3	3
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27	3	3	3	3	3	2	3	3	3	3	3	2	3	3	3	3	2	2	2	3	3	2.5	2.5	2.5
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36	4	4	4	4	4	3	4	4	4	4	4	2	4	4	4	4	3	3	3	4	4	4	4	4
37	3	3	4	4	3	2	4	3	3	3	3	3	4	4	3	3	3	4	4	3	3	3	3	3
38	4	4	4	4	4	3	4	4	4	4	4	4	3	4	2	4	4	4	4	4	4	4	4	4
39	3	4	3	3	3	3	3	4	4	4	3	2	3	3	3	3	2	3	3	3	3	4	4	4
40	4	4	4	4	3	2	4	4	4	4	3	4	4	3	1	4	3	4	4	2.5	4	2.5	2.5	2.5
41	3	3	3	3	3	3	3	3	4	4	4	2	3	3	2	3	2	2	2	2	2	2	4	4
42	3	3	3	4	3	3	3	3	4	3	3	3	4	4	1	3	3	3	3	3	3	2	2	2

* Q25 is the last question in the redundant survey.