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Understanding the role of the modality principle in multimedia learning environments

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by

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ABSTRACT

The modality principle was first addressed in 1989 by Mayer and Moreno. The modality principle asserts presenting words as speech, rather than on-screen text, is more effective for the learner. The modality principle states that learners are more successful with understanding information that uses narration than on-screen text because the on-screen text may produce a cognitive overload if it is accompanied by other visual elements. This overload may occur due to the learner needing to give attention to the visual graphic/image as well as provide visual attention to the on-screen text. However, if the on-screen text is narrated, the learner will be able to process this information with the auditory channel and thereby, not taxing the visual channel. Over the next fifteen years, additional studies were completed addressing the modality principle. Many of the studies provided additional data and support for the modality principle in multimedia learning environments. However, some studies began to show the modality principle's impact had certain parameters and was impacting different groups, conditions and environments differently. Recently, fewer studies have been conducted, but those that have been completed are also showing additional modifications to the impact of the modality principle. With the results of the previous studies indicating the changing impact of the modality principle, it seemed apparent that a near replication of the earliest modality principle study would benefit current understandings among today's learners. This replication is needed as the modality principle is impacting the field of education and corporations as they try to implement best practices for their students/clients. The early studies showing the predominately positive impact

of the modality principle have recently been brought into question. Replicating the original study will provide data to either support, question and/or refine the original study.

The current study replicated Mayer and Moreno's study of 1989 in part, which was also addressed in Moreno's study in 2006. Seventy-nine college students attending a Midwestern University participated in this study. The current study included the participants completing similar items that were presented in the original study: a pre-survey, a viewing of PowerPoint presentation, and an assessment. However, two variations of the original study were made. The first variation included changing the testing environment from a lab-like setting to the actual classroom of the participants (natural setting). The second variation was recognizing that the current participants, unlike the original group from nearly 15 years prior, would be experienced online learners who also had experience with multimedia formats and multimedia learning environments due the integration of technology into the classroom and daily life over the past 15 years.

The results of the study showed that the modality principle was not an effective strategy for the group of low-experience content users. The results from the study show the retention and transfer of knowledge is not as effective for students who viewed the narrated PowerPoint presentation. In fact, students who viewed the PowerPoint presentation that only included the onscreen text, had more effective retention and transfer of knowledge.

CHAPTER 1

INTRODUCTION

As we look to implement best practices and effective strategies into the classroom, it is imperative we review research and the strategies and practices they employed. These research studies undoubtedly brought positive changes for the time in which they first appeared. However, as our approach to education shifts, and our delivery formats expand and change, it is necessary to re-evaluate research studies that seem to no longer be as effective as they once were. For example, classrooms have changed from the face-to-face environment that involved instruction on a blackboard, whiteboard, overhead, movie, and/or lecture to something quite different. As noted by Purcell, Heaps, Buchanan, and Friedrich (2013), today's classrooms are comprised of technology solutions and environments that have students engaged in new ways of learning. Terms like eLearning, SMART Boards, cell phones, webcams, Learning Management Systems, online forum discussions, Google Docs., multimedia, and one-to-one initiatives have become nearly commonplace. Along with the changing classroom environment, comes the changing student as well. Today's students, as noted by Prensky (2001), are a part of the new generation that has grown up with technology readily available through computers, video games, digital music, cell phones, iPads, and many other digital toys and tools. This exciting and ever-changing world of technology enables instructional designers to provide educators and learners with improved strategies, techniques and best practices for the evolving, technology-enhanced learning environment. Creating reliable paths, providing effective engagement, developing connections to prior knowledge and enhancing student motivation as well as providing successful knowledge retention, matching, and transfer is on the "to do" list of the instructional designer.

In order to meet these new demands, two areas need to be discussed. First, in order to successfully develop technology-enhanced learning environments and provide positive instruction, the instructional designer must recognize the impact of cognitive load, the level of mental effort that the content itself requires, and how this affects the learning process. Instructional design around the content Calculus, which would have many elements of engagement and therefore a higher cognitive load for most learners, should be handled differently than content around the topic of addition, which would have much fewer elements of engagement and a lower cognitive load for most learners. Instructional design should not under-load or overload the cognitive resources of the learner but instead, provide the appropriate cognitive load that assist the learner in building schema and assist the learner's comprehension process.

Second, the instructional designer, when addressing this new online environment, needs to recognize the impact the actual instructional design can have on the learning process and therefore, on the learner. For example, an online learning page may be filled with pictures, text, animation and many hyperlinks. While this may seem to be providing effective engagement, this may actually distract the learner and cause cognitive overload of the learner's visual channel (Sweller, 1994). The learner may not be sure which area to give attention and may be overwhelmed by the many items that are demanding visual attention. The instructional designer has the ability to design learning resources that will guide the learner effectively and not overload the learner by recognizing the cognitive load of the items on each page and manipulating content and media types to meet the learner's needs. An effective instructional designer keeps this goal in mind in the instructional design process (Paas, Renkl & Sweller, 2003).

Cognitive load theory began in the 1980s and has continued to expand and change. The theory addresses three areas, intrinsic, extraneous and germane load (See Figure 1.1). While each area has acquired deeper understanding over the past 30 years, the germane cognitive load has become a point of interest and development for instructional designers. New approaches are being developed with the intent to provide the effective design of instruction which will build schema acquisition and automation. This includes increasing germane cognitive load through specific design instruction, and yet not depleting cognitive resources. Engaging students with online learning needs to reflect these best practices that support such learning environments and includes multimedia to enhance the cognitive process.

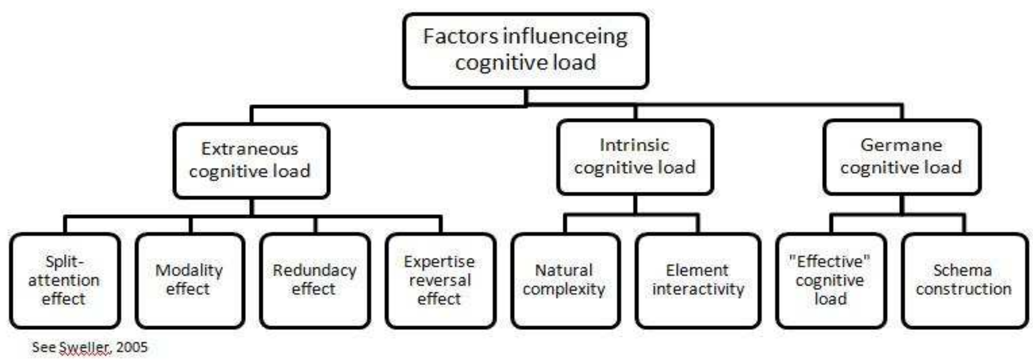

Figure 1.1. Cognitive Load Influences

This figure displays the framework of cognitive load influences. Adapted from "The modality principle in multimedia learning" Low, R., & Sweller, J., 2005. In R. E. Mayer (Ed.), Cambridge handbook of multimedia learning (pp. 147–158). Copyright 2005 by Cambridge, UK: Cambridge University Press.

In addressing the needs of cognitive load, the instructional designer can provide instruction that will limit extraneous cognitive load. Research suggests the instructional designer, by using the modality principle, can free up working memory space for learning. The dual-processing theory, along with split-attention theory provides the designer with knowledge and understanding of the modality principle. These ideas explain how learners, through utilizing both their visual and auditory learning channels, can free-up working memory space. If the instruction is all visual, an image and print text along with the image, the learner may overload visual cognitive space. However, instructional design that provides the content by making some of the information visual and the other auditory, image with print next narrated, has no longer created a cognitive overload (Mayer & Moreno, 1998). This idea is termed the modality principle. It states multimedia presentation explanations which include an image and onscreen text, should have the onscreen text presented auditorily (Mayer & Moreno, 1998).

Mayer and Moreno (1998) completed two experiments addressing instructional design. Experiment 1 had students viewing animation regarding lightning with two separate presentation styles, one used onscreen text, the other narration. Experiment 2 had students viewing the braking system of a car. One group had narration the other group onscreen text. Experiment 1 is the area of interest for this study. As stated above, this experiment utilized two different PowerPoint presentations. One had images with onscreen text, the other had the same images and onscreen text, but in addition, it had narration of the onscreen text. The experiment utilized a pre-survey to establish a low-experience participant pool. It then had the participants view the PowerPoint presentations over lightning. Following the viewing, the participants answered retention, matching, and transfer knowledge questions. The results were gathered in three areas addressing the modality principle: Split-attention effect on verbal recall, Split-attention effect on visual-verbal matching, and split-attention effect on problem-solving transfer. The results showed the participants did improve their retention, matching and transfer of knowledge when viewing the PowerPoint presentation that included narration. Additional research was completed by Mayer and Moreno (1999), Harskamp, Mayer and Suhre (2007), Mousavi, Low, and Sweller, (1995), supporting the modality principle.

As different types of media came onto the learning and educational stages, Moreno (2006) addresses the modality principle to assess its impact when presented with different types of media. In this research, Moreno describes the cognitive-affective theory of learning with media (CATLM). One of the important items to this discussion is the claim by CATLM that states meaningful learning cannot be fully reached when the visual channel is overloaded. The research utilized three experiments. Experiment 1, a multimedia explanation scenario; Experiment 2, an animated pedagogical agent scenario; Experiment 3, a virtual reality scenario. Experiment 1 is the focus of this current study and is the same Experiment 1 addressed earlier by Mayer and Moreno (1998). Utilizing the results from Mayer and Moreno (1998) which showed students that viewed online learning that included narration, outperformed students who watched the same online learning but without the narration, Moreno derived the data collected by Mayer and Moreno (1998) supported CATLM. The results did reveal the modality effect for both the retention and transfer tests. However, while these results may be an indicator of CATLM as an effective instructional method within the context of multimedia, it may be questionable that these results would hold to support today's learner who nearly all grew up with technology, have technology readily available, and know how to use technology. This group of learners is often referred to as digital natives. These learners, because of their greater experience with multimedia and online learning may have different instructional needs than the original participants who had less experience and access to these tools and media.

Additional research, while supportive of the modality principle overall, began to place parameters around the effectiveness of the modality principle. These parameters include discussions regarding the impact of redundancy, expertise reversal, segmenting, length of narration and/or onscreen text, and if the results will transfer to a typical classroom (Mayer &

Moreno, 2002; Kalyuga, Chandler, & Sweller, 2002; Cheon, J., Crooks, S., & Chung, S., 2014; Gerjets, Scheiter, Opfermann, Hesse, & Eysink, 2008; Harskamp, E.G., Mayer, R. E., & Suhre, C., 2007).

1.1 Purpose of the Study & Research Questions

There are several areas regarding the modality principle that are unresolved. However, the purpose of this study is to determine the impact of words on today's students in a multimedia presentation that are either presented visually or auditorily to promote deep learning. This study replicates the study referenced by Moreno (2006), which was completed by Mayer and Moreno (1998) to ascertain if the results would hold in a new environment that reflects a typical university classroom, and with today's learners who have greater exposure to narrated on-line learning and online experiences. Mayer and Moreno (1998) showed that narration fostered higher retention, matching, and transfer of information. As noted by Burman,, Reed, & Alm, (2010), replication of studies, whether they affirm or disaffirm the original study, should be completed and published. Their reasoning is to provide scientific integrity to the research. McCullough and Vinod (1999) showed that different types of packaged software programs developed different results for predominately straightforward statistical techniques applied to identical data sets. Replication of studies helps provide the additional research that can vet out any such areas of oversight.

The current research addresses the modality principle and its impact on the design of instruction. The modality principle states multimedia learning that utilizes narration of text versus visual on-screen text is more effective for transfer and retention of knowledge. This research study replicates the research conducted by Mayer and Moreno (1998) and Moreno (2006), referred here as the original study. The research questions were formulated to understand the modality principle for today's learners who experience a variety of media channels in online and blended learning. The questions are listed below.

1. Does the modality principle impact cognitive load and provide for schema development that allows for effective transfer and retention of knowledge?
2. Should words in a multimedia explanation be presented auditorily or visually to promote learning?

The following terms are addressed initially to guide understanding throughout this manuscript. These terms, when needed, and additional terms are addressed in closer context to their usage to provide ease of use for the reader.

- Modality Principle: The modality principle addresses the topic of how to effectively design online learning. The modality principle asserts presenting words as speech, rather on on-screen text is more effective for the learner. (Clark & Mayer, 2011). According to the modality principle, multimedia presentations should implement narration of words instead of using visual on-screen text.
- Cognitive Load: This is the effort necessary to cognitively address learning in the working memory. Cognitive load is comprised of two separate factors: extraneous cognitive load, which the instructor can manipulate, and intrinsic cognitive load over which the instructor has no control.
- Intrinsic Cognitive Load: This is the cognitive load, which is a constant for a given item. It is a basic component of the material. It is characterized by element interactivity, and the interactivity is fixed and cannot be reduced. It is considered as the inherent difficulty found with the content or item that is being addressed.

- Extraneous Cognitive Load: This is the cognitive load that occurs due to the mental activities that are required in order to process the content. Extraneous cognitive load is something, which the instructor can control. It is comprised of the instructional materials created by the instructor and when intrinsic cognitive load is high, extraneous cognitive load should be low.
- Germane Load: This is the conscious cognitive processing that is directly relevant to the construction of schemas. It is dedicated to the processing of information.
- Cognitive Theory of Multimedia Learning: This is the cognitive theory of multimedia learning developed by Richard Mayer (1997). It states learning, which includes words and graphics provides greater learning opportunities than text alone or graphics alone. It also states that learners gain more through relevant cognitive processes, and learners show deeper learning when provided graphics/images instead of text alone.
- Dual-Processing Theory: This is a theory that learning is more effective in multimedia environments where words and pictures are presented in separate modalities. When words are presented as pictures along with pictures, the visual working memory may overload and result in the learner not being able to select all the relevant information (Mayer & Moreno, 1998, p.318).
- Instructional design**:** This is development of content that effectively addresses the goal of the content through attention to such things as the needs of the intended audience, the mode of delivery, the cognitive load of the content, time constraints, financial constraints, and effective multimedia strategies that are based in theory and supported by best practices.

- Multimedia**:** This is the format that presents information through two or more types of media. This could be presenting information using text, animation, sound and images.
- Split-Attention**:** This is the effect that occurs when learner is required to split-attention between two items. For example, a learner views a page that has both a graphic and text information below the graph. The learner is required to split-attention to understand both of these items. A way to address split-attention would include implementing the modality principle.

1.2 Significance of the Study

Today students carry iPads, laptops, Notebooks, or other technology tools with them to class each day so they may engage in the classroom online learning environment. In these online learning environments, students encounter various multimedia formats that range from concept-mapping tools like Inspiration, graphing calculators, spreadsheets, digital movie tools, website creation tools like wiki, and importing images from a scanner into a PowerPoint presentation or Prezi presentation. Allen and Seaman (2009) stated there was no indication this trend of online learning was slowing down. They recorded "4.6 million students were taking at least one online course during the fall of 2008 term, a 17 percent increase over the number reported the previous year" (p. 1) (See Table 1.1). Allen and Seaman (2014) noted in that in 2002, less than one-half of all higher education institutions were claiming online learning was critical to their long-term strategy approach. In 2014, the proportion of institutions reporting online education is not critical to their long-term strategy dropped to a new low of 9.7 percent, and higher education students taking at least one online course in 2014 was at an all–time high of 33.5 percent.

Table 1.1

Total and Online Enrollment in Degree-Granting Postsecondary Institutions. Fall 2002 - Fall 2012.

	Total Enrollment	Annual Growth Rate Total Enrollment	Students Taking at Least One Online Course	Online Enrollment Increase over Previous Year	Annual Growth Rate Online Enrollment	Online Enrollment as a Percent of Total Enrollment
Fall 2002	16,611,710	NA	1,602,970	NA	NA	9.6%
Fall 2003	16,911,481	1.8%	1,971,397	368,427	23.0%	11.7%
Fall 2004	17,272,043	2.1%	2,329,783	358,386	18.2%	13.5%
Fall 2005	17,487,481	1.2%	3,180,050	850,267	36.5%	18.2%
Fall 2006	17,758,872	1.6%	3,488,381	308,331	9.7%	19.6%
Fall 2007	18,248,133	2.8%	3,938,111	449,730	12.9%	21.6%
Fall 2008	19,102,811	4.7%	4,606,353	668,242	16.9%	24.1%
Fall 2009	20,427,711	6.9%	5,579,022	972,669	21.1%	27.3%
Fall 2010	21,016,126	2.9%	6,142,280	563,258	10.1%	29.2%
Fall 2011	20,994,113	-0.1%	6,714,792	572,512	9.3%	32.0%
Fall 2012	21,253,086	1.2%	7,126,549	411,757	6.1%	33.5%

Note- Adapted from *Grade Change Tracking Online Education in the United States* by Allen, E., & Seaman, J., 2014, p. 15. Copyright 2014 by Babson Survey Research Group and Quahog Research Group, LLC.

These indications support the significance of providing effective online instructional design and effective multimedia formats. Developing best practices and finding tools that are anchored by theory and data to support the learners in these multimedia learning environments is necessary. One such tool that provides this effective guidance is the modality principle. The modality principle has shown its positive impact on online instructional design. It has provided the instructional designer the ability to develop free working load memory space for the learner, which in turn may enhance the learner's retention, matching, and transfer of knowledge. However, the research on the modality principle has been limited in the past 10 years. With the many changes that have occurred both in instructional design and with learners' knowledge regarding online learning, it is important to understand how the modality principle impacts the learning environment today. This knowledge will guide instructional designers and encourage best practices that will enable the learner to utilize, when productive, both the auditory and visual channels to avoid cognitive overload.

Narration of text is needed when it can enhance the learner's cognition, and studies have supported the modality principle's ability to do meet this objective. However, the conditions under which narration meets this criterion may not be as clear as once was held. Narration should not be employed when it becomes a distractor or provides unnecessary extraneous cognitive load. These instances take away from the learner's ability to effectively retain and transfer information. In conditions that do not support narration as a best practice, time, funds and development can be focused on such instructional items as motivation strategies and producing a cleaner and more effective end product for the learner.

CHAPTER 2

LITERATURE REVIEW

This chapter provides research on the positive impact the modality principle has made on instructional design for both the instructional designer and the learner. The modality principle can produce free working memory space and allows the instructional designer to create deeper learning through utilization of both processing channels, the auditory and visual. This advances more effective retention, transfer and recall of knowledge.

The chapter defines and discusses instructional design. It addresses how instructional design has changed during the increased demand of online instruction, and how this new demand has offered challenges as well as the opportunities to develop best practices and increase learner performance. Research is provided regarding the ever-increasing role instructional design plays in education and training and establishes the need for instructional design to adapt to meet the ever-changing learner as discussed by Prensky (2001). This discussion may help explain why instructional designers are often considered the facilitators of learning.

The chapter proceeds to address and provide common language around the modality principle. Definitions and a predominately chronological presentation of research, and discussions regarding memory, cognitive load, and the cognitive load theory develop and support the role of the modality principle as an effective instructional design tool. The cognitive load theory states some cognitive loads are high and some cognitive loads are low, and the learner's experience of these loads impacts the learning process. The modality principle allows for the learner to off-load high cognitive load by using both the visual and auditory modalities, and thereby increasing working memory space. This theory is accepted in this discussion and instructional design that is most successful utilizes this manipulation of cognitive load to provide the best learning opportunities for the participant.

The chapter continues with defining multimedia learning; a term that has become common place in today's educational environment. Multimedia learning involves delivering instructional content using multiple channels or modes. Among these channels are the auditory channel and the visual channel. The multimedia discussion is advanced through research and commentary regarding multimedia learning and the cognitive theory of multimedia learning (CTLM). Richard Mayer and Roxana Moreno provide specific research on the early stages of the multimedia format, especially that of the modality principle. Current research that supports, as well as questions some of the findings regarding the modality principle are included in this chapter.

2.1 Millennials and Digital Natives

Today's students are comprised of what some call the Millennials and Digital Natives. While no specific dates have been given for this Generation X group, and N-gen group respectively, the dates seem to fall from the early 1980s to the early 2000s. This group of students has been impacted by the advances of technology much in the same way as the generations before who experienced the development and use of such tools such as the phone, the radio and the television. However, the Millennials, seem to have experienced more technology tools coming into their learning environment than previous generations. New tools such as the computer, the laptop, the tablet and other digital technology tools that provide today's students with access to information at was seems like a couple of clicks. The rise in social networking platforms like MySpace, Facebook, LinkedIn, Twitter, Pinterest and others develops connections and pathways that earlier generations did not experience. In addition, the use of cell phones, iPads and iPods that incorporate such devices as ichat, snapchat, Instagram and others may be changing how this new generation learns. It is easy to wonder, is the advancements in technology changing how learning occurs? Dux et al (2006) noted that there is evidence showing benefits to greater connectivity, however, there are also downfalls. Dux et al. (2006) provide neuroscience evidence showing the human brain cannot effectively integrate multiple inputs at the same time (p. 1118).

This group of learner may also fall into the term Digital Natives as defined by Prensky in 2001. Digital Natives include students who have grown up with technology readily available to them and are native speakers of the digital language computers, video games and the Internet (Prensky, 2001). Prensky believes it is imperative for us to invent "Digital Native methodologies for all subjects, at all levels, using the students to guide us" (p. 4). This idea seems to be supported by Deal, Altman, and Rogelberg (2010) who expressed that while the millennial experience with technology is still under research and data is being gathered regarding the success of this group to multi-task effectively using various digital tools, one thing is evident- this group of learners has pinned, chatted, tweeted and posted more frequently than any before, and technology is impacting their processing and delivery of information. According to Oblinger (2003) the typical classroom lecture format of colleges and universities may no longer meet the need and expectations of students raised on the Internet and Interactive games .

2.2 Instructional Design and the Instructional Designer

Motivation, engagement, user-friendly materials, rigor, relevance, accessible content, diversification, and effective formative and summative assessments are some of the items found in instructional design. It includes the process of delivering content to meet the needs of the intended audience and is supported by best practices in learning and instructional theory that facilitate the transfer and retention of knowledge. There are many instructional design models with various approaches and some of the more well-known include the Dick and Carey (1996), Jerrold Kemp (1994), Rapid Prototyping (1993), and the Addie model (1980s) (Ryder, M., 2006). Current instructional design models are variations of the ADDIE model framework. It is a model that is learner-centered and provides a collaborative approach and involves an analysis phase, a design phase, a development phase, an implementation phase, and an evaluation phase as seen in Figure 2.2.

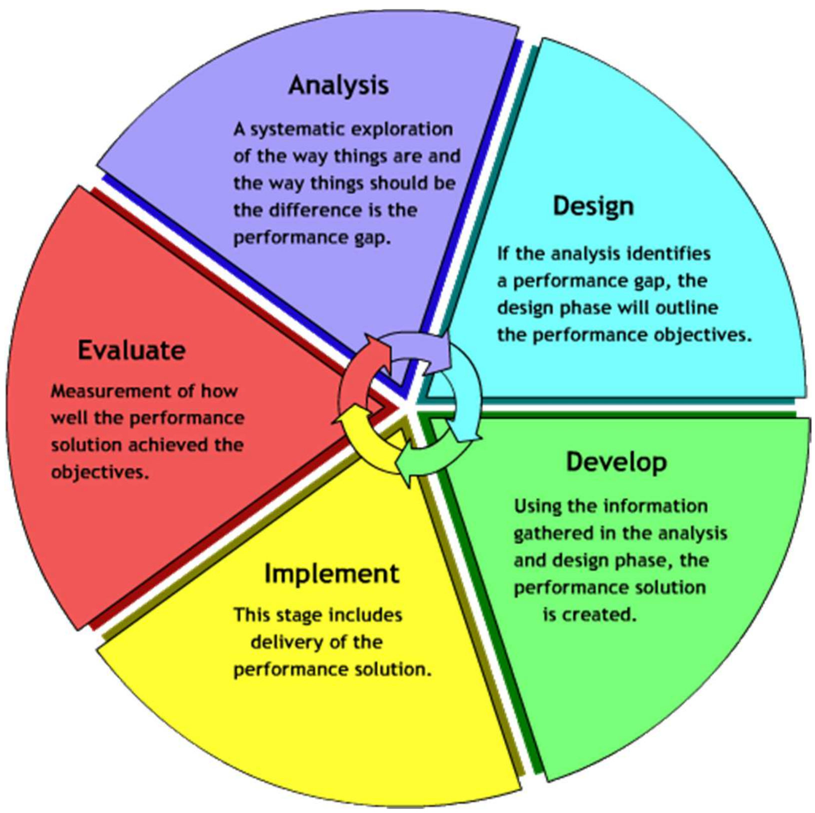

Figure 2.2 - ADDIE Model.
This image shows the interaction between the ADDIE elements.
Image retrieved at http://www.csuchico.edu/idts/img/addie.png

However, all the models have the same overall goal of providing the end-user with the most effective learning environment and best practice strategies. The instructional design process has been used by every instructor who designs a lesson, develops assignments, provides engagement, creates small group or large group work, and provides assessments. Specifically the instructional designer guides the learning process. The role of the instructional designer often begins with a needs assessment and identifies the intended audience and their needs as well so that this may guide the development. The designer then designs a curriculum often with the assistance of s subject matter expert, who can assist and provide specific content. The instructional designer will analyze the learning environment and the technology/tools that will best fit the learning environment and develop a design solution (Morrison, Ross & Kemp, 2011).

2.3 Modality Principle and Cognitive Load

Does the modality principle, which asserts narration is more effective than print text, assist the instructional designer in providing effective learning? Part of this answer lies in understanding the cognitive load of the content and how to engage the working memory in the process. The working memory plays a key role. Miller (1956) suggested the working memory has limits, 7 informational items plus or minus 2. It is easy to recognize that a learner will confront more than 7, plus or minus 2, informational elements, and therefore, it is equally understandable that the working memory is unable to handle all the items/elements of data that a learner confronts. Sweller (1999) addressed the ability of the working memory. He stated the working memory, with limited capacity, provides for 2 to 4 informational elements. This may appear to counter Miller's approach of 7 plus or minus 2 elements, but Sweller's discussion takes into account an understanding that the learner, while engaged in the learning process, is utilizing cognitive abilities, and therefore impacting the amount of cognitive abilities available to process items in the working memory. In addressing the question on how to assist a learner to transfer and retain knowledge, it is evident, cognitive resources are critical to the process.

Past research regarding the modality principle showed the modality principle as having the capability to lessen cognitive load. Wickens (1984) provided support for this understanding when he completed a study showing attention is more effective between eye and ear than between two auditory or two visual channels. Baddeley (1986) stated the working memory was similar to a visuospatial sketch pad and an audio loop. He went on to explain the dual-processing theory, which states these are two separate channels for organizing visual items and for organizing verbal items. These channels, while separate, do have connections between them. Clark and Paivio (1991) claimed cognitive connections could only be found if corresponding verbal and pictorial information is presented simultaneously in the working memory. This information meant the learner would either need to hold information in their working memory as they found and processed related information, which may cause cognitive overload, or they would engage in learning that provided simultaneously verbal information to the auditory channel, and pictorial information to the visual channel. Chandler and Sweller (1992) continued this discussion by completing a study showing that each of these channels, auditory and visual, have a limited capacity in connection with cognitive load theory. Utilizing these channels, to gain the most learning through least amount of space and without creating cognitive overload, would be a positive step for instructional design. Furthermore, the study showed students who utilized auditory and visual materials, even though they spent less time processing the instructions, scored significantly higher on tasks than their counterparts who utilized only visual. Penney (1989) experimented with presenting information in two different modalities. These experiments showed that when two tasks were presented concurrently, people did better if the tasks were presented in two different modalities. The mixed mode of presentation increased the amount processed by the working memory and supported the findings of earlier research.

Even with the above stated research, questions arose regarding these studies. Some of the questions involved the understanding of the working memory and the impact presentation speed had upon recall. A difference arose between to the two researchers Lieberman and Baddeley. Lieberman (1980) noted the idea of the working memory as a visuospatial sketch would infer that all spatial information was initially visual. However, blind people, Lieberman (1980) stated, have excellent spatial awareness and would not have any visual information. Regardless, of Lieberman's criticism, the idea of the dual processing theory continues today, and is considered a critical component of the modality principle.

Another question that was raised regarded the relationship between the presentation speed and serial recall. Penney (1989) noted the modality principle was not consistent depending on the presentation speed. Specifically the recall of auditory stimuli from short-term memory showed that rate either had no effect or a fast rate increased serial recall. Harskamp, Mayer and Suhre (2007) completed a study to verify the impact of the modality principle. They found the modality principle effective for students who required less time to learn. However, for students who required more time to learn, and were provided self-pacing presentations, the modality principle did not occur. This area of timing is one that is yet unresolved and requires additional research.

2.4 Increasing Working Memory Space

Instructional designers work as the architect of instruction. Their role includes focusing on the end-user by addressing what the look and feel, organization, functionality, accessibility, and overall design of the instruction contains. The instructional designer often works as the developer as well, and these additional roles include completing a needs assessment, task analysis, graphic layout, production of training materials and an evaluative tool like a context report. As the instructional designer begins course development, a key item is to provide the learner with the most effective instruction. Increasing the working memory's ability to process information is one of these effective strategies that allows for greater transfer and recall by providing the learner with free working memory space. This additional memory space is what enables the learner to work effectively, and creating this additional memory space directs future research of the modality principle.

To provide additional memory space, the working memory also relies on chunking individual items/elements or placing them into schema. As noted by Bartlett (1932) schema is where knowledge regarding subject matter is categorized. This categorization, which is created by the learner, impacts how this new information is to be experienced. Sweller (1994) provides an example of this process in his data analysis study. The topic of a tree is presented and explained detailing the fact that no tree is exactly like another tree. Yet, each tree is placed into a tree schema. If a person is asked to describe a tree, it is often not the particular tree elements that is described but instead elements that have been placed in the tree schema such as branches, leaves, bark, etc. This schema of trees allows a person to easily address the topic of trees, which has a vast amount of varying tree elements. Each part of the tree, such as a leaf, can be an element of its own. It can stand in isolation. However, the interactivity of the multiple elements, leaf, bark, branches, etc. create a schema that allows the learner to automatically know these items parts belong to a tree. Providing instructional design that recognizes the need to develop instruction supporting the user's current schema encourages a more efficient use of cognition and allows for a more fluid schema development.

Schema acquisition is not an automatic process. It occurs over time and experience with the items/elements. As acquisition of schema occurs and becomes more automated, the cognitive load to process related new information becomes less, freeing up cognitive resources. (van Merrienboer & Sweller, 2009). These items/elements can then be placed into long term memory which has a wealth of storage options. The modality principle can assist in providing space for this schema development and automation by freeing up working memory space which provides the learner with more freedom to associate content with current schema or build new schema.

Sweller (1994) states schema and automation are critical to the learning process. These enable the learner to build towards intellectual mastery. Sweller recognizes that the learner at times finds some material more difficult to learn than others, therefore impacting and slowing down the schema process and thereby impacting and complicating the automation process as well. It is important for instructional designers to assist learners in their transfer and retention of knowledge in these difficult learning environments. This includes developing instructional cognitive loads that have free working memory space for the learner. This free memory space enables the learner to make the necessary schema development and/or automation with current schema. In this development process, the instructional designer decreases extraneous cognitive load when able; provides prior knowledge links to assist in the automation process; and encourages the user to employ both their visual and auditory working memory to effectively utilize working memory.

2.5 A Closer Look at Cognitive Load

To understand how to provide this environment, a deeper conversation regarding cognitive load is needed. Cognitive load is the effort necessary to cognitively address learning in the working memory. Cognitive load is comprised of two separate factors: extraneous cognitive load, which the instructor can manipulate, and intrinsic cognitive load over which the instructor has no control. Cognitive load can also be classified as “high” or “low”. A high cognitive load has many interactive elements. For example, learning how to use commas may be considered as a high cognitive load. This is due to the fact that there are many different elements that need to be understood. Some of these elements include the following: subjects, verbs, appositives, dependent clauses, interjections, pauses, subordinate clause, and words in a series. All of these play a part in understanding when to use a comma, and each element can interact with other elements in various sentence structures. When a learner’s total cognition is reaching zero, due to both the visual and auditory channels having neared their capacity, the instructional load is labeled high cognitive load or cognitive overload. On the other hand, a low cognitive load has limited element interactivity. A low cognitive load might be learning the number one. This is considered a low cognitive load because the number one can be learned in isolation as has few interactive elements. This means when the total cognition of the learner is not reaching zero and the dual channels, the auditory and visual, are not near capacity, the learner has free cognitive space or a low cognitive load. This cognitive load can also be reached in a specific mode or channel. The auditory channel can be overloaded if there is too much auditory elements for the learner, and the same is true of the visual channel. If there are too many elements requiting visual attention, the learner’s visual channel can be overloaded and the learner’s cognition negatively impacted.

Does the modality principle impact cognitive load and enable free working memory space that provides for schema development, which allows for effective transfer and retention of knowledge? Controlled experiments completed by Mayer, Clark and Mayer (2011), as well as Mayer and Moreno (1998) utilizing multimedia and teaching scientific processes showed that if the learner’s attention (or central executive resources) is split between the need to hold words and pictures in visual working memory, there is little if any resources left to build connections. However, if the learner places visual text in visual memory and word text in auditory memory, the learner has greater ability to devote additional resources to creating connections.

With the recognition of low and high cognitive loads, it is also important for the instructional designer to have a deeper understanding of cognitive load. Two of the main types of cognitive load are intrinsic and extraneous. The first cognitive load to be addressed is intrinsic cognitive load, which is a constant for a given item. It is a basic component of the material. It is characterized by element interactivity, and the interactivity is fixed and cannot be reduced. This load is the inherent level of difficulty found within the content. The second cognitive load is extraneous cognitive load. Extraneous cognitive load occurs due to the mental activities that are required in order to process the content. Extraneous cognitive load is something, which the instructor can control. It is comprised of the instructional materials created by the instructor and when intrinsic cognitive load is high, extraneous cognitive load should be low.

The manipulation of cognitive load can be done by the instructional designer. This manipulation of content was addressed by Sweller (1988). He noted when intrinsic cognitive load is low, meaning there is little element interactivity, extraneous cognitive load may have no impact on instructional design. In fact, extraneous cognitive load may provide motivational aspects that increases the learner’s engagement with the content and possibly lead to deeper learning. This information supports the instructional designer’s need to be aware of the cognitive load of the content as well as the ability of the instructional designer to manipulate content to improve overall retention and transfer of knowledge. The instructional designer in these moments, can provide additional engagement through links, activities, surveys, or other enhanced learning items.

Sweller, van Meirrenboer and Paas (1998) extended the earlier findings on cognitive load theory and its impact on instructional design in their predominately qualitative research. The research addressed the effective use of long term memory and noted “working memory simply is incapable of highly complex interactions using novel (i.e., not previously stored in long term memory) elements” (p. 254). These findings somewhat mimic earlier findings regarding the working memory of seven items plus or minus two in that it helped create an understanding for instructional designers, it is imperative to help the learner to effectively build new schema but also to provide for fluid schema automation when able. This study reinforced the need to develop instruction that allows for the user to connect to prior knowledge, and provide learning that enables the user to have free cognitive load to devote to new instructional material. The modality principle and its connection to the dual processing theory recognize this need. The modality principle enables the instructional designer to create content that carries less cognitive load and provides for free cognitive space to attend to making new connections.

In addressing the need to meet provide appropriate levels of cognitive load, instructional techniques have shifted somewhat over the recent 10 years to identify instructional strategies that stimulate learners to invest cognitive resources in relevant activities of learning or germane cognitive load. Sweller, van Merrienboer, and Paas (1998) explain the use of cognitive load by referring to a paper that included working examples for students. Studies found that students often skipped these examples unless they needed to use them to solve the problem. However, if students were given questions that required them to think through the examples and process the information, this would build schema and fit the germane cognitive load (Perolli & Anderson, 1985); (Sweller et al., 1998); (van Merrienboer & Paas, 1990). These studies encouraged instructional design to provide content that engaged the learner. The modality principle allows for such engagement while making sure cognitive load is appropriate for understanding. In a multimedia online format, the modality principle might provide the worked examples as noted above as print text, and the screen may also have an animated problem that is narrated and requires the student to engage by responding to the problem by answering a question. In this design both the visual and auditory channels are used, and the germane load is engaged to develop schema.

Paas, Renkl, and Sweller (2003) added to the development of the impact of cognitive load, supporting Sweller's (1994) earlier findings. They discussed and provided current research on cognitive load theory and how it addressed new and sometimes counterintuitive instructional designs and procedures by cognitive load theorist. The important discussion focused on recognizing that cognitive load does not appear to be impacted by extraneous cognitive load when intrinsic load is low. Extraneous load does not detract from the learning process in these environments. This allows instructional designers to provide extraneous load for supportive purposes, visual engagement or navigational assistance without concern of cognitive overload for content that has low intrinsic cognitive load. Yet, when able, this extraneous load needs be extraneous germane cognitive load. Paas et al. (2003) included the idea of germane cognitive load enhancing the learning. It is the processing that is directly related to schema and acquisition of schema, as well as automation. Paas et al. (2003) explain that germane cognitive load does not take away from the working memory by creating a search but instead, germane cognitive load uses those resources to build schema acquisition and automation.

Laying the groundwork for the importance of schema development and automation, as well as noting the cognitive load implications involved with the content, bring us to deeper discussions regarding the modality principle. Research completed by Mousavil, Low, and

Sweller (1995) provided support for the modality principle. Their study involved 6 experiments presenting geometry worked examples in a partly auditory and partly visual mode that was completed on paper and utilized a tape recorded for the auditory elements. The study found that the learning of students was negatively impacted if the students were required to split their attention between multiple sources of information that then must be mentally integrated so to provide understanding. This was due to the need of the user to use working memory to integrate the knowledge. This depleted the working memory resources and did not allow the user the working memory resources necessary for schema acquisition or automation. The opposite was also shown. When the user was provided the information through two different modalities, visual and auditory, the split-attention that occurred earlier was negated. The researcher concluded that learners need both channels to provide deeper learning because both channels provide information concluded stating the results of the tests support using both the visual and auditory working memory channels may provide deeper learning because there are two channels holding the information. It also concluded the working memory can be increased by utilizing both the visual and auditory channels.

2.6 Multimedia Learning and the Modality Principle

With the technological advancement of the nearly past 15 years, instructional designers are working on providing effective instructional design in multimedia formats. Instructional design in these formats includes narration options, hyperlinks, video and streaming options, as well as animation of graphics and other visual content. Multimedia learning in general involves learning that is presented in two or more formats and includes words and pictures (Mayer, 1997). Multimedia formats aids the learner in understanding concepts through utilizing both words and images. Mayer’s research reflects higher learning scores from students who use multimedia formats than with those who do not, and show better transfer and retention of knowledge (Mayer & Moreno, 1998). These multimedia presentations coordinate the verbal narration with the nonverbal images and animations and place them on the computer screen for the user. The multimedia formats began with a focus on the technology tool that was being used to deliver the presentation. However, these presentations have recently shifted to become user-centered, and involve the intent to reduce extraneous cognitive load and/or provide free working memory space.

Mayer and Moreno (1998) recognized the complex issues involved with multimedia learning. Their research addressed the dual-processing theory. This theory incorporates two principles: split-attention, which refers to too many visuals on the screen which requires the student to split-attention amongst them, and modality. Their research included a study with 78 college students who were part of the psychology pool at the University of California, Santa Barbara. The study involved low-experience students with regard to meteorology knowledge. The study provided the students with an animation regarding the process of lightning. Nearly half of the students viewed the presentation that included onscreen print text. The other half, viewed the same animation, but the onscreen print text was narrated. The students where then given transfer and retention tests. The students who were provided the narration of the onscreen text, outscored the students who were not given narration of the onscreen text in both transfer and recall tests. Experiment Two involved 68 college students who were part of the psychology pool at the University of California, Santa Barbara. The students viewed an animation showing a car's braking system

Mayer and Moreno (2003) developed a framework for their discussion regarding cognitive load and multimedia as shown in Figure 2.6. They state pictorial and verbal material are processed by different systems and have limited data that can be processed at one time;

cognitive overload occurs in online learning; theory-based strategies can be implemented to address cognitive overload.

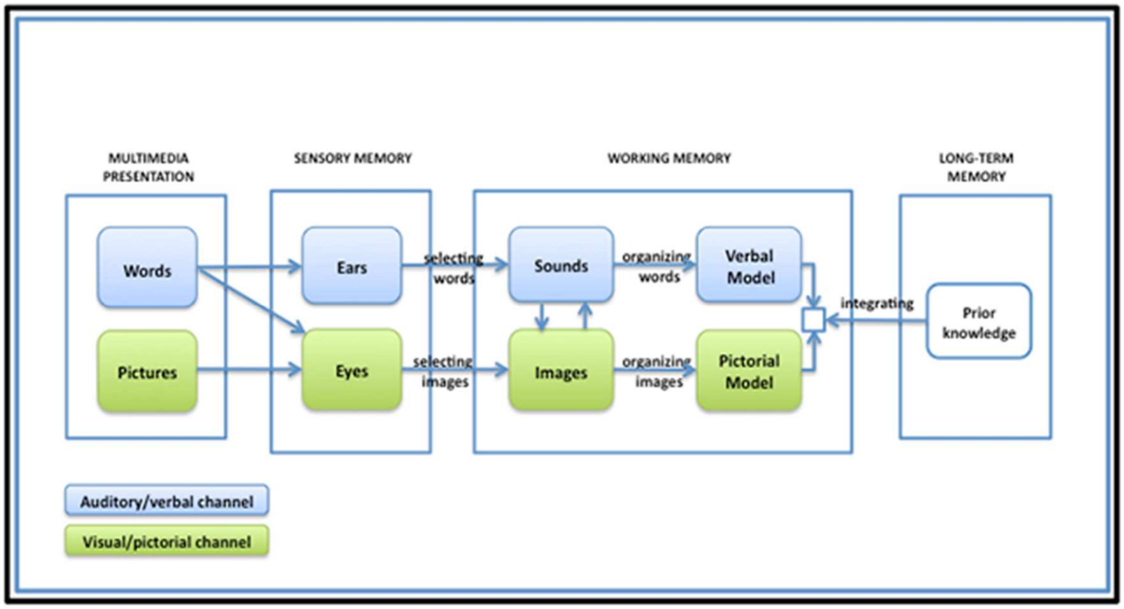

Figure 2.6. Cognitive Theory of Multimedia Learning.
This image shows process of the cognitive theory of multimedia learning.
"Cognitive Theory of Multimedia Learning," 2015. *Learning theories: cognitive theory of multimedia learning,* p. 1.

They proceed to address the instructional designers concern when presenting multimedia formats and the constraints that are placed on this instruction by cognitive load. They provide nine specific strategies that include off-loading, segmenting, pre-training, weeding, signaling, aligning words and pictures, eliminating redundancy, synchronizing, and individualizing. While these strategies have positive implications, it is apparent additional research is needed to further understand the full impact of such implementation. To address this concern, a closer look at the split-attention effect and its impact on off-loading and eliminating redundancy. Split-attention effect, as noted earlier, occurs when a learner's attention is split between two or more instructional items. These items could be a chart, a photo, descriptive text, or a hyperlink. In split-attention effect situations, the learner cannot view both items at the same time and therefore attention is split and creates cognitive overload (Sweller, 1994). Mayer and Moreno (2003) suggest off-loading one of the split-attention items to lessen the cognitive load. For instance, if a learner was looking at a chart on one page, and had to click to the next page to get the text description and additional details, the instructional designer may decrease the visual cognitive load by changing the textual information into narration, thereby moving the some of the visual cognitive load to auditory cognition, thereby employing the modality principle. The learner may also confront instruction that provides redundancy. While the approaches suggested by Mayer and Moreno seems effective, it is important to continue to investigate future studies and additional research.

2.7 The Redundancy Principle and Expertise Reversal

One such item is the redundancy effect. Redundancy is important element to discuss in relationship to the modality principle. Kalyuga, Chandler, Sweller (1999) completed a study that provided data showing auditory presentation of text was not beneficial when the text was presented in both the auditory and visual forms. In this situation, the visual form was redundant and created a cognitive overload. However, McNeill, Doolittle, and Hicks (2009) conducted a study to understand the impact of the modality principle in multimedia. This study found no significant differences between groups regarding the modality or the redundancy effects. These variations show the modality principle's impact may be changing from its earlier understandings, but the reason is unclear? Are there changes that are occurring with the learner that are impacting results? Is it possible that the more recent study reflects learners who are more experienced with online learning and narration and so were not as distracted by the redundancy of the material being presented in two formats?

Another important item to address is the expertise reversal effect. Kalyuga, Ayres, Chandler, and Sweller (2003) noted recent research that was indicating the level of expertise of the learner was impacting the effect of the modality principle and instructional design strategies overall. Kalyuga et al. (2003) reviewed empirical literature regarding this concern. He noted that within certain expertise groups, material became redundant, but the same material may be necessary for less knowledgeable learners and needed to be accessible. Unless the experience learners could skip this redundant information, it would pose as a distractor and would become an unnecessary load taking up working memory space that may be needed for other learning needs. These studies continually remind us of the importance of diversified instructional design and effective instructional design strategies.

2.8 Diversification

There are additional questions that arise regarding the modality principle. How does the modality principle impact learners with auditory difficulties, as well as learners who have strong visual learning behaviors? In addition, narration will increase the cost of instructional design. Will this impact the ability of educational and training companies to afford such a cost? Will instruction be limited and content be lessened in order to keep costs low? What other impacts would raising cost have on instructional content and design? Furthermore, careful instructional design will need to be in place to ensure narration, when used, enhances the visual experience and is not a distractor or provide redundancy of material. Additional modality implications follow.

Mayer and Sims (1994) conducted research that involved high- and low-spatial ability, the ability to understand and remember spatial relations among objects, for students who viewed a computer-generated animation. Two groups were formed. One group listened to simultaneous narration and the other group listened to successive narration. High spatial ability students replicated results shown by previous studies in that their scores were higher for the simultaneous narration than the successive narration. However, students with low-spatial ability needed to devote more cognitive resources to building connections, and they did not show a distinct difference between simultaneous narration or successive narration. This data seems to provide new questions on the modality principle's ability to effectively guide instruction for all users. Additional research regarding spatial ability is necessary.

An additional study by Yee, Hunt and Pellegrino (1991) noted that the ability to coordinate perceptual and verbal information was separate from the ability to deal with either perceptual or verbal information alone. Specifically, the difference that was produced between performance on easy and hard perceptual tasks was lessened when coordinating verbal tasks were present. Likewise, the differences between performance on easy and hard verbal tasks was reduced when a coordinating perceptual task was present. Again, additional research is needed to see if this data should impact instructional designer's use of the modality principle.

2.9 Current Research on the Modality Principle

Current research provides additional data to help understand the impact of cognitive load in a multimedia learning format and the outcomes that the modality principle can provide for the instructional designer. However, the research provides support for the modality principle within limitations. Studies providing supports are soon countered by additional studies that provide counter evidence. This certainly leads to questions, and if nothing more, it provides the context for future studies regarding the modality principle.

Tabbers (2002) and others questioned some of the earlier findings regarding the modality principle. Tabbers (2002) recognized that many of the studies were controlled, did not allow for user-pacing, were of shorter length, and the subject matter was scientific. Furthermore, Tabbers (2002) and others noted it is one thing to produce results in a lab like setting and quite another to produce the results in an actual classroom environment. Much of the research at this point had not addressed these concerns. However, empirical evidence of the modality effect has also been found in classroom settings with learner-paced instructions, utilizing longer amounts of time, and providing content that was not scientific in nature (e.g. Moreno, Mayer, Spires, & Lester, 2001; Mayer & Moreno, 2003; Mayer, Dow, & Mayer, 2003) also conducted a study. In this study, students viewed and answered questions about electric motors. The students were allowed to navigate through the content by clicking on various questions that were listed on the screen. Once they clicked on the question, the answer was revealed. The answers were presented in two ways: audio narration and printed text. The students who received the audio narration solved more problems on a subsequent problem-solving test. While these studies certainly have areas in which they contradict each other, it is evident the modality principle is something the needs further investigation.

Tabbers (2002) provided guidelines for future instructional design and research. These guidelines, These Guidelines are relevant today. The following is a list of the guidelines:

1. Get rid of redundant information – (However, this will depend on the goal of the instruction and whether redundancy is part of the memorization process being employed by the designer)
2. With system-paced instructions, use spoken text – (Unless your learners are experts on the topic in which this may cause the redundancy or expert-reversal effect)
3. With learner-paced instructions, use visual text – (Unless the learner is has reading difficulties and needs the narration for supportive purposes)

4. Prevent visual search – (Unless learning to navigate a map or other item is part of the learning process, and still visual cues to assist the user in understanding how to complete a visual search is suggested (p. 78-79)

van Merrienboer and Ayres (2005) address the high interactivity of elements within e-learning and other recent findings regarding cognitive load theory. In addressing the many parts of e-learning: hyperlinks, navigation tools, visuals, auditory, and text, the instructional designer may need to limit content to not create cognitive overload. van Merrienboer and Ayers discuss strategies that provide schema acquisition. These strategies included increasing the variability of practice and allowing students to manipulate the materials so as to actively engage with the material. Also, van Merrienboer and Ayers recognized the importance of utilizing narration to provide dual modalities that enable the learner to have free working memory space. The study also tested a simple to complex sequence of information as a possible way to control context for learners. This format, however, was not successful, and at times detrimental to the learning process.

Instructional designers can increase learning and schema acquisition by employing such strategies that enable the learner to manipulate the material and motivate the student, through mental interactivity. This can be done when information is presented in an effective manner utilizing the modality principle and thereby providing working memory space for the user to become engaged in the learning. Awareness of cognitive load and extraneous activities that may detract from the learning will also need to be taken into consideration, which may include limiting tools and providing variability of practice. Additional steps can also be taken to increase germane cognitive load. Paas and Van Gog (2006) who noted activities need to be on the appropriate level of difficulty for the learner and interest the learner so that the learner becomes engaged in the activity. While the information gained through these additional studies is promising, no conclusive evidence was provided for instructional effectiveness in terms of learning.

Moreno (2006) derives the modality principle from the cognitive-affective theory of learning with media (CATLM). Moreno explains the CATLM assumes dual channels for working memory, visual and auditory, limited capacity of the working memory as noted by Baddeley (1989) in explaining the visuospatial sketch pad and the auditory loop, and dual coding (Figure 2.3). This allows for expanded working memory capacity when the auditory channel is utilized to process onscreen text, and the visual working memory is utilized to process pictorial content. The instructional designer, in utilizing these ideas, can provide instruction that is not filled with unnecessary load and assist the learner in schema acquisition. The CATLM also assumes meaningful learning occurs with the following elements. While the modality principle is not directly related to these elements, it is through the use of the modality principle that these elements have more likelihood of coming into play. The elements include the learner consciously selecting, organizing and integrating new information with prior knowledge (Mayer & Moreno 2003), increasing motivation that is mediated through effective increasing and decreasing cognitive engagement (Gottfried 1990; Moreno *et al.* 2001), providing metacognitive mediation to regulate cognitive processing and affect, and providing for individual differences that will assist in connecting to prior knowledge and cognitive traits and learning styles.

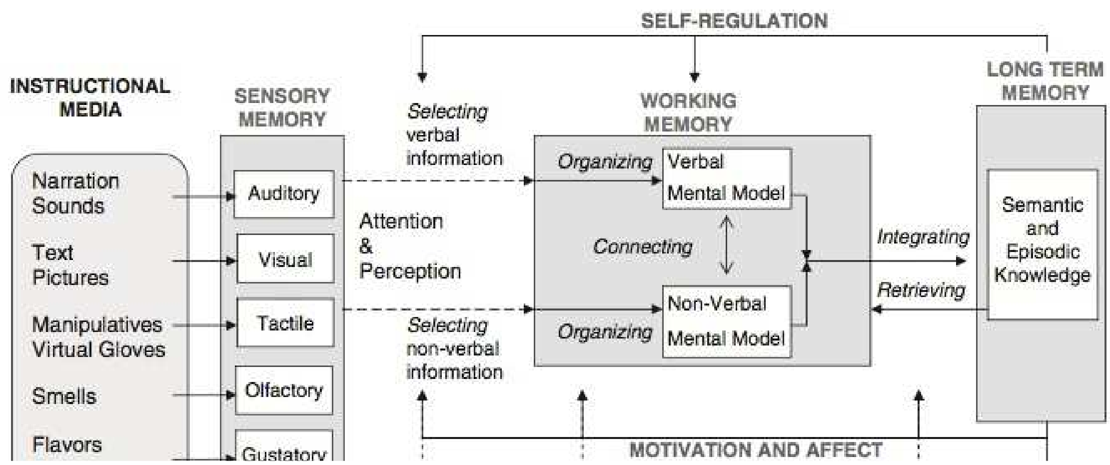

Figure 2.9. Cognitive-Affective Theory of Learning with Media (CATLM).
This figure shows the CATLM Process. Adapted from "Does the modality principle hold for different media? A test of the method-affects-learning hypothesis," by Moreno, R., 2006. *Journal of Computer Assisted Learning,* Vol. 22 (3) 149-158. Copyright 2006 by *Journal of Computer Assisted Learning.*

Moreno (2006) states that due to the sound cognitive research theory behind the modality principle, the instructional method it supports is effective for any type of media used to deliver the instruction. This is quite an advancement as initially the discussion regarding the effectiveness on multimedia instructional design was linked to the type of media. As noted early, this was part of the shift from the focus regarding the tool that delivered the instruction to a more user-centered approach.

As noted earlier, the modality principle is still a work in progress (Harskamp, Mayer, & Suhre, 2007; Cheon, Crooks & Chung, 2014). The following are more recent discussion regarding the modality principle. Stiller (2007) completed several investigations regarding the modality principle and prior knowledge. Stiller provided learner-paced instruction that was hierarchal in structure. The modality effect was found on structured knowledge. However, retention, transfer and labeling pictures was not affected, and the modality effect was not dependent on prior knowledge. These seem to counter the assumptions made by CATLM and requires additional research.

Ballantyne (2008) argued that the studies completed regarding the modality principle were quite narrow. He questioned their ability to impact broader, more realistic settings. Gall (2004) also noted that the controlled learning environment of many of the previous modality principle studies was not related to real-life situations. It is difficult to draw conclusions from such controlled settings that may or may not impact today's dynamic classrooms. De Jong (2010) criticized cognitive load theory's suggested guideline for instructional design. De Jong claimed the cognitive load theory lacked clarity about how the cognitive load worked. The biggest item of contention was intrinsic cognitive load. De Jong noted that due to the nature of intrinsic load, its interactivity is dependent on the load and not on the engagement by the learner. De Jong states intrinsic load's inclusion as a cognitive load is questionable. De Jong also argues that the types of loads are not as distinct as originally suggested (Moreno, 2010). Mayer (1997) noted high-experience students were less likely to exhibit the modality effect. Clark and Mayer (2011) noted the modality principle is likely to not apply in situations in which the text is long and complex, is not in the learner's native language, is presented at a slow rate and/or is paced by the learner.)

The recognition that cognitive load can be manipulated by the instructional designer in multimedia formats in encouraging. Paas, Renkl and Sweller (2004) continue to address cognitive load theory and the latest research. They note that earlier studies regarding cognitive load theory had been misinterpreted as stating, it is important to keep cognitive load low. Paas et al. (2004), explain that cognitive levels do not need to be low, but instead, should not be overloaded. The extraneous load should be low but the intrinsic and germane levels should be actively engaged in learning. This is a balance that requires attention to details that include keeping extraneous load low, when able, intrinsic load engaged but not too high and supporting germane load that helps the learner acquire schema and automation. This all needs to occur while keeping content relative and at times eliminating interacting elements with high intrinsic load.

Several recent studies suggest ways to impact cognitive load and provide more effective instructional design and processes that will enable the learner to retain, recall and transfer knowledge. Cheon, Crooks and Chung (2014) completed a study to assess the modality principle in relationship to segmenting principle which states providing animations in segments are more effective than continuous animations. Both the modality principle and the segmenting principle show the ability to lessen cognitive load and thereby provide the learner with free working memory space. The results of the study showed segmenting the animations provided learners with greater retention, recall, and transfer knowledge. When the modality principle and the segmenting principle were utilized together, the segmenting principle again showed greater retention, recall and transfer of knowledge. The modality principle showed no effect.

Fiorella, Vogel-Walcutt, and Schatz (2012) utilized the modality principle in several scenarios with real-time training. They created two groups. One group was given printed feedback. The other groups was given spoken feedback. In the first scenario, the results showed that performance training was more effective when feedback was spoken. In the second scenario regarding decision making application and transfer of knowledge, the spoken group also outperformed the print group. In the third scenario regarding paper-based knowledge tests, the feedback showed no modality effect on the acquisition of lower-level, general knowledge, but significant effect for procedural knowledge relevant to executing important tasks. It seems possible that these results could be reflecting redundancy principle regarding the no effect for general knowledge that the participants may already know, and the significant effect relates to new information or information they learner would deem necessary and therefore becomes more engaged in the learning process.

Summary

This chapter provided a review of selected, relevant modality principle research literature as it related to instructional design, cognitive load and the cognitive theory of multimedia design. The chapter presented currently available definitions regarding the modality principle, instructional design, and related information regarding cognitive load and cognitive theory of multimedia learning. This chapter also discussed research studies regarding the modality principle. The review of these studies and research reflect the need for future research regarding the impact of time, redundancy, expertise-reversal, learner's expertise regarding instructional content, learner's experience with multimedia and online learning, and testing environment.

To understand the role the modality principle a predominately chronological review of the research began with discussions regarding cognition, the process of learning and role the modality principle played in assisting the learner to utilize less cognitive load through instructional design engaging both modalities, the visual and the auditory. Background regarding cognitive load, intrinsic cognitive load, extraneous cognitive load, germane cognitive load and high or low cognitive load was discussed. This information developed the conversation regarding the modality principle's ability to provide free memory space, which is critical for the instructional designer as well as the learner. Some of the research discussed involved paper for visual text and audio was provided via a tape recorder or other audio device. The studies supported the modality principle showing stronger performance with retention and transfer of knowledge. Studies also implicated the modality principle as lessening the cognitive load.

The review continued with a discussion regarding the role the modality principle played in multimedia instructional design. The research showed the modality principle providing free memory working space to the learner and enabling the instructional designer to effectively manipulate some content to provide deeper learning. However, studies began to show reverse modality effects and brought questions into play regarding such things as the redundancy effect, the expertise reversal effect, the limited amount of studies that were real-classroom based, the understanding that low-knowledge learners did better if the pace of the instruction was under their control and even then, and complex learning was also better when under user control and at times without audio. In some of these studies, the audio actually worked as a distractor. The discussion arose regarding split-attention and how the modality principle could assist the learner in off-loading too much visual working memory onto the auditory working memory when narration was added. The modality effect was still having an overall positive effect on instructional design and for learners.

The review then moved into current research and questions surrounding the modality principle. These studies both supported earlier findings, and at the same time, contradicted earlier findings. Questions about the length of the narration, the complexity of the content, the expertise of the learner, the sequencing of the animations, and the ability of the user to control the pace of the presentation arose. Moreno (2006) introduced CATLM and its implications on instructional design the modality principle. CATLM, while providing great groundwork, Stiller and others provided research that countered some of its claims. Additional research continued to discuss the need for real-classroom situations that can provide accurate implementation of the modality principle and thereby give more accurate results. Research provided questions regarding expertise reversal and the need for learners to have control over the pace of complex instruction. Motivation needs and links to prior knowledge were also brought into discussion. The modality principle, along with cognitive load and the cognitive theory of multimedia learning have many unresolved issues. This study will address some of these concerns.

CHAPTER 3

METHODOLOGY

This chapter presents the methodology that guided this research study. This methodology when able, replicates the methodology used by Moreno (2006), which is the same methodology used by Mayer and Moreno (1998). Mayer and Moreno (1998) analyzed participants' knowledge regarding meteorology through randomly splitting participants into two groups and providing each group with a different PowerPoint presentation format with the same material, one format specifically included narration, the other format did not. The Mayer and Moreno study (1998) used low-experienced participants identified through a pre-survey, as stated earlier, an animated PowerPoint presentation that had two formats, one with narration, used with the AN group, and one without narration, used with the AT group, followed by three different sets of questions to assess retention, matching, and transfer of knowledge. The study results were analyzed using One-Way ANOVA tests indicated that narration fostered higher retention, matching, and transfer of information.

The current study replicates many of these same items completed by Mayer and Moreno (1998) to ascertain the impact of words on today's leaners in a multimedia experience that are either presented visually or auditorily content to promote deep learning. The goals of this study include the following:

- To assure the original study's results as well the scores found on this study are reliable and valid.
- To apply the previous results to new situations such as an online learning environment or a typical classroom setting versus a lab-like setting.
- To guide new research combing previous findings from related studies.

The methodology addresses four areas. The first area regards the participants and the testing environment in which the research was completed. This study's participants are similar to the original study in that this study's participants are low-experienced learners on the topic of meteorology and are randomly placed into two groups. However, this study differs from the original study's participants by the mere fact that today's participants have greater exposure to online learning, especially narrated online learning. In addition, the environment in this study differs from the original study in that it took the participants from the lab-like setting used in the original study, and placed the participants in a classroom-testing environment.

The second area explains the materials used for the study. This study includes the original study's pre-survey questions which addresses their knowledge about weather without specific reference to lightning and utilizes a similar scoring technique. This study also uses a replication of the original study's PowerPoint presentations focused on the content explaining how lightning occurs (APPENDIX A) and implements the same questions and scoring techniques for the retention, matching and transfer of knowledge questions that follow the participants viewing PowerPoint presentation. These noted items were changed very little to assist in assuring similar levels of difficulty for both the participants in the original study as well as those in the current study. Furthermore, keeping these items similar to the original study assists in helping for the control scoring difference that may occur due to changing topics or question formats..

The third area describes the research procedures used to conduct the study. These procedures cover the necessary steps to replicate this study. These steps begin with the items and research needed to complete prior to the study, items to address in order to receive permission to perform the study, as well as the necessary steps and procedures needed to continue to research and implement the study.

The fourth area includes the data analysis tools used to ascertain if the results of the Mayer and Moreno (1998) can be replicated in a classroom-testing environment and with today's learners who have greater exposure to online learning, especially narrated online learning environments.

3.1 Participants and Research Design

The participants included seventy-nine, undergraduate university students at a large Midwestern research university. The students ranged from college freshmen to college juniors. These students were pursuing an education major and were all enrolled in an introductory educational technology course. It was assumed that these students fit predominately into the Digital Native category and were therefore experienced online learners who utilize multimedia learning on weekly basis for their current studies. Many of these students most likely use learning technologies on a daily basis. Therefore, due the advancement of education technologies over the past fifteen years, these participants, in comparison to the original study's participants, would have greater experienced with online learning as well as narrated online learning. All of the participants expressed minimal meteorology knowledge as was assessed by the pre-survey and were included in the study because they are low-experience learners showing little knowledge of the topic of the study, meteorology. The participants were randomly paced into two groups that attempted to provide the most "typical" classroom environment for this process. The process provided open-seating and used the natural middle aisle, which nearly equally divided the class into two equal halves, to separate the participants into the two groups. The two groups were the AN group (the group who viewed Animation with Narration), comprised of 36 participants, and AT group (the group who viewed Animation without just the onscreen Text), comprised of 42 participants.

In addition, the week prior to the study, the participants' instructor informed the participants of the study and the process. The instructor also informed the participants that if they partook in completing the study items, they would receive 10 extra-credit points. The instructor included the details of timing for the study, approximately 20 minutes in total for the study itself, and also included that the extra-credit points were not contingent upon participation in the study itself or the completion of each question.

The participants completed the assessment items in their regular classroom environment. This environment included a stadium-seating format for approximately one hundred students. The classroom had a large desk, podium, pull-down screen, projector and computer in the front. It had two main seating areas divided by a large middle aisle, and two aisles also on both the far right and far left of the room. The participants sat in chairs that had an arm desk, and while there were approximately 20 open seats, these seats tended to be on the outer-right or outer-left side of the two main seating areas. This classroom was large and was somewhat isolated from the other classroom and so outside distractions were not noticed. Two doors were located on the left and right side of the classroom, and these doors were shut during the majority of the study.

3.2 Materials

The participants utilized two different types of materials: technology and paper and pencil. The technology tools included PC laptops, Mac laptops, iPads and other technology devices that could have access to the pre-survey and the online animation discussing lightning. The paper and pencil items included three pre-surveys for students who chose to complete the pre-survey on paper due to these participants experiencing technology difficulties, the one page retention test, the four-page transfer test, and the one page matching test.

Technology Tools: 20 PC laptops and 10 Mac laptops with compatible headphones were provided for the students. However, participants were encouraged to use their own technology device as long as it had internet access and PowerPoint 2007 or more recent, as well as their own compatible headphones. This was to provide the students with ease of use and allow for less time being consumed through handing out and collecting of technology tools both before and after assessments. The rest of the participants utilized their own technology tool. URL links for both the pre-survey and the animation of lightning were provided for the participants. (Paper was available for any participant who preferred to take the survey on paper. Three participants chose the paper alternative for the pre-survey.)

Pre-Survey: The participants were provided a URL address and/or a link to locate the pre-survey that was created on *Qualtrics*, which is a free software that provides online survey options that are user-friendly and provides real-time results. *Qualtrics* provides various data collection options, which include itemized results, overall results, tendencies, and other statistical analysis which were important to allow for easy analysis of the participants. The pre-survey questions replicated those used by Mayer and Moreno (1998) (See APPENDIX B). The first question asked the student to select their gender from the following options: female, male, and other. The next seven questions covered meteorology without specific references to lightning and provided the participants with a five-item self-rating scale. The self-rating scale asked the student to rate their knowledge regarding weather by clicking on the following choices: "very little," "between very little and average," "average," "between average and very much," or "very much."

The seven questions on the pre-survey included the following: "Please click the item that most reflects how often you read weather maps;" "Please click the item that most reflects your knowledge of cold fronts;" "Please click the item that best reflects the following statement: I can distinguish between cumulus and nimbus clouds;" "Please click the item that best reflects the following statement: I know what a low pressure is;" "Please click the item that best reflects the following statement: I can explain what makes the wind blow;" "Please click the item that best reflects the following statement: I know what this symbol means (symbol of cold front);" and "Please click on the item that best reflects the following statement: I know what this symbol means (symbol of a warm front)" (p. 314).

The PowerPoint presentation animation: The animation was an online, animated PowerPoint presentation. The PowerPoint presentation consisted of sixteen animated slides depicting lightning. Specifically, "the animation depicted air moving from the ocean to the land, water vapor condensing to form a cloud, the rising of the cloud beyond the freezing level, the formation of crystals in the cloud, the movement of updrafts and downdrafts, the building of electrical charges within the cloud, the division of positive and negative charges, the traveling of a negative stepped leader from the cloud to the ground, the traveling of a positive stepped leader from the ground to the cloud, the negative charges following the path to the ground, the meeting of the negative leader with the positive leader, and the positive charges following the path towards the cloud" (Mayer & Moreno, 1998, p. 315). The AN version also included concurrent narration reading the on-screen text in words spoken at a slow rate by a female voice. The AT version included concurrent text presented on the screen using the same words and similar timing as the AN narration. The multimedia animations were developed using audio talent who used the PowerPoint media, record audio option. The sampling of Lighting PowerPoint slides, Figure 3.2, presents selected frames from the animation.

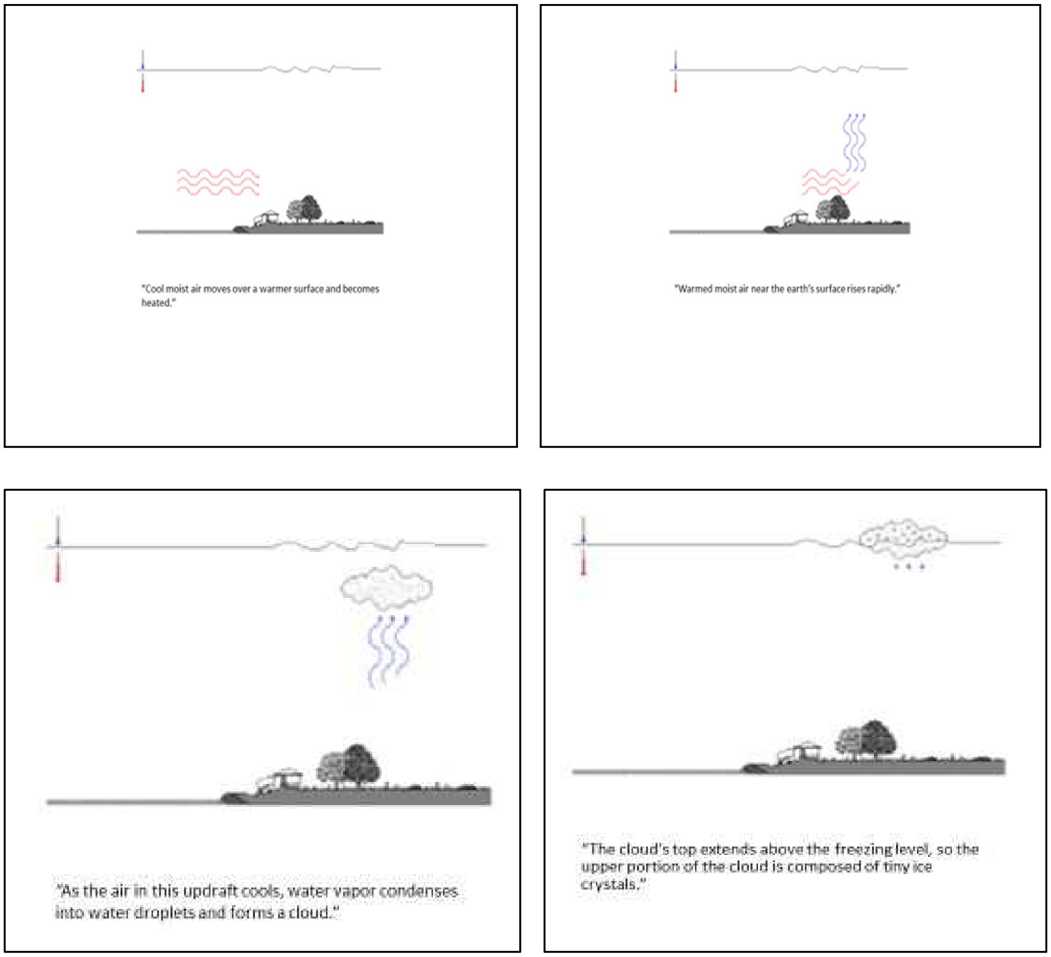

Figure 3.2. Sample of PowerPoint Slides
These figures show what students viewed.

Paper and Pencil: The paper and pencil items involved the pre-survey, the retention test, the four-page transfer test, and the matching test. The pre-survey was printed on two 8.5 x 11 (21.59 x 27.94 cm) sheets of paper (APPENDIX B). The pre-survey included the same testing questions as the original study but did allow students to access and complete the pre-survey online if they chose to do so. Only three students took the paper format of the pre-survey.

Pre-survey test: The pre-survey was completed by three participants on paper. The test consisted of seven questions regarding the participant's knowledge of weather. The only difference between the online version and the paper version was the change in the word "click" for online, to "choose" for the paper format. Samples of the questions include the following:

"Please choose the item that best reflects the following statement: I can explain what makes the wind blow;" (See APPENDIX B).

The Retention Test and Transfer Test formats: The retention test and each of the four items of the transfer test were printed on 8.5 x 11 in. (21.59 x 27.94 cm) sheets of paper. The retention test and the transfer test materials were identical to the items used in the previous study (See APPENDIX C and APPENDIX D). The matching test contained one 8.5 x 11 in. (21.59 x 27.94 cm) sheet of paper (See APPENDIX E). The matching test placed all four images from the PowerPoint presentation onto one sheet of paper. This was a change from the previous study, which had provided each image on a separate sheet of paper. However, the images were clear and easy to work with when combined on the same sheet of paper. In addition, there was enough space on the paper for labeling. This allowed the participants to have all four visuals readily available to limit distractions.

Retention Test: The retention test stated the following at top of the sheet of paper: "Please write down an explanation of how lightning works."

Transfer Test: The transfer test consisted of the following four questions, each typed on a separate sheet of paper:

1. "What could you do to decrease the intensity of lightning?"
2. "Suppose you see clouds in the sky, but no lightning. Why not?"
3. "What does air temperature have to do with lightning?"
4. "What causes lightning?"

The extra space on the paper allowed the participants to have enough space to write or draw an explanation if desired.

Matching Test: The matching test presented four frames from the animation. The four frames were placed together on one sheet of paper. The following instructions were placed on at the top of the first sheet of paper. "Circle cool moist air and write C next to it. Circle the warmer surface and write W next to it. Circle the updraft and write U next to it. Circle the freezing level and write F next to it. Circle the downdraft and write D next to it. Circle the gusts of cool wind and write G next to it. Circle the stepped leader and write S next to it. Circle the return stroke and write R next to it."

3.3 Research Procedures

The study began with the researcher completing a training course entitled, "Protecting Human Research Participants." At the same time, contact was made with the researchers from the original studies, and permission was granted to replicate the studies, and the original PowerPoint that was implemented in the initial study was shared. This was followed by completing the exempt-study form for the IRB (APPENDIX F). One of the key items in the exempt-study form was the participants section. It was necessary to differ from the previous studies to assess the viability of the modality principle for today's learners. The participants needed to be from a different background than those used in the previous study. Because of the advancement of technology in the past 20 years, and its frequent use in the classroom, the participants (undergraduate students at a large research university) would be more experienced with online learning tools, multimedia formats, and the use of narration in general. This study also wanted to address the concern of the previous study which some argued was not applicable because it had not been representative of a typical classroom environment. The previous study had taken 1 to 5 participants per session. Each participant sat in a separate cubicle and completed the process using a desk top computer. Each participant was randomly assigned to either group AN or group AT. To find participants for this study, several professors were contacted to check for participants' availability, as well as the classroom environment, and the number of possible participants. After several discussion, the participant groups was found. The study included 79 education majors. It was completed in the students' classroom, which they used on a weekly basis. The classroom was comprised of individual stadium seats that included an arm/desk. The participants were able to utilize their own technology device provided it allowed them to use the internet and had access to PowerPoint that was at least 2007, or were provided a laptop. Participants who were part of the AN group were also provided with compatible headphones as needed.

PowerPoint Replication: Upon completion of the exempt-study form and following approval from the University IRB, replication of the PowerPoint presentation that was used in the original studies was completed using PowerPoint 2007. In fact, two PowerPoints presentations were made. The first PowerPoint presentation that was made was to be used by the AN group. This PowerPoint presentation utilized the PowerPoint slides that were used in the original study and copied the items to the newer 2007 version. However, the original PowerPoint presentation that was provided did not include the original audio. Therefore, audio talent recorded the on-screen text by using the PowerPoint, media, record audio option. The second PowerPoint presentation was made using the original PowerPoint slides as well and copying the slides to a 2007 version. Copies of the PowerPoint presentations were sent, along with the question items, to the cooperating instructor and teaching assistants.

The final step was contacting the technology center located in the University's School of Education to secure additional laptops and the headphones for participants who chose not to use their own technology devices. Additionally, the laptops were checked to make sure they had internet access, were equipped with PowerPoint 2007 or newer, and that the laptops and headphones that could be transported to the classroom location being utilized for the study on the given date/s.

One week prior to the study, the cooperating instructor informed the participants of the opportunity to participate in the study, which would follow their regularly scheduled class. The cooperating teacher also provided the opportunity for anyone who attempted the study to receive 10 extra-credit points. The total points for the course was 1400. A variety of extra-credit opportunities ranging from 10 to 50 points had been provided to the participants throughout the course, and these 10 points are on the low end of the extra-credit scale. Room availability, laptops and headphones pickup were confirmed again to insure all items were set.

The day of the study began with locating the classroom and securing and transporting the laptops and headphones from the School of Education's technology center to the classroom. Once the classroom instruction was completed, by the cooperating teacher, a brief introduction was given to the participants explaining the process of the study which included taking a pre-survey, giving several directions, viewing an animated PowerPoint presentation, and completing transfer, recall and retention questions. The participants who needed a laptop were instructed to come to the front of the room where a laptop and headphones, if needed, was provided. After the distribution of the technology tools, the participants were provided with oral instructions stating they should use the URL that was projected on the screen at the front of the room. This URL would take them to the pre-survey. If they would rather complete the pre-survey on paper, they could raise their hand and a paper pre-survey would be brought to them. The participants were instructed to complete the survey and when done, close their laptop or turn-over their technology device on their desk to indicate their completion. If the participant took the paper version, they should raise their hand when they completed the pre-survey and a teacher assistant would pick it up. During the survey several teacher assistants walked around verifying student progress.

Once all participants had completed the pre-survey, the following oral directions were given as teacher assistants continued walking around the classroom. “Teacher assistants are walking around the room to provide assistance as needed and allowed. Please feel free to raise your hand to call them to your seat for any questions you may have. Projected on the screen in the front of the room are the directions for today as well as the URL links that will provide the animated PowerPoint regarding the process of lightning (APPENDIX E). Please notice the arrows that show which side of the room will be designated the left side of the room and which side of the room will be designated the right side of the room. Groups will be established by using the center aisle as a dividing line. The group on the right, the AT group, will have animation and on-screen text. The group on the right side of the room will not have audio. Everyone on the right side of the room please place your headphones under your seat. The other group on the left side of the room, the AN group, will have the animation, on-screen text, and audio. Therefore, the group on the left side of the room will have audio, and will need headphones. Does anyone on the left side of the room need headphones? Are there any questions at this point?

The oral directions continued. Before accessing the PowerPoint presentation, the following directions will be important for you to know. When you have completed viewing the animated PowerPoint presentation, close your laptop or turn-over you technology tool on your desk. Please raise your hand. A teacher assistant will bring you the test questions and will ask you to label your test with either the word “audio,” indicating you were in the AN group, or the words “no audio,” indicating you were in the AT group. You will then be given the following test items. A retention question which is on the first page, transfer questions which are on the following pages and are presented one question per page, followed by matching questions which are on one page. The test questions are not timed. Please follow the directions for each of the questions, and raise your hand if you have any questions.

When you have completed the test questions, please bring your test items to the desk at the front of the room. Two spaces have been set up. One space for the audio test groups’ packets, and another space for the no audio test groups’ packets. An assistant will be in the area to help you place your packet in the right space. If you borrowed a laptop and/or headphones, please return those after dropping off your packet.

Please know this is a testing environment so you will need to be quiet and proceed with normal testing processes that your instructor has in place for such times. Are there any questions? Again, the directions are projected on the screen in the front of the room. Please use the URL link that is needed for your group and begin the study. Are there any questions? Please begin. Once the directions were given, the teacher assistants and I walked around the room to verify student progress, answer any questions about the process, and provide question packets as participants completed viewing the animation and had either closed the laptop or turned-over their technology device on their desk.

3.4 Scoring the Test Items

To score the items the following process was used, and when able followed the same process put in place by the original study (Mayer & Moreno, 1998). The scorer who scored each test item was not aware of the testing conditions.

Pre-survey Score- On the pre-survey, the first item showed gender numbers. The following 7 questions were scored as follows. Each question had 5-item multiple choice answers. Points were awarded for the multiple choice answers: very little was given a score of 0, between very little and average was given a score of 1, average was given a score of 2, between average and very much was given a score of 3, and very much was given a score of 4. This gave a total points possible as 28. An average score was reached by dividing the number of points received by the number of points possible. The percentage for each participant was acquired to assess if they were a low-experience learner. Table 3.1 shows the generally accepted United States grading scale for universities and colleges.

Table 3.1
General USA University Grading Scale

Grade	Grade Point	Percentage of Marks
A	4.0	93% and above
A-	3.670	87-92.9%
B+	3.330	84-86.9%
B	3.0	80-83.9%
B-	2.670	77-79.9%
C+	2.330	74-76.9%
C	2.000	70-73.9%
C-	1.670	67-69.9%
D+	1.330	65-66.9%
D	1.000	62-64.9%
D-	.670	59-61.9%
F	0.000	<59%

Note: Adapted from “How is GPA computed in US schools? GPA Computation formula?” by Kumar, 2014, *RedBus2US.com*. Copyright 2014 by RedBus2US.

Using the Table 3.1, the current study chose to utilize anyone that scored <59% as a low-experience scorer.

A scorer that was not aware of the testing conditions was used to assess the responses of the students. The scorer has over 15 years of teaching experience, has acquired a master's degree in the field of science, has obtained an administration degree and has developed and assessed formative and summative assessments for over 15 years as well. For this data collection, the scorer was given a rubric to assist in the assessment process and the answer key that was used in the original study. Several sample tests were used by both the scorer and the researcher to compare results and establish a baseline.

Retention Score- The retention score was acquired by awarding one point for each one of the eight major idea units that the participant produced. There were a total of eight points possible. One point was awarded for stating one of the following eight units regardless of wording: "(a) air rises, (b) water condenses, (c) water and crystals fall, (d) wind is dragged downward, (e) negative charges fall to the bottom of the cloud, (f) the leaders meet, (g) negative charges rush down, (h) positive charges rush up" (Mayer & Moreno, 1998, p. 315).

Transfer Score-The transfer test score was computed by counting the number of correct responses, out of 12 possible, that the participant provided across the four transfer problems. The following provided direction on acceptable answers and were utilized in the original study.

> "(T)he first question about decreasing lightning intensity included removing positive ions from the ground; acceptable answers for the second question about the reason for the presence clouds without lightning included stating that the tops of the clouds might not be high enough to freeze; acceptable answers for the third question about temperature's relation to lightning included stating that the air must

be cooler than the ground; acceptable answers for the fourth question about the causes of lightning included the difference in electrical charges in the cloud. Participants received no more than three points per problem" (p. 315).

The matching score was acquired by counting the correctly labeled elements, out of eight possible, that the participant provided. The participants were awarded one point for each part that was circled and labeled with the correct letter.

CHAPTER 4

DATA ANALYSIS & RESULTS

This chapter provides the data analysis and results of this study. The data were collected and analyzed to produce responses to the research questions posed in chapter 1. The questions included the following:

1. Does the modality principle impact cognitive load and provide for schema development that allows for effective transfer and retention of knowledge?
2. Should words in a multimedia explanation be presented auditorily or visually to promote learning?
3. Does the increased experience of the learner with technology and multimedia impact the effect of the modality principle?

These questions include several fundamental goals that drove the collection of the data and the subsequent data analysis. The goals encompass responding to research regarding the modality principle which have begun to suggest that the modality effect is impacting instructional design differently than had it has in the past (Tabbers, 2002; Mayer & Moreno, 2003). This important research addressed in Chapter 2 has qualified certain parameters of the modality principle. Studies showing the length of the narration, the level of knowledge of the participant, participant self-pacing, and the effects of scaffolding are providing different learner results than originally assessed by Mayer and Moreno (1998). These new results dramatically impact instructional design, requiring new techniques to address how to provide best practices that free working memory and build schema for the learner. This study's collected data and analysis could either assert the original findings, narration of text is more effective than onscreen text, or provide results that show the modality principle, while still important, is no longer impacting learning in the same way as it had nearly fifteen years ago, and therefore additional research is needed.

The collected data and the analysis in this study also develops a common language around the modality principle and brings to the table both the past research and current research to broaden understandings. This allows for a knowledgeable discussion, which recognizes the participants of today vary from the learners from a decade ago. Today's learners have been exposed to a variety of multimedia experiences and especially are more frequent users of narrated multimedia than the participants of the original study (Moreno, 1998). Many, face-to-face, online and blended lessons use a variety of technologies and media formats to support learning such as VoiceThread, LMS, discussion forums, wikis, and other technology tools. In addition, the leaners of the current study were placed in a different environment than the original study. The original study's process included testing in groups of one to five participants at each session, and each participant was seated at an individual cubicle in front of a computer (Mayer & Moreno, 1998). The current study's process involved testing the learners in their classroom (natural setting) in opposition to a laboratory environment. It is also important to note that current research on the modality principle is limited, and with continual increase in technology in the field of education, it seems pertinent to further study the implications of the modality principle to ensure best practices are being put into place.

4.1 Pre-Survey Data Analysis & Results

The first area in which data were collected was the pre-survey. The pre-survey was given to the seventy-nine participants who stayed after class to complete the survey. The data was collected using *Qualtrics*. This tool allows data to be collected anonymously via an online survey and provides a quick analysis of data. The first question on the survey asked the participants to indicate gender. The data showed thirty participants were male, and forty-nine were female.

The next seven questions addressed the topic of meteorology. This study did differ from the original studies scoring method. In order to capture the results that would relate to today's participants, this study used the accepted scoring percentages for universities and colleges in the United States. The generally acceptable passing score is 60% and above. This study set the low-experience learner as those who scored below that 60% passing grade. In this study all participants fell into the low-experience range scoring 15 or below on the 28 point pre-survey. The median score was 9, and the average score was 9.075. Mayer and Moreno (1999) recognized if presenting verbal information in an auditory mode allows students to increase their effective working memory capacity, low-experience students who lack a mental model for the instructional material would be the ones to benefit the most from having more cognitive resources available (e.g., narration). This would infer data results for low-experience learners should show the modality effect.

It is interesting to note that on the pre-survey many of the participants, over 50%, scored high on the last two questions of the pre-survey. These two questions asked the participant to correctly recognize the meteorological symbols of a cold and warm front.

4.2 Overall Picture of Data Analyzed

Following the pre-survey, the participants viewed the PowerPoint presentation over lightning and replied to three different types of questions: retention, transfer and matching. The data was collected on paper and scored. Below are the overall results. These results give a general picture of each group and how each group performed. It is easy to note that the AN group (the group with narrated audio) did not perform as well on the retention test as the AT group (the group without narrated audio). Likewise, Table 4.1 shows the AN group not performing as well on the transfer test as the AT group. Finally the Table 3 results also displays the AN group not doing as well on the matching test as the AT group.

Table 4.1
Data for Question Type, Number of Questions, and Number of Participants Per Group.

Data Collected Following PowerPoint presentation			
Question Type	Total Points for the Question/s	Audio Group AN 36 Participants Correct Answers	No Audio Group AT 43 Participants Correct Answers
Retention Question	8	61	121
Transfer Questions	12	101	213
Matching	8	101	165

Note. No audio group outperformed audio group in all areas.

4.3 Reliability Analysis

When completing a study it is important to verify the reliability of the study to insure the test is measuring what is intended. This study replicated a study completed nearly 15 years ago. Therefore the questions that were generated in the original study may no longer show internal consistency? To address this concern a Cronbach's Alpha was calculated. The objective was to measure the variability amongst the scores generated by the questions. While there was only one test given, the tests were given in response to two different viewings. This of course does not change the questions, but it may change the way the questions are experienced. With this in mind, two Cronbach's Alpha analyses were completed. One was completed with the AN (animation and audio group), and one was completed with the AT (animation with text group). The reliability coefficient, the Cronbach's Alpha, which is considered acceptable is 0.70. It is also accepted knowledge that the more questions and the more participants, the more reliable the test. Because both of the two tests were done separately they used lower participant numbers and the number of questions were also on the low scale.

The AN group scores showed an acceptable score in the Cronbach's Alpha Based on Standardized Items of 0.752. The Cronbach's Alpha fell just short of the 0.70 at 0.659 as seen in Table 4.2.

Table 4.2

Results from Cronbach's Alpha with AN Group

AN Group (animation with narration)	
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items
0.659	0.752

The AT group scores showed less reliability. However, this lower Alpha reflects the fact that 3 of the 6 questions, 3, 4, and 6, showed no variability. All the students received a score of 1 for those items. The Cronbach's Alpha is 0.470, and the Cronbach's Alpha Based on Standardized Items is 0.547 as seen in Table 4.3.

Table 4.3

Results from Cronbach's Alpha with AT Group

AT Group (animation with text)	
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items
0.470	0.547

4.4 T-Tests Results

Two-sample t-tests assuming unequal variance were completed between the two groups (AN and AT) for each of the testing types: retention, transfer and matching. These t-tests are used to test the null hypothesis that the means of two populations are equal. The t-test asks if a difference between two groups' averages, the AN group and the AT group, is meaningful because it meets the following:

(1) there is a large difference between the averages,

(2) the sample size is large, and

(3) responses are not widely spread out so the standard deviation is low, and therefore, the responses are consistently close to the average.

There are two primary outputs of the t-test. The first is statistical significance, which specifies whether the differences between the sampled averages is likely to represent a real difference between the sampled items. The second is the t-test's effect size. The effect size specifies whether the differences between the sampled averages is large enough to be meaningful.

This study was comprised of a sample size of seventy-nine university participants enrolled in an large undergraduate class in Educational Technology. This was nearly identical to the original study (Mayer & Moreno, 1998) sample size of seventy-eight college students. The t-tests set p-value $\geq$ 0 .05 for each testing type follows.

Retention T-Test: The retention t-test showed the AT group, the group without narration, performed better on the retention test than the AN group, the group with narration (Table 4.4). The p-value 0.007 is statistically significant. This data counters the original study which showed statistically significant data that reflected the AN group outperforming the AT group.

Table 4.4
Results of Retention T-Test.

t-Test: Two-Sample Assuming Unequal Variances		
	Group AT Retention Scores	*Group AN Retention Scores*
Mean	2.79	1.72
Variance	3.03	2.83
Observations	43	36
Hypothesized Mean Difference	0	
df	75	
t Stat	2.77	
P(T<=t) two-tail	0.007	
t Critical two-tail	1.99	

Transfer T-Test: The transfer test results are compiled in Table 4.5. The data shows the AT group, the group without narration, performing better than the AN group, the group with narration. Statistical significance is noted by the p-value of 0.0000329. This also counters the original studies data which showed the AN group scoring higher than the AT group.

Table 4.5
Results of Transfer T-Test

t-Test: Two-Sample Assuming Unequal Variances		
	Group AT Transfer	*Group AN Transfer*
Mean	5.02	2.8
Variance	6.35	3.76
Observations	43	36
Hypothesized Mean Difference	0	
df	76	
t Stat	4.42	
P(T<=t) two-tail	3.29E-05	
t Critical two-tail	1.99	

Matching T-Test: The matching test data is compiled in Table 4.6. The data shows that the AT group did perform better than the AN group. However, this fell just short of being labeled statistically significant with a p-value of 0.065.

Table 4.6
Results of Matching T-Test

t-Test Two-Sample Assuming Unequal Variances		
	Group AT Recall/matching scores	*Group AN Recall/matching Scores*
Mean	3.84	2.81
Variance	4.71	6.96
Observations	43	36
Hypothesized Mean Difference	0	
df	68	
t Stat	1.87	
P(T<=t) two-tail	0.07	
t Critical two-tail	1.99	

4.5 One-Way ANOVA Tests Results

With such different results from the original study being reflected by the t-tests, it was decided to run the one-way analysis of the variance (ANOVA) as had been completed in the original study to see if the current study's data still countered the original study's findings. This would help to see if there were any Type 1 errors in the t-tests as multiple t-tests were run on the same data.

The one-way analysis of variance (ANOVA) is used to determine if there are any significant differences between the means of independent groups. The test is predominately used when there are three groups or more but can be used in our two group example as well especially because we were using two different types of study design: one group with animation and narration and the other with animation and text. The test compares the means between the groups. It determines if there are any significant differences amongst them. In our study the null hypothesis was used and the ANOVA is well suited for this format.

There are three main assumptions when using one-way ANOVA.

1. The dependent variable is normally distributed in each group that is being compared. (in this study the dependent variable was the specific test type.)
2. There is homogeneity of variance, the population variances in each group, are equal. (there was equal variance in this study.)
3. Independence of observations. (classrooms were observed by four TAs and the researcher to assure independent test taking.)

The ANOVA tests confirmed the t-test results. Tables 4.7 – 4.9 provide the data and explanations follow.

Table 4.7
One-Way ANOVA Retention Scores – showing significant results with a P-value 0.007

Anova: Single Factor						
Retention Scores						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Group AT Recall Scores	43	120	2.79	3.03		
Group AN Recall Scores	36	62	1.72	2.83		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	22.37	1	22.37	7.61	0.007	3.97
Within Groups	226.34	77	2.94			
Total	248.71	78				

Table 4.8

One-Way ANOVA Transfer Scores- showing significant results with P-value 4.69E-05

Anova: Single Factor Transfer Scores						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Group AT Transfer	43	216	5.02	6.36		
Group AT Transfer	36	101	2.81	3.76		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	96.37	1	96.37	18.62	4.69E-05	3.96
Within Groups	398.62	77	5.18			
Total	494.99	78				

Table 4.9

One-Way ANOVA Matching Scores - showing results with P-value 0.06

Anova: Single Factor Matching/Recall Scores						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Group AT Recall/matching scores	43	165	3.84	4.71		
Group AN Recall/mathing Scores	36	101	2.81	6.96		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.86	1	20.86	3.64	0.06	3.97
Within Groups	441.49	77	5.733			
Total	462.35	78				

Figure 4.1 provides a look at the three tests together. Again, the first question addressed was retention as shown in Table 4.7. The modality principle supports that low-experience learners remember more from verbal material when it is presented as narration rather than presented as text. The bars to the far right on Figure 8 show the retention scores for the current study. These scores reflect the proportion of the eight idea units correctly recalled by the participants in the AT group, the group with animation and text, and the AN group, the group with animation and narration. As was done in the original study, ANOVA was conducted with group (AT vs. AN) as the between-subjects factor and the retention score as the dependent measure. As is shown by the retention bars, the modality effect did not occur. The participants without narration remembered more than the participants who had narration. There is statistical significance between AT group and AN group on retention questions with $p<0.01$. AT group mean = 2.97, and the AN group mean = 1.72.

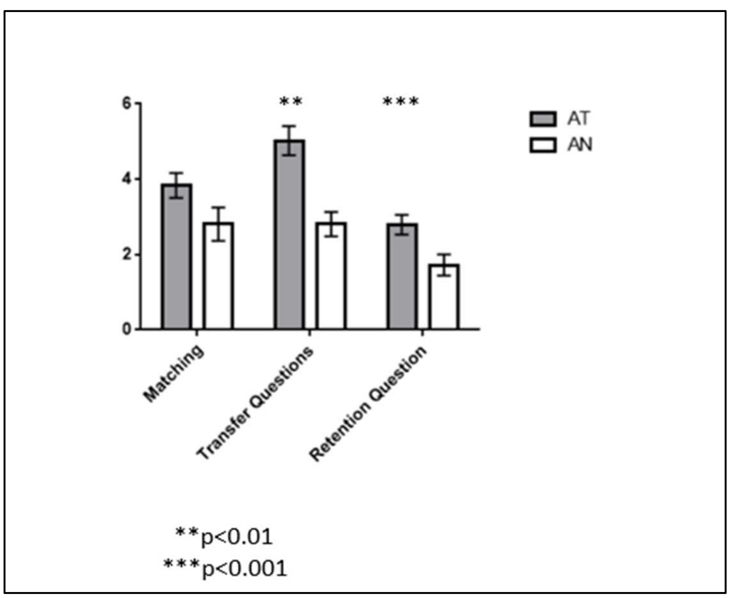

Figure 4.1. Three-Test Comparison.
This figure compares the three test types between groups and between tests.

The second question addressed transfer of knowledge as shown in Table 4.8. According to the modality principle, low-experience learners should generate more problem-solving solutions when verbal narration occurs than when verbal material is presented as text. The transfer bars in the middle of Figure 8 show the proportion of correct solutions on the transfer test by participants in the AT group and participants in the AN group. (The maximum score for this test was 12. This was the same maximum score as the original study.) An ANOVA was completed with group (AT vs AN) as the between-subjects factor and the problem-solving scores as the dependent measure. The transfer bars in the middle of Figure 8 show the modality effect did not occur. The participants without narration (AT) were able to generate more solutions than did the group with narration (AN). There was statistical significance between the text group (AT) and the narrative group (AN) with regards to transfer questions, $p<0.001$. The AT mean = 5.02, and the AN mean = 2.81.

The third question reflected the participant's ability with matching which was shown in Table 4.9. The modality principle asserts low-experience learners should be able to match more items if the verbal material is presented as narration than when it is presented as text. The matching bars on the far left of Figure 8 show the proportion correct on the eight-item matching test for each group, the AT group without narration and the AN group with narration. An ANOVA was completed with group (AT vs. AN) as the between-subjects factor and matching score as the dependent measure. Figure 4 shows there was no statistical significance for matching between the groups. No statistical significance between the text group (AT) and the narrative group (AN) on matching questions with $p>0.05$. The AT mean = 3.84, and the AN mean = 2.81.

In addition to completing the data analysis to understand the level of significance, an effect size test was completed as well. For this study effect size was calculated using the t-tests. T-test's effect size indicates whether or not the difference between two groups' averages is large enough to have practical meaning. Effect size is a test used to compare two means. It is simply the difference in the two groups' means divided by the average of their standard deviations. For example, if the result is a *d* of 1, the two groups' means differ by one standard deviation; a *d* of .5 indicates that the two groups' means differ by half a standard deviation. Cohen (1992), who was extremely influential with effect size, suggested that *d* = 0.2 should be considered a 'small' effect size, 0.5 represents a 'medium' effect size and 0.8 a 'large' effect size. This means that if two groups' means don't differ by 0.2 standard deviations or more, the difference is trivial, even if it is statistically significant. Below is effect size data for each of the t-tests.

Retention t-test data for effect size

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Score * Group	79	100.0%	0	0.0%	79	100.0%

Report

Score

Group	Mean	N	Std. Deviation
Group 1	2.721	43	1.7502
Group 2	1.694	36	1.6702
Total	2.253	79	1.7793

Effect size:

Cohen's *d* = 0.60

This would be a large effect size.

Transfer t-test data for effect size

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Score * Group	79	100.0%	0	0.0%	79	100.0%

Report

Score

Group	Mean	N	Std. Deviation
Group 1	5.0233	43	2.52123
Group 2	2.7222	36	1.90655
Total	3.9747	79	2.52665

Effect size:

Cohen's *d* = 1.03

This would be a large effect size.

Matching t-test data for effect size

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Score * Group	79	100.0%	0	0.0%	79	100.0%

Report

Score

Group	Mean	N	Std. Deviation
Group 1	3.8372	43	2.17048
Group 2	2.8056	36	2.63839
Total	3.3671	79	2.43467

Effect size:

Cohen's $d = 0.43$

This would be a medium effect size.

These results support the t-test results and the One-Way ANOVA results, showing the participants who viewed the PowerPoint presentations that did not include narration, were providing more effective results than their counterparts, the participants who viewed the PowerPoint presentations which included narration.

Summary

The overall results of this study show a change in the earlier reported impact of the modality principle which stated narration is more effective for low-experience learners than onscreen text (Moreno, 1998). The first step included an analysis of the pre-survey to understand the level of experience for the participants. The results showed the participants to be low-experienced learners. This fit the original study's participant profile. The next step was to analyze the viewing of the PowerPoint presentations and the completion of the assessment, as these tasks were done in the participant's classroom. The PowerPoint presentation viewing and test completion were done with supervision including 4 TAs and the researcher to insure students were completing the test individually. A Cronbach's Alpha was then completed to assure the test was reliable, and while the number of participants were on the lower end, as were the number of questions, the results showed the variance within the test to be predominately within the acceptable range. There was a lower number with the AT group, but this may reflect that three of the items on this test showed no variance.

The next step was to complete t-tests. The results of the t-test showed the AN group, the group with narration, not performing as well as the AT group, the group with only onscreen text. These results did not coincide with the original study's results. Therefore, a second set of tests were run. One-way ANOVA tests were completed, this was the test used in the original study. In addition, running this test may address any Type 1 error that may have occurred in the t-test results. The results of the one-way ANOVA for retention and transfer of knowledge were statistically significant, showing that onscreen text was more effective for the low-experienced learner than the narrated version.

CHAPTER 5

CONCLUSION AND DISCUSSIONS

In the past the modality principle has shown that low-experience learners benefit from utilizing both the auditory and the visual channels in multimedia learning environments. However, this current study provides conflicting results for this belief. In fact, this study suggests low-experience learners benefit more from visual presentation than auditorial presentation for retention and transfer of knowledge. This dramatic difference from the previously held results brings about several areas of discussion.

The first area concerns the testing environment. Studies were completed to understand if results produced in lab-like settings, similar to the original study's setting, would transfer to the typical classroom. One such study on the topic of the modality principle was completed by Harskamp, Mayer and Suhre (2007). Their study showed the modality principle was effective in a typical science classroom for K-12 students, but these results also came with allowing students to self-navigate, and in one testing group, the students who needed more time to learn did not show the modality effect. Their study noted the effect was supported more when measuring learner understanding (transfer tests vs. retention tests). It also noted that the group who received narration did not outperform the group who did not receive narration on transfer tests for participants who required more time to learn. While the study completed by Harskamp, Mayer and Suhre (2007) does support the modality effect, it also shows that the impact of the modality principle is changing from the original study's finding. Because of this changing impact, it is important to continue the discussions around conditions that may be causing this change in effect. One of these conditions is the testing environment. As noted, the testing environment of the original study utilized a lab-like approach, and the current study utilized the participants' actual classroom (natural setting). The classroom was observed the entire time by the researcher and the teacher assistants. During the study process, participants worked individually, and the very few consultations that occurred between a participant and a teacher assistants or the researcher were extremely short in duration. However, the change in the testing environment, from the lab-like setting to a classroom-testing environment, that may have created additional audio and visual engagement and thereby made the narrated content less effective include the following:

- the seventy-nine participants who were engaged in the activity all at the same time and were seated next to each other in stadium seating on chairs with arm desks,
- the movement and noises that would accompany such a large number of participants,
- the oral directions may have taken longer and seemed less personal and therefore required more focus by the participants than the original study's direction process which addressed only one to five participants at a time,
- the process of handing out and retrieving testing materials would comprise additional time, noise and engagement, and
- the visual and auditory engagement that occurs as students came to the front of the room to turn in the completed assessment.

It seems quite plausible that these additional variables may have had an impact on the participants' abilities to focus on the narrated content as would be needed for the modality effect to occur. With so many additional participants seated in close proximity and with no visual blocks to detract wandering eyes and hold down any noise disruptions, these additional items may have been just enough straws, so to speak, to break the camel's back or the modality principles effectiveness.

Another area of discussion addresses the participants' background knowledge regarding technology, online learning and multimedia learning formats. In most of today's large U.S. universities, learners are considered digital natives as coined by Prensky (2001). Digital natives are people who grew up with technology, have technology readily accessible to them, and who anuse technology at an increased level. Does this increased level of knowledge regarding technology impact the participants' experience with the online, multimedia learning formats? As was discussed earlier in the research study, previous studies have shown such items as prior-knowledge and increased levels of expertise to impact the modality effect. However, in the study by Kalyuga et al. (2003), the prior-knowledge and increased level of expertise pertained to the content with which the participants were engaging and not the tool they with which they had chosen to engage. Yet, it seems possible this increased level of experience with narration and technology may be impacting the participants, who, as they left the testing environment, put on their ear buds, gathered their remaining materials and stepped out in the hallway while texting on their phone. Have these participants becomes so multi-task oriented that they lose out on some of the information that they confront? Have they learned to ignore narrated content and be less engaged in its process because of the frequency with which they have experienced this format? Does reading the text require more mental engagement by the learner so that it provides greater comprehension for those who do not have accommodations for reading? The genuine discussion becomes, is narration no longer providing learners what it once did, especially the low-level learner?

Three research questions guided the current study. Based on these results, these questions may be answered as follows:

1. Does the modality principle impact cognitive load and provide for schema development that allows for effective transfer and retention of knowledge? This study would not disagree with the original study's findings that state narration is more effective for transfer and retention of knowledge. It would, however, qualify this statement. This study suggests there may be other factors, not found in the original study, which may be effecting the participants experience with the modality principle and therefore, the results. This study, while small, shows that the modality effect is no longer impacting low-experience learners as it was nearly 20 years ago. This study provided two possible rationales behind this change, one was the classroom environment, the other the high-experience level of the participants, not with content of the study but instead, with technology, online learning, and multimedia formats that include narration. This latter rationale seems not to have been addressed in earlier studies, and future research in this area is warranted.
2. Should words in a multimedia explanation be presented auditorily or visually to promote learning? This study showed that auditory presentation of material did not provide more effective and retention and transfer of knowledge. However, this study was small and the overall past data has provided strong support for the modality principle. This study would suggest additional research is needed on the when and how the modality principle is effective.
3. Does the increased experience of the learner with technology and multimedia impact the effect of the modality principle? The results of this study provides discussions around this point. It is apparent from the results that the participants did not experience higher ability to retain or transfer knowledge due to narration of content. Why? Is this due to the

participants' being accustom to narration and multimedia? Are participants half-listening and half-reading the content and therefore not fully perceiving either? Have these participants, who often wear headphones as they complete other tasks, no longer paying attention to the spoken language as they once did? It seems to be that most participants in this age ranges prefer a text message over picking up a phone to have a vocal conversation, is this part of the reasoning narration is not as impactful as in previous studies? This area needs future research.

5.1 Contributions of this Study

This study supports the replication of previous studies to assert the validity of the results for today's learners. Replication provides the opportunity to utilize previous methods and strategies that provided effective results at a certain point and time in history. The replicated process provides data that either affirms these earlier results or provides parameters within which the original results may or may not be effective. Stanovich and Stanovich (2003) state that education is susceptible to fads and trends due to the nature of educators who believe knowledge acquisition is a personalized event and that science dehumanizes people. However, science "actually democratizes knowledge. It frees practitioners and researchers from slavish dependence on authority" (p. 10). Robinson and Levin (1997) also recognized the need for the replication of educational studies stating replications are invaluable contributions to the cumulative knowledge in any given domain.

Furthermore, the modality principle has provided effective strategies for instructional designers for over thirty years. These studies, which began in 1998, have shown that the utilization of the dual channels, auditory and visual, allows the instructional designer to provide free working memory space. With the progress of technology, the classroom has become energized with online learning tools that utilize various multimedia formats. Many schools have taken on various degrees of one-to-one initiatives in which every student in a class is given a technology tool, iPad, Notebook, lap top, to utilize throughout the school year. These one-to-one initiatives are sometimes done school wide, and at other times brought in one grade at time. As these changes continue to grow, it is evident students will become more immersed in online and multimedia learning environments. Colleges and universities have incorporated various Learning Management Systems where students can look up grades, receive teacher feedback, and be provided a multitude of learning experiences through such items as a wiki, survey, discussion, forum, or other tools like VoiceThread and Google Apps. These online learning tools are comprised of various multimedia formats that include animation, narration, and images, therefore require the students to be comfortable in multimedia learning environments. Furthermore, as well as the level of technology experience of the learner, few studies, within the past ten years, have addressed these changes. This study provides a contribution of knowledge. This study, while supporting the modality principle as a strategy that allows the instructional designer to address cognitive load, reflects the changing impact of the modality principle. Specifically, the low-experience learner is not benefiting from the modality principle as originally understood. This information requires continued research to understand the best practices around the utilization of the modality principle.

The current study has also made contributions to the methodology. The current study provides data that show the original methodology needs to include additional variables. The pre-survey tool that is used in the original study is an effective way to gather prior knowledge data regarding the topic that will be addressed. However, this pre-survey needs to include questions regarding the participant's experience with online learning, multimedia formats and narration.

Furthermore, a process of how to designate participants as low-experience learners needs to be fully developed and implemented in a way that it can be replicated. This will allow for a closer-matching participant pool to be established and therefore, more effective comparisons.

In addition, current research in this area has also been very limited. This current study addresses low-experience learners who worked with PowerPoint presentation modules that animated for just under 4 minutes and had very short-narrated content, usually only one sentence long per slide. This study replicated the original study's PowerPoint presentation and provided results that counter the original study's findings specifically for low-experience learners. This would be the first study to show that both retention and transfer of knowledge were not more effective for low-experience students who viewed the original study's PowerPoint presentation with narration.

Implications

The implications of the current study include recognizing that narration does not always create a better way to assist learners with transfer and retention of knowledge. This requires instructional designers to stay on top of current and future research so that they may provide best practices for instructional design. This also requires past instructional content that utilizes narration and is still being implemented, to be revisited to assess the impact of the narration on the intended audience when creating multimedia learning environments. This change impacts educational institutions, businesses and companies who provide multimedia instruction or training online. This change requires a shift in allocation of funds, as the dollars that were originally designated for script writers, voice talent, studios, and necessary time and talent to synchronize the voice with the text may now be used in other areas. This study also implies that the participant population has changed in their response to narrated, online learning. This may have something to do with the learning environment and/or their prior-knowledge with multimedia, online learning and technology. The modality principle needs further research to recognize when it is an effective process for instructional designers to implement for providing retention and transfer of knowledge.

Limitations of the Study and Further Research

This research did use a small sample, seventy-nine participants, and quantitative research often suggests the more the numbers the better the data. However, this number of participants was chosen to replicate the original study and provided an effective way to compare the studies' data. Another possible limitation of this study was the inability to verify the process used by the original study in designating low-experience learners. This required a new method to be established to designate this population. The new method relied on the accepted university practices in the United States and used their general grading scale to designate any participant who scored below 60% as a low-experience participant. This seems like a logical solution as falling below this percentage would be someone who failed content assessment and would fit the designated title low-experience. Another possible limitation is the fact that the narrated content on the slides also included the onscreen text. This was done because the onscreen text was very short, usually only one sentence. If the onscreen text had been longer, and appeared to have the possibility to be a distractor or reflect the redundancy principle, it would have been removed. However, leaving the onscreen text available to the group who received narration, allowed the two groups to have very similar experiences with the only one difference of the narration.

Future research on the modality principle is needed. Areas of interest should whether lab-like settings can reflect real classroom experience, and how environments may impact visual and auditory cognitive load. Future research should also address how prior-knowledge of multimedia, and narrated online learning may be impacting participants as they work with narrated content. Research regarding effective practices for instructional design that utilizes onscreen text is needed as this format may become more widely used. Finally, additional research is necessary to understand how narrated content can be used to enhance retention and transfer of knowledge. Is narration that does not just narrate the onscreen content but instead enhances and develops the animation of the onscreen content able to reflect the modality principle? Are there ways to utilize the modality strategy effectively and gain the free working memory space to assist learners in their comprehension process and provide deep learning? This powerful tool requires further research so that we may harness its potential and pass on the learning rewards.

In addition, with the changes in classroom delivery becoming more online, research regarding the modality principle and its implications is needed. Take for example a flipped classroom. Flipped classrooms, a blended educational format that delivers instructional content online and provides face-to-face classroom time for discussion, questions and activities, is on the rise. Berret (2010), notes this format has many shapes and when appropriately implemented, requires the students to actively engage in the content. In some courses, students complete the readings prior to class so they may actively discuss and work on problems collaboratively in the classroom environment. According to Berret (2010) students in Michigan who were at risk of failure showed the same gain as students who demonstrated the largest increase in understanding from traditional lecture formats elsewhere (p. 4). Therefore, with the increase in online learning, it is imperative that the instructional design be effective for the learner. Understanding the modality principle and its implications for the learner will help build best practices to meet this goal.

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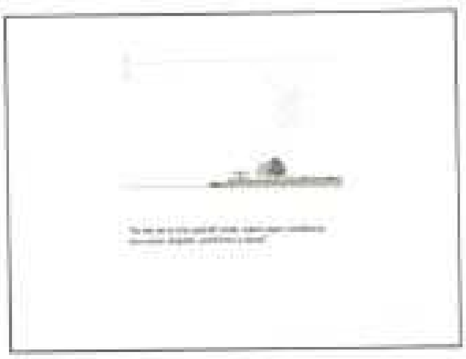
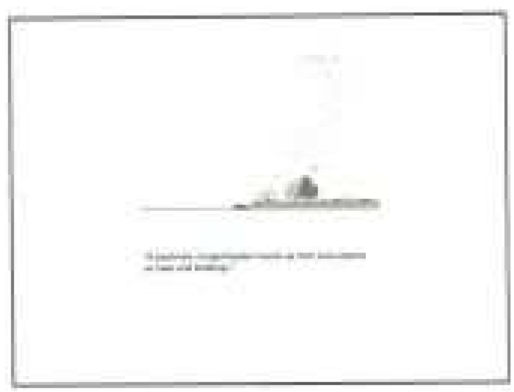
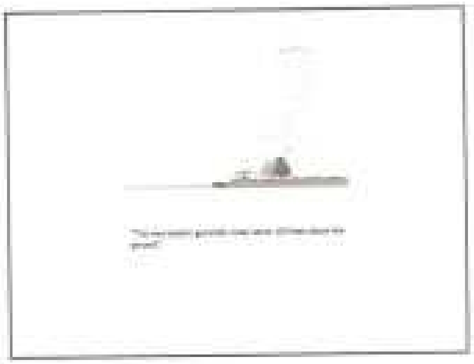
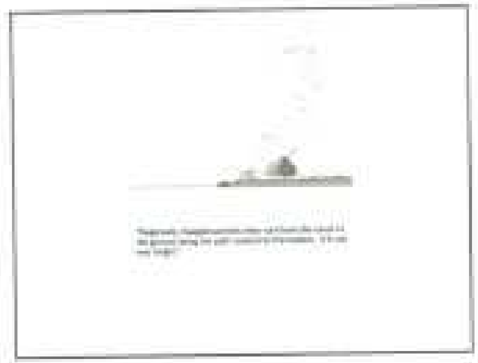
APPENDIX A

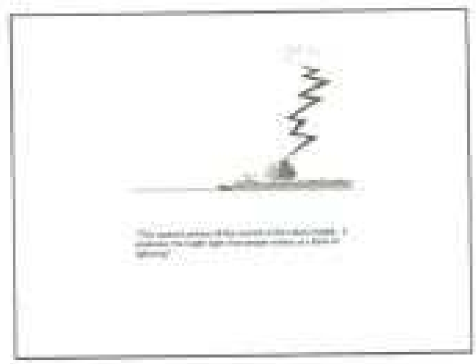
POWERPOINTS USED IN STUDY











APPENDIX B

PRE-SURVEY

Pre-Survey:

Link for online form- https://qtrial2015az1.az1.qualtrics.com/SE/?SID=SV_1zgFs1BZCpMA7el

Thank you for agreeing to participate in this study. Please note you will need to stop by and record your name with me before leaving today if you want to receive the 10 extra-credits points.

Please choose the answer. What is our gender?

___ Female

___ Male

___ Other

1. Please choose the item that most reflects how often you read weather maps.

   ___ very little

   ___ between very little and average

   ___ average

   ___ between average and very much

   ___ very much

2. Please choose the item that most reflects you knowledge of cold fronts

   ___ very little

   ___ between very little and average

   ___ average

   ___ between average and very much

   ___ very much

3. Please choose the item that most reflects the following statement. I can distinguish between cumulus and nimbus clouds.

___ very little

___ between very little and average

___ average

___ between average and very much

___ very much

4. Please choose the item that best reflects the following statement: I know what a low pressure is.

___ very little

___ between very little and average

___ average

___ between average and very much

___ very much

5. Please choose the item that best reflects the following statement: I can explain what makes the wind blow.

___ very little

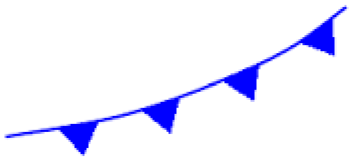
___ between very little and average

___ average

___ between average and very much

___ very much

6. Please choose the item that best reflects the following statement: I know this symbol



___ very little

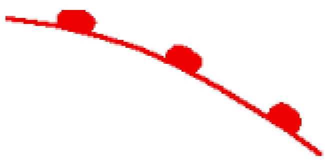
___ between very little and average

___ average

___ between average and very much

___ very much

7. Please choose the item that best reflects this statement: I know what this symbol means



___ very little

___ between very little and average

___ average

___ between average and very much

___ very much

APPENDIX C

RETENTION TEST QUESTION

Retention Test

Please write down all you can remember about how lightning works.

APPENDIX D

TRANSFER TEST QUESTIONS

Each question was on a separate sheet of 8 x 11 paper

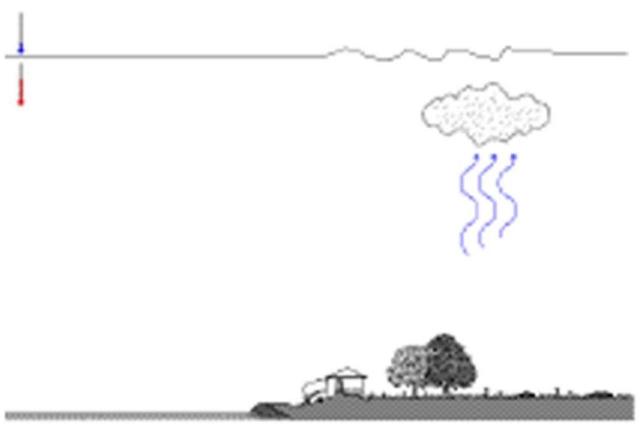
1. What could you do to reduce the intensity of lightning?
2. Suppose you see clouds in the sky but no lightning. Why not?
3. What does air temperature have to do with lightning?
4. What causes lightning?

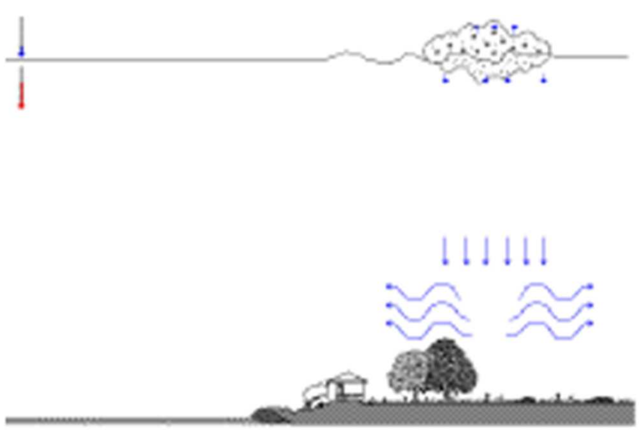
APPENDIX E

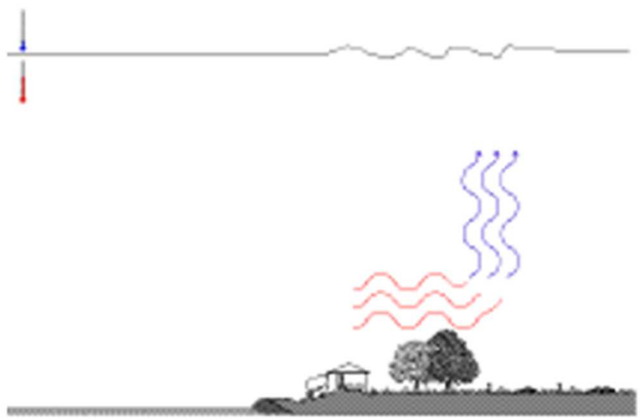
MATCHING

Follow the direction below circling and labeling as needed.

Circle cool moist air and write C next to it. Circle the warmer surface and write W next to it. Circle the updraft and write U next to it. Circle the freezing level and write F next to it. Circle the downdraft and write D next to it. Circle the gusts of cool wind and write G next to it. Circle the stepped leader and write S next to it. Circle the stroke and write R next to it.







APPENDIX F

EXEMPT FORM IRB

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
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Date: 3/20/2015

To: Amy Oberfoell
2051 Bever Ave SE
Cedar Rapids, IA 52403

CC: Dr. Ana-Paula Correia
N165B Lagomarcino Hall
Roger Oberfoell
2051 Bever Ave SE

From: Office for Responsible Research

Title: Understanding the Modality Principle in Curriculum Design

IRB ID: 15-150

Study Review Date: 3/20/2015

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.