ABSTRACT

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Title: The Effects of Using Different Types of Multimedia Presentations on Thai Seventh-grade Learners’ Understanding of a Social Studies Text

Major: Educational Technology  Degree: Doctor of Education

Approved by:  Date:

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NORTHERN ILLINOIS UNIVERSITY
ABSTRACT

As computers have become more powerful and cheaper, education has increased use of multimedia for learning. Despite research, questions concerning multimedia’s impact on learning remain. The purpose of this study was to compare Thai seventh graders’ comprehension of a social studies text on local history using four multimedia formats – written text only (W), written text with graphics (WG), audio with graphics (AG), and written text with audio and graphics (WAG).

A posttest I – posttest II quasi-experimental design was used to gather comprehension data. There were 132 seventh-grade participants (85 female and 47 male). A questionnaire gathered demographic data and assessed the participants’ computer usage and behavior. The paper-based comprehension posttest consisted of 20 multiple-choice questions.

One-way ANOVA showed that participants in the W group scored significantly higher than the other groups on the immediate posttest, and they spent less time completing the learning task. The WAG group, however, scored significantly higher than the other groups on the delayed posttest. The number of times learners accessed help was not significantly different among the groups.
Two-way ANOVA indicated that gender and the number of years participants had studied local history did not interact and showed no significant main effects. Correlation showed that longer time to completion was associated with higher test scores on the immediate posttest but not on the delayed posttest. The number of times participants accessed help and the number of visits to a temple diagram page were associated with higher scores on both tests. More use of help was associated with more visits to the temple diagram. Students who used more help and viewed the diagram page more often took less time to complete the learning task.

The findings suggest that pattern recognition and cognitive load may have contributed to higher test scores in the W group on the immediate posttest. The results add support for dual coding theory and cognitive multimedia learning theory. Findings show that multimedia benefits younger students using a language other than English and content other than science, especially low-prior-knowledge learners.
NORTHERN ILLINOIS UNIVERSITY

THE EFFECTS OF USING DIFFERENT TYPES OF MULTIMEDIA PRESENTATIONS ON THAI SEVENTH-GRADE LEARNERS' UNDERSTANDING OF A SOCIAL STUDIES TEXT

A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE DOCTOR OF EDUCATION

DEPARTMENT OF EDUCATIONAL TECHNOLOGY, RESEARCH AND ASSESSMENT

BY

ROSARIN ADULSERANEE

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DEKALB, ILLINOIS

MAY 2007

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DEDICATION

To my mom, dad, and grandma, with love and gratitude
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CHAPTER 1

Introduction to the Study

Researchers have long pursued the need to understand how humans learn and process information. The availability of multimedia technology promised new ways of developing and integrating multimedia into classroom learning, but also raised many questions. Does one use both audio and visual channels to receive and process information? If both channels are being used, how much information can one handle at a time without overloading cognition capacity? As computers have become more powerful and less expensive, multimedia presentations have been produced and employed in education more than in the past. Nonetheless, the question of whether multimedia has any effect on learning still remains. If multimedia has any effect on learning, which format is the most effective – text only, text with graphics, audio with graphics, or text and audio with graphics?

Designing multimedia presentations involves the understanding of screen design, learner interaction, and the use of graphics, audio, and video (Stemler, 1997). Screen design, according to Grabinger (1998), is a way of communicating with learners as well as gaining attention in Gagné’s events of instruction model (Stemler, 1997). Good screen design should focus on learners’ attention, develop
and maintain interest, promote the process of learning, promote engagement between the learner and lesson content, help learners find and organize information, and facilitate lesson navigation (Grabinger, 1998; Hannafin & Rieber, 1989; Mukherjee & Edmonds, 1993; Stemler, 1997). In addition, some of the general design principles (Moore & Kearsley, 2005), such as well-organized materials, clear objectives, and small units, should be applied when designing multimedia presentations.

Apart from screen design, learners’ interaction with multimedia presentations should be taken into consideration as well. Schwier and Misanchuk (1993) stated that the major difference between traditional instruction and instruction delivered by multimedia is interaction, a point confirmed by Alessi and Trollip (2001). Interaction could be thought of as how students interact with instruction (Schwier, 1989). Moreover, interaction could be designed to foster comprehension, metacognition, and recall (Alessi & Trollip, 2001).

Hannafin (1989) defined five basic interaction functions - navigation, query, verification, elaboration, and procedural control. Navigation interaction provides learners with controlled access to a lesson. It also helps learners understand where they are and where they can go (Rosenfeld & Morville, 2007). This involves using menu or option buttons. Query interaction allows learners to pose questions rather than answer them, such as a keyword search. Verification interaction focuses on learner achievement of intended lesson objectives, for
instance, using embedded questions during a lesson. Elaboration interaction allows learners to combine prior knowledge with new knowledge. This type of interaction occurs when learners compare and contrast existing knowledge with new lesson content. Procedural control or pacing interaction allows learners to control their learning pace. Therefore, designing meaningful interaction in multimedia presentations is important, but complex (Hannafin, 1989; Schwier & Misanchuk, 1988).

Another issue concerning the development of multimedia presentations is the use of graphics. Information in multimedia presentations should be presented in both text and graphics modes (Mayer, 2001; Mayer & Moreno, 1998; Overbaugh, 1994). Students who have difficulty with text only information may learn better from graphics presentations (Clark & Mayer, 2003; Mayer, 2001; Merrill, 1983). In addition, Stemler (1997) stated that graphics could be used to indicate students' choices on the screens. For example, using left and right arrows on the screen indicates that learners can go to the next or previous pages, or a question mark on the screen can represent the availability of help.

Photos and still graphics could be used to illustrate facts, concepts, or procedures (Sponder & Hilgenfeld, 1994). A study by Hasebrook and Gremm (1999) found that photographs supported recall of all factual information that was related to illustrated jobs. Video, on the other hand, yielded no significant support for recall of factual information. Similarly, Anglin, Towers, and Moore (1997) found that participants who studied from text and static graphics had
higher recall scores than those who studied from text and animation. Animation could be used for highlighting key information, motivating students, attracting students' interest, and facilitating students' recall, but it did not increase the learning effect (Alessi & Trollip, 2001; Hannafin & Rieber, 1989; Orr, Golas, & Yao, 1994; Rieber, 1994).

Many multimedia presentations employ the use of audio. Research studies have shown the benefit of using audio explanation along with visual presentations (Clark & Mayer, 2003; Mayer, 2001; Mayer, Dow, & Mayer, 2003; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Tabbers, Martens, & van Merriënboer, 2001; Wright, 1993). Audio can be used to gain learners' attention or provide directions to learners while text directions are often ignored (Alessi & Trollip, 2001). The results of these studies could be explained by the multiple-channel communication theory (Dwyer, 1978; Moore, Burton, & Myers, 2003), the dual coding theory (Paivio, 1971, 1986, 1991), the cognitive load theory (Garner, 2001; Miller, 1956; Sweller, 1994), and the cognitive multimedia learning theory (Clark & Mayer, 2003; Mayer, 2001).

When designing multimedia presentations, educational software, or other types of software, the product should be tested for its usability. Usability consists of five attributes: learnability, efficiency, memorability, errors, and subjective satisfaction (Nielsen, 1993). When the software is easy to learn and learners can rapidly get work done, the software is learnable. Once learners become familiar with the software, efficiency or a high level of productivity is
possible. Moreover, it should be easy to remember how to use software (memorability), it should have a low error rate (errors), and the product should be pleasant to use (subjective satisfaction).

Nonetheless, a concern was raised whether multimedia could produce better learning than a text only presentation could (Hamilton, 2003; Kinnamon, 2003; Wallen, 2002). Kahn (2004) examined the effectiveness of multimedia by reviewing eight studies that compared the effects of a text only presentation mode with a multimedia mode on comprehension, word recall, and word retention. None of these studies showed significant differences. Similarly, a study by Hall, Phipot, Flori, Yellamraju, and Subramanian (2003) found no significant differences among the test scores of subjects who learned from video, static text/graphics, and animation.

However, Escalada, Grabhorn, and Zollman (1996) concluded from their study that using videos or motion pictures to present information enhanced learning about abstract or technical systems, such as science or engineering. Similarly, Mayer and his colleagues (Mayer & Anderson, 1991, 1992; Mayer, Dow, & Mayer, 2003; Mayer & Moreno, 1998; Mayer, Sobko, & Mautone, 2003) found that multimedia could enhance learning. They investigated the effects of different types of multimedia, namely text and graphics, audio and text, and audio and graphics, on retention and transfer problems (Mayer & Moreno, 1998; Moreno & Mayer, 1999). The results revealed that participants who used audio
and graphics scored higher on both retention and transfer tests than those who used written text and graphics.

Problem Statement

Because the studies cited previously show inconsistent results regarding the benefits of multimedia elements, more studies are needed with other groups of learners using different types of content. Most of the participants from the studies cited previously were college-level English speakers. The results shown from the cited studies might vary with younger populations (Mayer, 1999) or among other linguistic groups. The specific problem is that no studies have yet to be conducted regarding the impact of multimedia on Thai seventh-grade students' learning, specifically in social studies.

Purpose of the Study

The purpose of this study, therefore, was to investigate and compare Thai seventh graders' comprehension of a social studies text under four different multimedia presentation formats.

Research Questions

To achieve the aforementioned purpose, the following research questions guided this study:

1. What is the relationship between learning environment - a written text (W), a written text with graphics (WG), an audio text with graphics (AG), and an audio text with graphics (AWG) - and task performance?
(AG), or a written text with audio and graphics (WAG) – and learners’ scores on an immediate comprehension test?

2. What is the relationship between learning environment – W, WG, AG, or WAG – and learners’ scores on a delayed comprehension test?

3. What is the relationship between learning environment and learners’ total time to completion?

4. What is the relationship between learning environment and the number of times learners access help?

5. What are the relationships among gender, the number of years learners studied Lanna history, and the immediate comprehension posttest scores?

6. What are the relationships among gender, the number of years learners studied Lanna history, and the delayed comprehension posttest scores?

7. What are the relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page?

Hypotheses

From the above research questions, the following hypotheses were proposed.
1. There is no significant relationship between learning environment - W, WG, AG, or WAG - and learners' scores on an immediate comprehension test.

2. There is no significant relationship between learning environment and learners' scores on a delayed comprehension test.

3. There is no significant relationship between learning environment and learners' total time to completion.

4. There is no significant relationship between learning environment and the number of times learners access help.

5. There are no significant relationships among gender, the number of years learners studied Lanna history, and the immediate comprehension posttest scores.

6. There are no significant relationships among gender, the number of years learners studied Lanna history, and the delayed comprehension posttest scores.

7. There are no significant relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page.
Significance of the Study

This study was significant in at least four ways. First, despite the popularity and the availability of computer technology, only a modest amount of literature regarding the effectiveness of multimedia presentations to enhance learning was available (e.g., Hamilton, 2003; Wallen, 2002), and the findings were inconsistent. Ellis (2001) compared a written tutorial to a computer-based multimedia tutorial and found no significant difference in learning from both types of materials. Jones and Plass (2002) investigated the effectiveness of written and pictorial annotations on second language students' listening comprehension. They found a small but significant difference in immediate comprehension test scores between the pictorial plus written group and the pictorial only group. However, there was no significant difference in delayed comprehension test scores between the two groups. The present study adds to the body of knowledge concerning the value of multimedia in learning. To assure maximum potential value, the multimedia presentation design for this study was carefully evaluated, its usability was tested, and revisions were made following evaluation by a group of experts. These experts consisted of graphic designers, content experts, and instructional designers. In addition, the guidelines for designing multimedia presentations from Alessi and Trollip (2001), Grabinger (1998), Grabinger and Osman-Jouchoux (1996), and Mayer (2001) were followed in designing software for this study.
Second, most studies investigated the effects of multimedia on college students. Studies with younger populations are rare. The need for more research with younger populations was, therefore, clear (Beckett, McGivern, Reeder, & Semenova, 1999; Mayer, 1999; Mayer and Moreno, 1998). This study extends the knowledge base to middle-school-age students.

Furthermore, the content used in studies about multimedia learning had been mostly from the sciences. Many researchers (e.g., Ellis, 2001; Hamilton, 2003; Mayer, 1999; Mayer & Moreno, 1998) had stated the need for research using other content such as social studies, which was the focus in this study.

Finally, studies about the effects of multimedia presentations on Thai learners had yet to be found. This study in Thailand therefore adds another dimension to this line of research.

Definition of Terms

The following terms were operationally defined for this study:

Audio text the presentation of a text in the form of a narration by a native speaker of Thai

Graphics still pictures used to illustrate the context of a text

Lanna land of a million rice fields, consisting of eight provinces in northern Thailand (Chiang Mai, Chiang Rai, Mae Hong-song, Prae, Pa-yao, Nan, Lampoon, and Lampang)
Multimedia the combination of written text, pictures, and audio presented to learners

Multimedia presentation any presentation containing graphics, on-screen text, and/or narration

Plan page a layout of a temple and also content help (Figure 1)

Figure 1. Plan page.

Traditional instruction teacher-centered, in which students act as passive learners while taking notes from the instructors

Delimitations of the Study

This study was delimited to Thai seventh-grade students from one of the secondary schools in Chiang Mai Province, Thailand. Second, written text, still graphics, and narration were the media attributes that were used in the study. Written text was chosen because it is the form of information that is always included in instructional multimedia presentations (Alessi & Trollips, 2001; Muter, 1996). Moreover, a written text was easy and inexpensive to develop and maintain; it also required a minimal amount of computer memory (Kensworthy,
1993). Still graphics such as realistic photographs, diagrams, and artistic drawings were used in this study because they could help enhance the look and feel of the software and the motivation of learners, especially with the local-history content (Alessi & Trollip, 2001; Sponder & Hilgenfeld, 1994). Although animation could capture learners' attention, it was not used in this study because animation should be used to explain dynamic processes and to heighten the impact of a presentation (Alessi & Trollip, 2001; Stemler, 1997) rather than to provide a description, as in the present study. Therefore, using still graphics in this study was sufficient. Similar to animation, audio can be used to gain attention, especially when learners are not looking at the screen. Moreover, producing audio is easier and cheaper than producing video (Alessi & Trollip, 2001); therefore, audio was used in this study. Video is an ideal medium for presenting materials that are abstract (C. D. Taylor, 1992) and can be used as an advance organizer or a lesson summary (Stemler, 1997). Nonetheless, producing video requires time and expense, and prior research suggested no benefit for the current study; therefore, video was not selected as one of the presentation media.

Summary and Organization of the Study

This chapter introduced the topic and the background problem of the study. The problem statement, purpose for conducting the research, the research questions investigated, hypotheses, the operational definitions of terms used in this study, and delimitations of the study were presented in this chapter.
Chapter 2 presents the theoretical frameworks and discusses the relevant literature concerning multimedia studies. Chapter 3 describes the Thai formal educational system, the setting and participants, the research design, the learning materials, instrumentation, data collection procedures, and data analysis. Chapter 4 presents the findings of the study. Chapter 5 discusses the findings, draws conclusions, addresses limitations of the study, and suggests potential areas for future research.
CHAPTER 2
REVIEW OF THE LITERATURE

This chapter is divided into two parts. The first part reviews theories related to multimedia and learning. The second part reviews and discusses studies related to multimedia and learning.

Theoretical Framework

The purpose of this study was to investigate and compare four types of multimedia content presentation using Thai seventh graders' social studies comprehension scores. Moore, Burton, and Myers (2003) suggested researchers look at learning theories related to multimedia. Two main theories were used as a framework for this study: information processing theory (Miller, 1956) and the cognitive multimedia learning theory (Clark & Mayer, 2003; Mayer, 2001). Topics related to information processing theory such as multiple-channel communication (Moore et al., 2003), cue summation (Severin, 1967), dual coding theory (Paivio, 1971, 1986, 1991), and cognitive load theory (Garner, 2001; Miller, 1956; Sweller, 1994) are included in the study. The following sections review the above theories and related topics.
Information Processing Theory

Information processing theory (IP) became the center of interest for both psychology and education in the late 1960s (Moore et al., 2003). This theory focuses on human memory, which is divided into three main stages: sensory memory, short-term memory (STM), and long-term memory (LTM). The IP theory has often relied on the computer as an analogy; as examples, the sensory memory can be thought of as a cache in a web browser; the STM can be thought of as RAM; and the LTM can be thought of as the hard drive (Hall, 2001).

The flow of information processing starts with registering stimuli in the sensory memory. The information will be briefly held (less than $\frac{1}{2}$ second for visual stimuli and about 3 seconds for auditory) in this memory until attention or pattern recognition has occurred (Huitt, 2003; Moore et al., 2003). When attention or pattern recognition occurs, the information is sent to STM. STM can hold information longer than the sensory memory. Nonetheless, if repetition has not happened within 15-20 seconds, then the information can be lost. Organization of information is also important since there is a limited capacity in STM. Miller (1956) suggested that the information should be chunked into seven units to help prevent the loss of information. When information has been repeated or rehearsed, it will be retained in LTM. LTM is the most important part in information processing theory because it has an unlimited capacity to hold information.
The following sections review topics that are related to information processing theory, including multiple-channel communication, cue summation, dual coding theory, and cognitive load theory.

**Multiple-Channel Communication**

Computers nowadays have become more powerful and advanced than in the past. Developers, designers, educators, and researchers can combine different types of media or multimedia into one device. Moore et al. (2003) and Najjar (1996) define multimedia as the use of text, graphics, animation, pictures, video, and sound to present information. It is obvious from this definition that multiple-channel communication plays a major role in understanding the concept of multimedia. Multiple-channel communication, according to Dwyer (1978), involves how humans process simultaneous presentation of information over two or more channels. In other words, when audio and graphical information are presented to learners simultaneously, the cues for learner interaction are increased. As a result, learners can achieve their learning task better by interacting with the combination of the available cues.

The terms "multiple-channel communication" and "cue summation" are used interchangeably in the literature (Moore et al., 2003). Severin (1967) stated that when the number of the available cues or stimuli is increased, learning increases. Dwyer (1978) referred to this view as realism theories, which also state that learning will be more complete as the number of cues in the learning situation increases.
In addition to the number of cues, relevance of cues or information helps increase learning in multiple-channel communication. Severin (1967) conducted a study comparing six groups of conditions, i.e., audio only, text only, audio with text, audio with related pictures, audio with unrelated pictures of the same category, and audio with unrelated pictures of a different category. The subjects were seventh-grade students from a public school in the Midwest. Each group was assigned to one of the experimental conditions and was tested according to the stimulus generalization theory, which states that when the testing situations are similar to the presentation situations, learning can be improved. Therefore, for example, the subjects who were in the audio only group received the audio only test of recall. The results from Severin’s study showed that audio with related pictures was significantly better than audio with text in the recall test. Audio with text results were not significantly better than text only. Audio with unrelated pictures showed the poorest result in the recall test. He concluded that “multiple-channel communications appear to be superior to single-channel communication when relevant cues are summated across channels, neither is superior when redundant between channels, and are inferior when irrelevant cues are combined (presumably because irrelevant cues cause interference between them)” (p. 397).

Nonetheless, a concern has been raised regarding the effectiveness of using multiple modalities. After reviewing numerous studies related to multimedia from different fields of studies, Najjar (1996) concluded that learning
does not always improve when comparing redundant multimedia to a single medium. One of the results from Severin's study (1967) revealed that the audio with text group (redundant media) did not score higher in the recall test than the text only group (single medium). Moreover, unrelated or redundant information presented through multiple channels could lead to cognitive overload or information interference (Hartman, 1961; Hsia, 1968).

The amount of information presented to learners and the limitation of the human information processing system are also concerns when using multiple-channel communications. Hsia (1968) concluded from the review of many single-channel and multiple-channel communications studies that learning from multiple modalities will be superior to single modalities when the amount of information received is not greater than the subject's information processing capacity.

**Dual Coding Theory**

Paivio (1971, 1986, 1991) proposed a theory, called dual coding, that explains how the mind processes information. According to Paivio, the two types of information (verbal and visual) are encoded simultaneously in human memory by two subsystems. The verbal subsystem processes and stores linguistic or language information, whereas the visual subsystem processes and stores images and pictorial information. Visual imagery includes different senses such as hearing, smell, touch, taste, and sight (Paivio, 1971).
The verbal and visual subsystems are independent of each other. In other words, they can operate independently or can work parallel to each other. Despite this fact, the two subsystems are interconnected, so that a concept represented as an image can be converted to the verbal system, or vice versa - allowing the dual coding of information (Klatzky, 1980).

Cognitive Load Theory

Cognitive load theory (CLT) states that human working memory is limited and that only two or three elements can be dealt with simultaneously (Garner, 2001; Miller, 1956; Sweller, 1994). The working memory may be affected by intrinsic cognitive load, extraneous or ineffective cognitive load, and germane effective cognitive load (Pass, Renkl, & Sweller, 2003; Sweller, 1994; Sweller, van Merriënboer, & Pass, 1998).

Intrinsic cognitive load deals with the impact of element interactivity on working memory. Element interactivity is defined as the degree to which the elements of some information can or cannot be understood in isolation (Cooper, 1998). When an item can be understood and learned without any reference to other items, its element interactivity is low. In contrast, high-element interactive materials can be learned individually, but they cannot be understood until all of the elements and their interactions are processed simultaneously (Pass et al., 2003). For instance, learning the basic vocabulary of a foreign language is considered low-element interactivity and low cognitive load. On the other hand, learning the grammar of a foreign language is considered high-element
interactivity and high cognitive load. The intrinsic cognitive load cannot be reduced or modified by instructional designs because it involves the difficulty of the content (Cooper, 1998).

Extraneous cognitive load derives from instructional materials that are used to present information to students. This type of cognitive load is “generated by the instructional format used in the teaching and learning process” (Garner, 2001, p. 2). High extraneous cognitive load occurs when the instructional material is poorly designed. When both intrinsic and extraneous cognitive loads are high, the working memory will be overloaded (Garner, 2001). Unlike intrinsic cognitive load, the level of extraneous cognitive load can be modified. Changing instructional materials to facilitate learning is one way to reduce extraneous cognitive load. For instance, integrating diagrams next to the related texts helped students learn better because extraneous cognitive load was reduced (Pass et al., 2003).

The third type of cognitive load is the germane or effective cognitive load. This concept refers to unused working memory that exists when the extraneous cognitive load is low and the intrinsic cognitive load is not too high (Garner, 2001). While extraneous cognitive load interferes with learning, germane cognitive load enhances learning (Pass et al., 2003). Examples of germane cognitive load can be found in problems or solutions provided in computer programming lessons (Cooper, 1998).
The cognitive multimedia learning theory of Mayer (2001) is based on multiple-channel communication (Dwyer, 1978) and dual coding theory (Paivio, 1971, 1986, 1991). Mayer stated in his theory that human information processing systems consist of visual/pictorial and auditory/verbal channels. Each channel has limited capacity in information processing, and active learning occurs when learners pay attention, organize incoming information, and integrate new knowledge with prior knowledge and/or with new knowledge from the other channel.


1. It is better to present information in words and pictures rather than in words alone.

2. Students learn better when corresponding words and pictures are presented near to each other rather than far from each other on the screen.

3. Students learn better when corresponding words and pictures are presented simultaneously rather than successively.
4. The exclusion of extraneous words, pictures, and sounds increases learning achievement.

5. Students learn better from animation and narration than from animation and on-screen text.

6. Students learn better from animation and narration than from animation, narration, and on-screen text.

7. The effects of designing a multimedia presentation are stronger for high-spatial learners and low-knowledge learners than low-spatial learners and high-knowledge learners. High-spatial learners are those who have the ability to generate, maintain, and manipulate visual images (Carroll, 1993; Mayer, 2001).

Review of Related Multimedia Research Studies

Although many educators believe multimedia is a tool that can enhance learning, studies of its impact on learners' retention have yielded varying results. Clark and Craig (1992) conducted meta-analyses and found that multiple media were not the factors that influenced learning. They stated that if there was evidence for unique learning benefits from any medium, then additive learning benefits from combining media would be possible. This is called the additive assumption. The most common sources of confounding in additive media research are from the uncontrolled effects of instructional method or content differences between treatments being compared and a novelty effect for newer
media (Clark, 1983). Therefore, when examining the effects of different media, only the media being compared can be different (Clark & Craig, 1992). Moreover, if the gain in achievement with new media is due to increased effort or attention from learners, the gain tends to diminish as learners become more familiar with the media.

Another assumption is termed multiplicative, or the expectation that media in combination may produce learning benefits that are not possible from any of the separate media (Clark & Craig, 1992). Clark and Craig examined studies that had been conducted on interactive video lessons using computer control of videodisc access. They concluded that learning benefits from using multiple media were not greater than using a single medium. They suggested that the lack of instructional method control was the primary cause of negative results in media comparison studies.

To avoid the additive and multiplicative assumptions, the content used in this study was the same for all four treatments. Participants in each group (a written text, a written text with graphics, an audio text with graphics, or a written text with audio and graphics) used the computer as a medium in this study. Since the computer is not a new instructional medium to Thai seventh graders, there should have been no novelty effect in this study.

For example, Ellis (2001) compared two instructional materials, conventional printed text and a multimedia-enhanced tutorial. The content for both materials was the same, how to use the AltaVista search engine. The
participants were fairly familiar with using the computer because they were selected from one of three classes that required using a computer - Introduction to Computers, Introduction to Keyboarding, and Medical Office Procedures. The research showed that multimedia-enhanced educational products were more effective in developing critical thinking skills than were the traditional, text-based products. The results of Ellis's study are consistent with other studies (e.g., Escalada, Grabhorn, & Zollman, 1996; Mayer & Anderson, 1991, 1992; Rieber, 1990, 1991).

In addition to the additive and multiplicative assumptions, other concerns related to the effectiveness of multimedia on learning are cognitive load, the use of text and images, the use of static or animated images, and the use of on-screen text or audio text. The following subsections review and discuss studies associated with these concerns.

**Cognitive Load**

When cognitive load is reduced, study time may prove to be more efficient. Martin-Michiellot and Mendelsohn (2000) investigated the effects of cognitive load while learning from three different types of computer manuals: a conventional manual and a computer, a manual with juxtaposed screen images with no computer, and integrated screen images with no computer. The conventional manual consisted of sections of instructions only. The juxtaposed manual consisted of computer screen images and juxtaposed sections of instructions. The integrated manual consisted of computer screen images with
arrows connecting to the corresponding sections of instructions. The researchers found no significant difference in the cognitive load effects on practical and written tests between the three groups. However, with regard to study time, the juxtaposed manual and the integrated manual groups learned faster than did the conventional manual group.

Another study about the effect of cognitive load and different types of presentation formats was conducted by ChanLin (2001). ChanLin investigated the effects of three different presentation formats and learners' prior knowledge on descriptive learning and procedural learning of a computer-based physics lesson. The three different presentation formats were animation, still graphics, and text. ChanLin defined descriptive learning as a recital of facts, or the description of objects or events, and procedural learning as the learning and construction of the problem-solving steps or procedures in physics concepts. The study divided the participants into novice (eighth-grade) and experienced (ninth-grade) learners. The results showed that novice learners who used still graphics had higher test scores than those who used text for descriptive learning. For procedural learning, the novice learners who used still graphics had higher test scores than both those who used text and those who used animation. Furthermore, there was no significant difference in experienced learners' test scores between text, still graphics, or animation. The researcher concluded that animation should be used with some caution, especially when novice learners must process both the visual component and the spatial-sequential component of
the illustration from animation. Cognitive overload in the working memory might occur.

**The Use of Text and Images**

According to the multimedia principle of the cognitive theory of multimedia learning (Clark & Mayer, 2003; Mayer, 2001), providing text and images together produces the greatest effects on learning. Evidence can be found from empirical studies such as those conducted by Wiedenbeck (1999). Wiedenbeck investigated the effects of using different icon interfaces on learners' retention of knowledge in an end-user application. The interfaces were text only, icon only, and icon and text. The text only interface was simple and consisted of one to three words. The icon only interface was visually simple and did not incorporate great detail. The icon and text interface was the combination of the text only and icon only interfaces. The results of the study revealed that the icon and text group and the text only group performed better in the immediate recall test than the icon only group in terms of correctness of tasks, time, and the use of help. The text only group performed better than the other two groups in the delayed recall session.

**The Use of Static or Animated Images**

When words and graphics are presented to learners simultaneously, a question is whether the graphics should be static or animated (Hamilton, 2003). Anglin, Towers, and Moore (1997) suggested that animated graphics could help facilitate learning when they were congruent to the text materials, when they
were used as a critical attribute for drawing learners' attention to specific learning materials, and when the learning material was complex and could not be explained readily by using only a verbal description. To investigate these conditions, these researchers conducted a study to compare three types of presentation formats: text only, text with static pictures, and text with animated pictures. Their study showed no significant difference in either recall or comprehension tests between the text only group and the text with static pictures group. Furthermore, adding animation to text did not yield any significant difference on the recall and comprehension tests. They concluded that if verbal descriptions were designed carefully, adding animations to the learning material might not be helpful for adult learners.

Similarly, Jones and Scaife (1999) compared the effects of media type using two different forms of learning task on diagrams of blood flow. The media types used in the study were paper-based diagrams and computer-based animation. The two different forms of learning task were structured and open. Jones and Scaife found no significant difference on the subjects' overall test performance by the media types, although students who used computer-based animation made more errors in the test. The researchers explained that too much movement of different parts and different types of blood in the animation made it difficult for students to see where each element was going and what each part was doing. However, significant differences by task type were found. Students
who used the structured worksheet performed significantly better than those who had the open-ended task regardless of media type.

In their second experiment, Jones and Scaife (1999) investigated the ways students worked with animation and static diagrams of blood flow. Students in the computer-based animation group were allowed to work with an animated diagram only, while students in the static paper group were allowed to see only the diagram on the paper. The results showed that providing only animation was insufficient to aid comprehensive learning of a dynamic process. Moreover, animations appeared to generate artificially high confidence levels, increasing complexity and preventing learners from paying attention to the information. Nonetheless, if learners were directed and attention was focused, animation could convey more information about the dynamics of the system than a static diagram, according to the researchers.

Another study comparing animation and static graphics was conducted by Lee, Chua, and Mak (2002). The participants were divided into two groups: animation with narration and static pictures with narration. The content was lightning formation. Participants in the animation with narration viewed an animation of 190 seconds on lightning formation, while the others viewed 11 static pictures that represented critical steps of lightning formation. Matching verbal labels, recalling verbal narration, and sorting a sequence of 11 pictures were the measurements. The last measurement was developed in the study to measure spatial-temporal coding. The results showed that the animation with
narration group outperformed the static pictures with narration group on all three measurements. In addition, animation was found to be superior to static graphics in assisting spatial-temporal coding, the ability to visualize spatial patterns (Lee et al., 2002).

The Use of On-Screen Text or Audio Text

Another concern in designing multimedia presentations is whether the information presented should be in the form of on-screen text or audio text. According to the multiple channel communication theory (Dwyer, 1978; Moore et al., 2003) and the cognitive multimedia learning theory (Clark & Mayer, 2003; Mayer, 2001), more learning occurs when visual information and audio information are presented simultaneously than when only one type of information is presented. Mayer and Moreno (1998) conducted two experimental studies to investigate whether students learned better when auditory narration was presented along with a corresponding animation (AN) than when on-screen text was presented along with a corresponding animation (AT). Scientific system (how-it-works) material (i.e., how lightening forms and how a car’s braking system works) was used in both experimental studies. The animation was about 140 seconds long. Retention of verbal material, matching of pictorial and verbal material, and problem-solving transfer were measured in these studies. The results of both studies revealed that the participants in the AN group recalled more relevant idea units than did the participants in the AT group. Regarding the matching of pictorial and verbal material, the participants
in the AN group correctly matched more items than did the AT group. The same results were found for the problem-solving transfer; the AN group could generate more solutions than did the AT group. The results of Mayer and Moreno's study were later called the modality effect or modality principle (Moreno & Mayer, 1999; Tabbers, Martens, & van Merriënboer, 2001).

More studies have been conducted to test the modality effect. Moreno and Mayer (1999) conducted a study with college students whose prior knowledge of meteorology was low. The participants were divided into three different multimedia presentations – on-screen text that was integrated close to the animation (IT), on-screen text that was separated far from the animation (ST), and a presentation with concurrent animation and narration (N). Once again, the animation was 140 seconds long. The effects on verbal recall, problem-solving transfer, and visual-verbal matching were measured. The results revealed that the participants in the N group recalled more verbal material, solved problems better, and were able to match the visual and verbal elements better than those participants in the IT and ST groups.

On the other hand, a study by Hall, Phipot, Flori, Yellamraju, and Subramanian (2003) revealed a contradictory result to Mayer's modality principle. They compared three different formats for presenting example engineering problems on shear flow. The study found that there was no significant difference in achievement whether students viewed example problems in the form of a video lecture, static text/graphics, or 3-D animation.
The result of their study contradicts the modality principle in that students who received both visual and verbal channels (video and 3-D animation) did not score higher than students who received only one channel (static text/graphics).

Tabbers, Martens, and van Merriënboer (2001) questioned whether the modality effect could be found with types of content other than in the technical domain and if the animation were presented longer than 140 seconds. Two experimental studies were conducted to explore their questions. In the first study, Tabbers et al. examined the modality effect using longer multimedia instruction in a nontechnical subject domain. The participants were divided into two groups, the audio group and the visual group. In addition to a retention test and transfer test, the researchers measured mental effort spent on instruction. The results revealed that there were no significant differences on either the retention or the transfer tests between the audio group and the visual group. The mental effort measurement showed that the audio group spent less effort than the visual group on the transfer test. Furthermore, there was no significant difference in mental effort between the audio group and the visual group on the retention test. Tabbers et al. suggested that the modality effect study should be replicated with longer multimedia instruction on a nontechnical subject.

In their second experimental study, Tabbers et al. (2001) examined whether the modality effect could be found if the participants in the on-screen text group had more time to review the verbal information. The participants were divided into four groups: audio-user, audio-system, visual-user and visual-
system. The audio-user group was able to replay the sentences by clicking on a play button. The visual-user group was able to reread the text as many times as they wanted. The measurements were the same as in the first experimental study, except that the tests in the second study were presented on the computer. The results showed that the participants in the visual-user group spent significantly more time on the instructions than did the participants in the audio-user group. The researchers did not compare the time spent on the instructions of the audio-system group and that of the visual-system group because both groups were allowed the same amount of time to complete the tasks. There were no significant differences between the groups' mental effort during instruction, on the retention test, or on the transfer test. On the retention tests, the audio-system group scored higher than the visual-system group, whereas the visual-user group did better than the audio-user group. The transfer test yielded results similar to the retention test. The only difference was that the audio-user group scored higher than the visual-user group. In general, Tabbers et al. concluded that "replacing on-screen text with audio would increase the effectiveness of multimedia instruction only if learners had no control over the pacing of the instruction and the pace was set by the timing of the narration" (p. 6).

Summary

This chapter reviewed relevant theories related to designing an effective multimedia presentation. Related studies of the use of multimedia presentations
to enhance learning, cognitive overload while using multimedia, and effects when presenting written text with relevant graphics and audio were discussed. First, should a graphic used in a multimedia presentation be static or animated? Most of the studies reviewed supported the use of static graphics. Second, presenting information in the multimedia environment is another issue. Research has shown that using an audio text with relevant graphics helped students recall verbal material better than using on-screen text with relevant graphics. However, the content used in these studies was science, taught using the English language. Moreover, the participants were mostly college students. A study using social studies content with a group of seventh-grade subjects whose language is Thai is an appropriate extension of existing research. The results from this study add to the knowledge base of the effects of multimedia on learning.
CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate and compare Thai seventh graders' comprehension of a social studies text under four different multimedia presentation formats: a written text, a written text with graphics, an audio text with graphics, and a written text with audio and graphics. Specifically, this study aimed to answer seven research questions:

1. What is the relationship between learning environment - a written text (W), a written text with graphics (WG), an audio text with graphics (AG), or a written text with audio and graphics (WAG) - and learners' scores on an immediate comprehension test?

2. What is the relationship between learning environment - W, WG, AG, or WAG - and learners' scores on a delayed comprehension test?

3. What is the relationship between learning environment and learners' total time to completion?

4. What is the relationship between learning environment and the number of times learners access help?
5. What are the relationships among gender, the number of years learners studied Lanna history, and the immediate comprehension posttest scores?

6. What are the relationships among gender, the number of years learners studied Lanna history, and the delayed comprehension posttest scores?

7. What are the relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page?

This chapter describes the Thai formal educational system and then presents the setting and participants, the research design, the learning materials, instrumentation, procedures, and data analysis.

The Thai Formal Educational System

At the time of this study, the system of formal Thai education consisted of four levels of education: one or two years of preschool education, six years of primary education, six years of secondary education (three years at the lower secondary level and three years at the upper secondary level), and higher education or college level (Ministry of University Affairs, 2004). Compulsory education consists of six years of primary school and three years of lower secondary school. According to the Compulsory Education Act (Office of the
Basic Education Commission, 2002), all sixth-grade students who live within three miles of most secondary schools will be automatically admitted to the nearest school as long as seats are available. If the number of students exceeds the available seats, a raffle will be held; those who lose in the raffle have to go to other schools and take an entrance examination. However, if seats are still open, sixth-grade students who live farther than three miles from the school are allowed to fill those seats.

For the ten top-rated secondary schools throughout all of Thailand, the ratio 50:40:10 is used (Ministry of Education, 2005). Fifty percent of the seats are reserved for students who live within three miles of the school. Another 40 percent are reserved for students who score high on an entrance examination. The subject areas tested in the entrance examination are languages (Thai and English), mathematics, and science. This number is further divided into 30:10 where 30% of the seats are for students who live farther away than three miles and are from other provinces and 10% are for those who live farther than three miles but within the province. The last ten percent is further divided into 5:5, where the first 5% is reserved for gifted students and the last 5% is reserved for students with physical disabilities. The ten top-rated secondary schools are determined by factors such as the number of their students who pass the university entrance examination and the number of students who win science project or mathematics competitions.
The school year in Thailand starts in May, and the first semester concludes at the end of September. The second semester starts in November and ends in March. The admission to seventh grade for all students occurs from March 16-20. The required entrance examination to get into seventh grade in the top schools takes place only once at the beginning of April. After admission, students are required to take school exams in order to be placed in class A, B, C, and so on. There is no difference in class A, B, C at the lower secondary level. However, starting from tenth grade, students are assigned to class depending on the track (science or language) they choose. The subject areas tested are the same as the entrance examination: languages, mathematics, and science. This exam applies to both top-rated and neighborhood secondary schools throughout all of Thailand.

Setting and Participants

For this study the seventh-grade population was selected because that is the first year when social studies is a distinct subject. In addition, the K-12 curriculum in Thailand is mandatory and standardized. Students are required to take an entrance examination before they are accepted to the top ten secondary schools, and to take school examinations for the neighborhood schools after they are accepted into seventh grade. Therefore, the seventh-grade population is relatively homogeneous.

This study took place in a secondary school in a suburban area in Chiang Mai Province, Thailand. The school is co-ed and has three computer labs: a
mathematics lab, a science lab, and an English lab. All labs are equipped with computers, Internet access, and headphones. The researcher chose this neighborhood school because it met the equipment requirements to conduct the experiment. The required sample size for the study was determined by G*Power 3 software using ANOVA for four groups as the desired test, $p = 0.05$, and large effect size (0.4) as factors. The result indicated a need for a total sample size of 112 participants.

The researcher contacted the school principal asking for permission (Appendix A) to conduct the study using his school and seventh-grade students. After permission was granted, the researcher contacted a social studies teacher and computer administrator to explain the purpose and the need to conduct the study. Although the school had three computer labs, they were all reserved for specific classes and grade levels. Moreover, social studies was the subject of the experiment, but it is also a subject that does not require students to use a computer lab, so there was no social studies lab. The social studies teacher and computer administrator suggested using English classes and the English Department's computer lab because all students are required to use the computer lab for their English class at least once a month.

The researcher contacted the teacher in charge of the English computer lab and learned that only four classes would be available during the time frame of the study. Since the school had been selected as a model or lab school (see Appendix B) for the district in the school year 2005, many observers from other
schools came to visit. The researcher could include only the four seventh-grade classes whose schedules were to use the English computer lab on a day when there were no visitors.

The researcher then contacted the four English teachers to explain the purpose of the study, the need to use their class time, and the need to use a computer lab. All four teachers agreed to allow their classes to participate. The researcher had the English teachers draw numbers from 1 to 4 to determine which group their class would be.

After the random assignment of groups, the researcher went to visit participants in the English classes, introduced herself, explained the purpose of the visit, asked for volunteers, and gave students the parental consent form (Appendix C). The researcher went to collect the parental consent forms one week later and allowed only those whose parents had signed the form to participate in the study. The classes that were assigned to the WG and AG groups returned 33 forms equally. The class that was assigned to WAG returned 43 forms, and the W class returned only 23. Therefore, potential participants in this study were 132 students (85 females and 47 males) from the total of 180 seventh-grade students in four classes that the researcher visited. To make the number of participants in each group equal (33), students in the WAG group drew a number to be re-assigned to the W group.

The researcher gave the list of participants to the English teachers so that they could bring the students to the lab on the experimental day. Those students
who had been re-assigned to the W group were asked to come during their study hall. Those students who did not return the forms were allowed to sit quietly outside the computer lab.

**Participant Demographics**

Participant demographic data were self-reported on a questionnaire (Appendix D). Of the 132 participants, 85 (64.4%) were female and 47 (35.6%) were male students. The age of the participants ranged from 11 to 15 years with a mean age of 12.2 years old. One hundred and three participants (78%) indicated that they did not have background knowledge about the history of Lanna. In addition, 129 participants (97.7%) reported that they had never heard about Kra-ti-jak-kra-wan, the principles that are the main subject of the lesson. Table 1 provides a summary of these demographic data.

Inspection of the gender data raised a concern about gender imbalance in the groups. Table 2 shows participant data with national and provincial data. A chi-square test revealed that there were significantly more females in the participant group than expected (chi-square = 10.94, df = 1, \( p = 0.001 \)), a possible concern. However, the most important initial concern would be the effect of the gender imbalance on knowledge of the content for the experiment. Chi-square tests using participant's gender and knowledge of Lanna history revealed no statistically significant differences between the genders (chi-square = 3.6, df = 1, \( p = 0.06 \)).
Table 1

Participant Demographics Overall

(N = 132)

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<th>Variable</th>
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<th>%</th>
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</thead>
<tbody>
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<td>Gender</td>
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<tr>
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</tr>
<tr>
<td>Male</td>
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<tr>
<td>Age (mean = 12.2)</td>
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<td>Knowledge of Lanna history</td>
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<tr>
<td>Number of years participants studied Lanna history</td>
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</tr>
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<tr>
<td>4 year</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>5 year</td>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>Knowledge of Kra-ti-jak-kra-wan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>2.3</td>
</tr>
<tr>
<td>No</td>
<td>129</td>
<td>97.7</td>
</tr>
<tr>
<td>Definition of Kra-ti-jak-kra-wan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>No</td>
<td>131</td>
<td>99.2</td>
</tr>
</tbody>
</table>
To address concerns of a possible novelty effect for using a computer in this study, subjects were asked about their own computer usage. Regarding hours of computer usage, 68.2% of participants indicated that they used computers 1-3 hours per week. In addition, 12.9% reported that they used computers 3-5 hours per week. The percentage of participants who used computers less than 1 hour per week was 8.3%, while 7.6% of subjects reported that they used computers more than 5 hours per week.

Table 3 shows the gender distribution across the four treatment groups, and again there was an imbalance. The written text only group had surprisingly few males. A chi-square test showed that this difference was significant statistically (chi-square = 8.03, df = 3, p = 0.045). However, since gender was not significant in terms of content knowledge, this difference should not have affected the outcome.
Table 3

Gender Distribution Across the Four Treatment Groups

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Written Text Only</th>
<th>Written Text and Graphics</th>
<th>Audio and Graphics</th>
<th>Written Text, Audio, and Graphics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant's Gender</td>
<td>5</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>47</td>
</tr>
<tr>
<td>Male</td>
<td>28</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>85</td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>132</td>
</tr>
</tbody>
</table>

Table 4 provides a summary of the computer usage hours and the reported purposes of using computers. Seventy-eight percent of the participants in this study indicated that they used computers to play games. In addition, 70.5% indicated that they used computers to listen to music, and 66.7% used computers for doing their research from the Internet. Far fewer of the 132 participants reported that they used computers to browse the web (41.7%), to watch movies from the Internet (40.2%), or to read newspapers or magazines online (37.9%). Emailing, chatting, downloading programs, using the Internet as a phone, printing papers/reports, searching for images, and pursuing personal interests such as how to feed fish were listed by even fewer students.
Table 4

Computer Usage Hours and Purposes of Using

(N = 132)

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer usage hours per week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>11</td>
<td>8.3</td>
</tr>
<tr>
<td>1 - 3</td>
<td>90</td>
<td>68.2</td>
</tr>
<tr>
<td>3 - 5</td>
<td>17</td>
<td>12.9</td>
</tr>
<tr>
<td>&gt; 5</td>
<td>10</td>
<td>7.6</td>
</tr>
<tr>
<td>No answer</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>Purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37</td>
<td>28.0</td>
</tr>
<tr>
<td>No</td>
<td>93</td>
<td>70.5</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Web browsing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>55</td>
<td>41.7</td>
</tr>
<tr>
<td>No</td>
<td>75</td>
<td>56.8</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Research using the Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>88</td>
<td>66.7</td>
</tr>
<tr>
<td>No</td>
<td>42</td>
<td>31.8</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Listen to music</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>93</td>
<td>70.5</td>
</tr>
<tr>
<td>No</td>
<td>37</td>
<td>28.0</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Internet phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>6.1</td>
</tr>
<tr>
<td>No</td>
<td>122</td>
<td>92.4</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

(continued on the following page)
Table 4 (continued)

(N = 132)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$n$</th>
<th>$%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purposes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Download programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>9.1</td>
</tr>
<tr>
<td>No</td>
<td>118</td>
<td>89.4</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Chat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18</td>
<td>13.6</td>
</tr>
<tr>
<td>No</td>
<td>112</td>
<td>84.8</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Watch movies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>53</td>
<td>40.2</td>
</tr>
<tr>
<td>No</td>
<td>77</td>
<td>58.3</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Read online newspaper/magazine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>50</td>
<td>37.9</td>
</tr>
<tr>
<td>No</td>
<td>80</td>
<td>60.6</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Play games</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>103</td>
<td>78.0</td>
</tr>
<tr>
<td>No</td>
<td>27</td>
<td>20.5</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Search for images</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>No</td>
<td>128</td>
<td>97.0</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Print paper/report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>3.8</td>
</tr>
<tr>
<td>No</td>
<td>125</td>
<td>94.7</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

(continued on the following page)
Table 4 (continued)

\[(N = 132)\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>(n)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal interest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>No</td>
<td>128</td>
<td>97.0</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Research Design

A questionnaire was given to participants before the experiment to gather demographic data, assess prior knowledge of the content, and explore computer usage patterns. This research was quasi-experimental because it was conducted in intact classes. A research design using four treatment groups (W, WG, AG, and WAG) was chosen for this study. A Posttest I (immediate) - Posttest II (delayed) design was used in the study. Posttest I was administered immediately after the experiment, and Posttest II came two weeks later.

Random assignment of participants to seats in the computer lab was done by counting numbers 1 to 4 so that those who knew each other well could not sit next to each other. This was to prevent participants from talking to one another while performing the reading task. It was also to ensure that participants in each group received the two sets of tests (Set A and Set B) equally. The difference between Set A and Set B was the order of the test items, e.g., Set B used item 20 in
Set A as item 1. The same method of random assignment was repeated for every group.

Learning Material

This section describes the content and design of the learning material.

General Design

The researcher obtained the seventh-grade social studies textbook from Thailand. Since study that focused on local places, people, and cultures had been added recently to the curriculum, the history of Lanna and local places was selected as the content of this study. A specific unit focusing on local places - Wat Phra That Lampang Luang and Kra-ti-jak-kra-wan - was used in this study. Wat Phra That Lampang Luang is located in Ko Kha district, Lampang Province (see Appendix E). The Wat itself was an ancient city called Lam Pa Kap Pa.

During the 21st Buddhist era (ca. 1557 - 1656), there were a few places in Chiang Mai (Wat Phra Singh), Lampoon (Wat Phra That Haripunchai), and Lampang (Wat Phra That Lampang Luang) that ideally applied Kra-ti-jak-kra-wan or the way of building a sacred place on an empty sand space.

According to Kra-ti-jak-kra-wan, sand space represents the Sri-tan-dorn ocean and sand itself means a drop of water. To build a sacred place, the pagoda (chedi) must be placed on the center of the space with four temples (viharn) on the north, south, east, and west. These buildings can be surrounded by small temples, a building of Buddhist scriptures, a belfry, Footprint-of-the-Buddha chapel, trees, ponds, and pagoda protectors (yak). The principal temple, which is
always on the east side of the pagoda, is the place for ritual practice (Freeman, 2001; see Appendix F).

The researcher rewrote the content and sent it to the social studies teachers in Thailand for a review. After the content was approved, the researcher started to develop the multimedia versions. The first version was sent to a group of experts in Thailand – graphic designers, programmers, and a social studies teacher – for an evaluation. The final version was modified according to the results of the evaluations.

All the written and audio texts used in this study were in Thai and were designed using Macromedia Flash MX because materials designed with Flash MX could be exported as a stand-alone player or as a web application. The advantage of using a stand-alone application was that it did not require an Internet connection in the lab where students participated in the study.

All four formats had the same screen design and consisted of the same navigational icons (see Appendix G), which addresses concerns of confounding factors raised by Clark and Craig (1992). The navigational buttons were placed at the bottom of every screen. Headings and subheadings were used as an organizer on each screen to help facilitate recall and retrieval of information (Grabinger, 1998). The content of each screen was kept in low density and was double spaced to reduce lesson completion time, the number of eye fixations, and total reading time. In addition, the text was left justified so that it was easier to read (Grabinger, 1998; Hartley, 1987). To keep the unity of the design, only
one type font, AngsanaUPC, with the size of 27 (equivalent to 20-point Times New Roman in Flash MX) was used in this study. AngsanaUPC was chosen because it is a common font used in Thailand.

The first screen was a title page to inform learners about the program they were about to use, the author's name, and copyright information (Alessi & Trollip, 2001). The next screen provided the objectives of the program. The third screen explained how to use the program and was available throughout the program as a help screen. The fourth screen was the main menu page.

When participants completed each topic, a red checkmark would appear in front of that topic (Figure 2). After participants finished reading all the topics, they would see the "do not enter" sign on the main menu page indicating that they had finished the reading task and could exit the program (Figure 3). Additionally, participants could exit the program at any time by clicking the exit button available on every screen. If they exited before completing the lesson, a warning message would appear on the exit page (Figure 4). At this point, participants could choose to return to the program or could choose to exit by clicking on the exit button again. If they completed the lesson and clicked on the exit button, a thank you message would appear on the exit page (Figure 5). The times when they logged in and exited the program were recorded using a computer log file.

In addition to the log-in time and exit time, the number of times each participant accessed help or the Plan page and the number of pages each visited
were recorded using computer log files. Although the number of pages participants visited was gathered, the data were not included in this study because they were not relevant to the purpose of the study. Nonetheless, these data could be used to improve the interface design for future research.

**Figure 2.** Red checkmarks indicating that the topic was completed.

**Figure 3.** A “do not enter” sign indicated that all topics were completed.
Figure 4. Warning message on the Exit page indicating that not all the topics had been completed.

Figure 5. A thank you message on the Exit page when all topics were completed.
Specific Design

Four multimedia formats, a written text (W), a written text with still graphics (WG), an audio text with graphics (AG), and a written text with audio and graphics (WAG), were used in this study. The first format (W) consisted of text only (Figure 6). The second format (WG) consisted of text and relevant graphics (Figure 7). Photos were used in this study as graphics elements to help learners understand the materials (Clark & Mayer, 2003). The third format consisted of audio and relevant graphics (Figure 8). The only difference between the second and the third types was the presentation of the text. While the second type presented the text in written form, the third type presented it only in audio form, which was the narration of the text by a native Thai. The fourth format consisted of the written text, audio, and graphics (Figure 9). The groups that had audio were provided with basic controls: rewind, play/pause, and stop buttons. The audio controls and the length of audio in each text were placed on the lower left side of the screen (Figures 8 and 9).

Instrumentation

The instruments used to collect data were a questionnaire and a comprehension test (Appendix H) developed by the researcher with review by two Thai social studies teachers. The questionnaire was used to gather demographic data and prior knowledge and to assess the participants’ computer usage and behavior. The questionnaire was reviewed by four faculty members. The comprehension test was 20 multiple-choice paper-based questions. Two
seventh-grade social studies teachers in Thailand reviewed the test items with regard to content accuracy and appropriateness for seventh-grade students. The participants were tested twice, immediately after the learning task and two weeks after the learning task. The time interval of two weeks is common in instructional design and multimedia research. The study was conducted at the fifth week of the first semester when students were not overly busy. Two sets of tests were made to prevent participants from cheating. Participants who sat at the odd-number machines received a Set A test; those who sat at the even-number machines received a Set B test. The questions on both sets were the same, but they were listed in different order. The same sets were used for the immediate and delayed posttests. A correct answer was scored one point. A wrong answer or no response received no point.

Figure 6. Text only.
Figure 7. Text and relevant graphic.

Figure 8. Audio with relevant graphic.
Data Collection Procedures

The study took place in a computer lab where the researcher and the English teacher were available at all times. All 132 potential participants whose parents signed the parental permission forms remained for the experiment on the day that the study was conducted. The researcher conducted the process of assent (Appendix I) by explaining the purpose of the study and the nature and expected duration of the experiment. In addition, the researcher reassured all participants that participation was voluntary and they could withdraw from the experiment at any time. The participants were allowed to ask any questions during this time.

After the process of assent, the researcher and the teacher distributed the questionnaire to the participants. The time allowed to complete the
questionnaire was ten minutes. Then, the researcher explained how to use the program to the participants and that there would be a test after the reading task. The researcher also informed the participants that their test result would not affect their G.P.A.

The participants worked independently and were allowed 30 minutes to finish the learning task. The posttest was distributed immediately after they finished the learning task. The time allowed to complete the test was ten minutes. The entire process took 50 minutes. Participants who finished early were allowed to use the Internet quietly in the lab. Two weeks later, the participants were asked to take the same comprehension test again in their regular classrooms.

Computerized log files were used to calculate time to completion, use of help, and the number of visits to the Plan page. The start time was recorded immediately after participants logged in to the program. The end time was recorded after they clicked on the exit button on the exit page. Time to completion was calculated by subtracting start time from end time. Use of help was measured by the number of times participants clicked on the help button. Each visit to the Plan page was also recorded.

Variables and Data Analysis

The data gathered from the questionnaire were analyzed by descriptive statistics. The independent variables for this study were the four experimental...
groups (W, WG, AG, and WAG), gender, and the number of years participants had studied local (Lanna) history. The dependent variables were the comprehension posttest scores, total time to completion, the number of times subjects accessed help, and the number of visits to the Plan page (a diagram of the temple). All data were coded and put into SPSS for analysis.

The data were analyzed using a one-way analysis of variance (ANOVA) to examine whether there were any significant differences among the four experimental groups with regard to their immediate and delayed comprehension posttest scores, total time to completion, and the number of times they accessed help. In addition, a factorial (two-way) ANOVA was used to examine the relationships among gender, the number of years participants studied Lanna history, and comprehension posttest scores (immediate and delayed). Factorial ANOVA was selected as the statistical procedure in this study because the nature of the independent variables (gender and the number of years participants studied Lanna history) is categorical and the nature of the dependent variables (immediate and delayed posttest scores) is ratio. Finally, correlation was used to examine possible relationships between the comprehension posttest scores and total time to completion, the number of times subjects accessed help, and the number of visits to the Plan page. The correlation coefficient selected for this study was Pearson's $r$ because the type of the data (immediate and delayed posttest scores, total time to completion, the number of times subjects accessed help, and the number of visits to the Plan page) is continuous. In addition, the
two-tailed significance test was chosen for this study because the researcher did not make a specific prediction about the direction of the relationship between the correlated variables.

According to Crowl (1996), if an ANOVA yields a significant $F$ value, additional statistical analysis using a post hoc test is necessary. Therefore, a post hoc test, Tukey's honestly significant difference (HSD), was selected to analyze the data to determine which group means were significantly different from other group means (Crowl, 1996). For all statistical tests, a significance level of .05 was applied.

Summary

The methodology utilized for this investigation of the effects of four different types of multimedia learning environments on Thai seventh-grade learners' understanding of a social studies text was a quasi-experimental comparative study using four treatment groups. The participants were 132 seventh-grade students from a suburban school in Chiang Mai Province, Thailand. Two instruments, a questionnaire and a comprehension test, were used to collect data. Descriptive statistics were used to analyze data gathered from the questionnaire. The comprehension test was administered twice, immediately and two weeks after the learning task. A one-way ANOVA and a post hoc test were used to analyze immediate and delayed comprehension test scores, total time to completion, and the number of times subjects accessed help. A two-way ANOVA was used to analyze the relationships among participants'
gender, the number of years participants had studied Lanna history, and their comprehension posttest scores (immediate and delayed). Correlation was used to examine the relationship between total time to completion and the comprehension posttest scores (immediate and delayed), between the number of times subjects accessed help and their comprehension posttest scores (immediate and delayed), and between the number of visits to the Plan page and the comprehension posttest scores (immediate and delayed).
CHAPTER 4
FINDINGS

The purpose of this study was to investigate learners’ understanding of a social studies text using four different media formats as the learning material: a written text (W), a written text with graphics (WG), an audio text with graphics (AG), and a written text with audio and graphics (WAG). This chapter describes the demographic data of the participants involved in the study, summarizes dependent and independent variables and statistical procedures, and presents findings relating to the research questions. The chapter concludes with a summary of the findings of this study.

Participant Demographics

Of the 132 participants, 85 were female and 47 were male students with a mean age of 12.2 years old. One hundred and three participants indicated that they did not have background knowledge about the content of the study, namely the history of Lanna. In addition, 129 participants reported that they had never heard about Kra-ti-jak-kra-wan, the concept of building a sacred place on an empty sand space, which is explained in Appendix F.
The subjects were asked about their computer use to determine whether the results might be influenced by a novelty effect. Regarding hours of computer usage, 90 out of 132 participants indicated that they used computers 1-3 hours per week. Another 17 participants reported that they used computers 3-5 hours per week. The main purpose for using computers for this group of participants was to play games (103 out of 132 participants). The most common other purposes for using computers for the participants were to listen to music (93 out of 132 participants) and for doing their research from the Internet (88 out of 132 participants). This confirms the initial assumption that participants in this study were relatively familiar with the computer and that there is no novelty effect with the technology.

Variables and Statistical Procedures

The independent variables for this study were the four experimental groups (W, WG, AG, and WAG), gender, and the number of years participants had studied Lanna history. The dependent variables were the comprehension posttest scores (immediate and delayed), total time to completion, the number of times the subjects accessed help, and the number of visits to the Plan page (a diagram of the temple).

A one-way analysis of variance (ANOVA) was used to examine potentially significant differences among the four experimental groups with regard to their immediate and delayed comprehension posttest scores, total time
to completion, and the number of times they accessed help. In addition, a
factorial (two-way) ANOVA was used to examine the relationships among
gender, the number of years participants studied Lanna history, and
comprehension posttest scores (immediate and delayed). Finally, correlation
with a two-tailed significance test was used to examine possible relationships
between the comprehension posttest scores and total time to completion, the
number of times subjects accessed help, and the number of visits to the Plan
page. The two-tailed significance test was chosen for this study because the
researcher did not make a specific prediction about the direction of the
relationship between the correlated variables.

Findings

The findings section is organized according to the seven research
questions of the study, providing statistical procedures and results.

Findings for Research Question 1

Question 1: What is the relationship between learning environment - a
written text (W), a written text with graphics (WG), an audio text with
graphics (AG), or a written text with audio and graphics (WAG) - and
learners' scores on an immediate comprehension test?

Figure 10 presents a bar graph for the means comparison of the immediate
comprehension posttest scores for each experimental group. The mean scores for
the W, the WG, and the WAG groups were 7.70, 7.21, and 7.15 respectively. The mean score for the AG group was 5.94, a difference of almost 2 points less than the W group.

![Bar chart](image)

**Figure 10.** Means comparison of the immediate posttest scores.

To determine if there were significant differences among the four groups on the immediate comprehension posttest scores, an ANOVA was carried out using the number of correct answers on the immediate posttest. The results of the one-way ANOVA indicated that there was a statistically significant difference in immediate comprehension posttest scores among the four experimental groups, $F(3, 128) = 3.244, p = 0.024$. Based on Cohen’s (1988) standards for effect size (.01 = small effect; .06 = medium effect; .14 = large
effect), the effect size (partial eta squared) for the learning group was medium, \( \eta_p^2 = 0.071 \), as shown in Table 5.

Table 5

One-way ANOVA for Immediate Comprehension Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
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</thead>
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<tr>
<td>Group</td>
<td>55.394(^{(a)})</td>
<td>3</td>
<td>18.465</td>
<td>3.244</td>
<td>.024</td>
<td>.071</td>
</tr>
<tr>
<td>Error</td>
<td>728.606</td>
<td>128</td>
<td>5.692</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7252.000</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( a \) R squared = .071

Since there was a statistically significant difference in the immediate comprehension posttest scores among the four experimental groups, a Tukey HSD post hoc test was used to determine which group mean was significantly different from another. The results of the Tukey HSD post hoc analysis showed that the W group (\( M = 7.69, SD = 2.60 \)) scored significantly higher (\( p = 0.003 \)) on the immediate comprehension posttest than the AG group (\( M = 5.94, SD = 2.41 \)), as shown in Table 6. The WG group (\( M = 7.21, SD = 2.31 \)) scored significantly higher (\( p = 0.032 \)) on the immediate comprehension posttest than the AG group (\( M = 5.94, SD = 2.41 \)). The WAG group (\( M = 7.15, SD = 2.2 \)) also scored significantly higher (\( p = 0.41 \)) on the immediate comprehension posttest than the
AG group \((M = 5.94, \ SD = 2.41)\). No other group differences among the W, WG, and WAG groups were found.

Table 6

Pairwise Comparisons with Tukey HSD of Immediate Comprehension Posttest

Scores by Four Experimental Groups

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) Group name</th>
<th>(J) Group name</th>
<th>Mean difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate posttest scores</td>
<td>W</td>
<td>WG</td>
<td>0.485</td>
<td>.587</td>
<td>.411</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>1.758*</td>
<td>.587</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>0.545</td>
<td>.587</td>
<td>.355</td>
</tr>
<tr>
<td></td>
<td>WG</td>
<td>W</td>
<td>-0.485</td>
<td>.587</td>
<td>.411</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>1.273*</td>
<td>.587</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>0.061</td>
<td>.587</td>
<td>.918</td>
</tr>
<tr>
<td></td>
<td>AG</td>
<td>W</td>
<td>-1.758*</td>
<td>.587</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>-1.273*</td>
<td>.587</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>-1.212*</td>
<td>.587</td>
<td>.041</td>
</tr>
<tr>
<td></td>
<td>WAG</td>
<td>W</td>
<td>-0.545</td>
<td>.587</td>
<td>.355</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>-0.061</td>
<td>.587</td>
<td>.918</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>1.212*</td>
<td>.587</td>
<td>.041</td>
</tr>
</tbody>
</table>

Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Findings for Research Question 2

Question 2: What is the relationship between learning environment – W, WG, AG, and WAG – and learners' scores on a delayed comprehension test?
Figure 11 presents a bar graph for the means comparison of the delayed comprehension posttest scores for each experimental group. The mean scores for the WG and the WAG groups were 6.49 and 6.73 respectively. The mean score for the W group was 5.28. The mean score for the AG group was 4.76, a difference of almost 2 points less than the WG and the WAG groups, but only 0.5 points less than the W group.

Figure 11. Means comparison of the delayed posttest scores.

To determine if there were any significant differences among the four experimental groups on the delayed comprehension posttest scores, an ANOVA was carried out using the number of correct answers on the delayed posttest. The results of the one-way ANOVA indicated that there was a statistically significant difference in delayed comprehension posttest scores among the four
experimental groups, $F(3, 128) = 5.128, p < .05$. The effect size was medium to large, $\eta_p^2 = 0.107$, as shown in Table 7.

Table 7

One-way ANOVA for Delayed Comprehension Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>88.871(^{(a)})</td>
<td>3</td>
<td>29.624</td>
<td>5.128</td>
<td>.002</td>
<td>.107</td>
</tr>
<tr>
<td>Error</td>
<td>739.394</td>
<td>128</td>
<td>5.777</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5285.000</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) R squared = .107

Since there was a statistically significant difference in the delayed comprehension posttest scores among the four experimental groups, a Tukey HSD post hoc test was used to determine which group means were significantly different from one another. The results of the Tukey HSD post hoc analysis showed that the WG group ($M = 6.49, SD = 2.57$) and the WAG group ($M = 6.73, SD = 2.00$) scored significantly higher on the delayed comprehension posttest than the AG group ($M = 4.76, SD = 2.10$), as shown in Table 8. The WG group ($M = 6.49, SD = 2.57$) scored significantly higher on the delayed comprehension posttest than the W group ($M = 5.273, SD = 2.84$). The WAG group ($M = 6.727, SD = 2.0$) also scored significantly higher than the W group ($M = 5.273, SD =$
No other significant group difference was found between the W and the AG groups.

Table 8

Pairwise Comparisons with Tukey HSD of Delayed Comprehension Posttest Scores by Four Experimental Groups

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) Group name</th>
<th>(J) Group name</th>
<th>Mean difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed posttest scores</td>
<td>W</td>
<td>WG</td>
<td>-1.212(*)</td>
<td>.592</td>
<td>.043</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>0.515</td>
<td>.592</td>
<td>.386</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>-1.455(*)</td>
<td>.592</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>WG</td>
<td>W</td>
<td>1.212(*)</td>
<td>.592</td>
<td>.043</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>1.727(*)</td>
<td>.592</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>-0.242</td>
<td>.592</td>
<td>.683</td>
</tr>
<tr>
<td></td>
<td>AG</td>
<td>W</td>
<td>-0.515</td>
<td>.592</td>
<td>.386</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>-1.727(*)</td>
<td>.592</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>-1.970(*)</td>
<td>.592</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>WAG</td>
<td>W</td>
<td>1.455(*)</td>
<td>.592</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>0.242</td>
<td>.592</td>
<td>.683</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>1.970(*)</td>
<td>.592</td>
<td>.001</td>
</tr>
</tbody>
</table>

Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Findings for Research Question 3

Question 3: What is the relationship between learning environment and learners’ total time to completion?
Figure 12 presents a bar graph for the means comparison of the total time to completion (in minutes) for each experimental group. The mean for the W group was 18.30 minutes, which was the fastest time among the four experimental groups. The means for the WAG and the WG groups were 19.40 minutes and 21.55 minutes respectively. The mean for the AG group was 25.58 minutes, a difference of 7.28 minutes greater than the W group, 6.18 minutes greater than the WAG group, and 4.03 minutes greater than the WG group.

An ANOVA was used to determine if there was any significant difference in total time to completion among the four experimental groups. The results of the one-way ANOVA indicated that there was a statistically significant difference, $F(3, 128) = 24.199, p < .001$. The effect size was large, $\eta_p^2 = 0.362$, as shown in Table 9.

![Figure 12. Means comparison of the total time to completion (in minutes).](Image)
Table 9

One-way ANOVA for the Total Time to Completion

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1020.386(^{(a)})</td>
<td>3</td>
<td>340.129</td>
<td>24.199</td>
<td>.000</td>
<td>.362</td>
</tr>
<tr>
<td>Error</td>
<td>1799.091</td>
<td>128</td>
<td>14.055</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>62171.000</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) R squared = .362

Since there was a statistically significant difference in the total time to completion among the four experimental groups, a Tukey HSD post hoc test was used to determine which group means were significantly different from one another. The results of the Tukey HSD post hoc analysis showed that the W group (\(M = 18.30, SD = 4.70\)) spent significantly less time completing the learning task than the WG group (\(M = 21.55, SD = 3.91\)), as shown in Table 10. The W group (\(M = 18.30, SD = 4.70\)), the WAG group (\(M = 19.40, SD = 3.23\)), and the WG group (\(M = 21.55, SD = 3.91\)) all spent significantly less time completing the learning task than the AG group (\(M = 25.58, SD = 2.90\)). In addition, the WAG group (\(M = 19.40, SD = 3.23\)) spent significantly less time completing the learning task than the WG group (\(M = 21.55, SD = 3.91\)).
Table 10

Pairwise Comparisons with Tukey HSD of Completion Time by Four Experimental Groups

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) Group name</th>
<th>(J) Group name</th>
<th>Mean difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion time</td>
<td>W</td>
<td>WG</td>
<td>-3.242&lt;sup&gt;(* *)&lt;/sup&gt;</td>
<td>.923</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>-7.273&lt;sup&gt;(* *)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>-1.091</td>
<td>.923</td>
<td>.239</td>
</tr>
<tr>
<td></td>
<td>WG</td>
<td>W</td>
<td>3.242&lt;sup&gt;(* *)&lt;/sup&gt;</td>
<td>.923</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>-4.030&lt;sup&gt;(* *)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>2.152&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.021</td>
</tr>
<tr>
<td></td>
<td>AG</td>
<td>W</td>
<td>7.273&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>4.030&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WAG</td>
<td>6.182&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>WAG</td>
<td>W</td>
<td>1.091</td>
<td>.923</td>
<td>.239</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WG</td>
<td>-2.152&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AG</td>
<td>-6.182&lt;sup&gt;(*)&lt;/sup&gt;</td>
<td>.923</td>
<td>.000</td>
</tr>
</tbody>
</table>

Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Findings for Research Question 4

Question 4: What is the relationship between learning environment and the number of times learners accessed help?

Figure 13 presents a bar graph for the means comparison of the number of times each treatment group accessed help. The means for the control group, the
WAG, the AG, and the WG groups were 0.12, 0.15, 0.30, and 0.27 respectively, which shows that usage of help was very low in all groups.

Figure 13. Means comparison of the number of times subjects accessed help.

An ANOVA was used to determine if there was any significant difference by group in the number of times subjects accessed help. The results of the one-way ANOVA indicated that there was no statistically significant difference among the four treatment groups, $F(3, 128) = 0.682, p = 0.564$. The effect size was small, $\eta_p^2 = 0.016$, as shown in Table 11.

Since there was no statistically significant difference among the four experimental groups in the mean number of times they accessed help, no further analysis was appropriate.
Findings for Research Question 5

Question 5: What are the relationships among gender, the number of years of study of Lanna history, and the immediate comprehension posttest scores?

The number of years of study of Lanna history was coded in categories from 0 - 5. The interaction effect was not significant and the effect size was small ($\eta^2_p = 0.005$), as shown in Table 12. Turning to main effects, the main effect for gender was not significant, and the effect size was small ($\eta^2_p = 0.009$). The main effect for years also was not significant, and again the effect size was small ($\eta^2_p = 0.005$). No further analysis was appropriate.
Table 12

Two-way ANOVA for Gender and Years with Immediate Posttest Scores as Dependent Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Table III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>6.808</td>
<td>1</td>
<td>6.808</td>
<td>1.115</td>
<td>.293</td>
<td>.009</td>
</tr>
<tr>
<td>Years</td>
<td>4.010</td>
<td>4</td>
<td>1.002</td>
<td>0.164</td>
<td>.956</td>
<td>.005</td>
</tr>
<tr>
<td>Gender * Years</td>
<td>3.526</td>
<td>3</td>
<td>3.526</td>
<td>0.578</td>
<td>.449</td>
<td>.005</td>
</tr>
<tr>
<td>Error</td>
<td>762.951</td>
<td>125</td>
<td>6.104</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7252.000</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Findings for Research Question 6

Question 6: What are the relationships among gender, the number of years of study of Lanna history, and the delayed comprehension posttest scores?

The number of years of study of Lanna history was coded in categories from 0 - 5. Similar to the results in Research Question 5, the interaction effect was not significant and the effect size was small ($\eta_p^2 = 0.003$), as shown in Table 13. The main effect of gender was not significant and the effect size was small ($\eta_p^2 = 0.008$). The main effect for years was also not significant and the effect size was small ($\eta_p^2 = 0.015$). Since no significant effects were found, further analysis was not appropriate.
Table 13

Two-way ANOVA for Gender and Years with Delayed Posttest Scores as the Dependent Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>6.371</td>
<td>1</td>
<td>6.371</td>
<td>.984</td>
<td>.323</td>
<td>.008</td>
</tr>
<tr>
<td>Years</td>
<td>12.378</td>
<td>4</td>
<td>3.094</td>
<td>.478</td>
<td>.752</td>
<td>.015</td>
</tr>
<tr>
<td>Gender * Years</td>
<td>2.605</td>
<td>1</td>
<td>2.605</td>
<td>.402</td>
<td>.527</td>
<td>.003</td>
</tr>
<tr>
<td>Error</td>
<td>809.408</td>
<td>125</td>
<td>6.475</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5285.000</td>
<td>132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Findings for Research Question 7

Question 7: What are the relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page?

Correlation was utilized to explore relationships among the variables. The results of this analysis revealed that the correlation between the immediate posttest scores and total time to completion was positive but not statistically significant, $r(130) = 0.098$, $p = 0.27$. Higher test scores were associated with longer time to completion. The correlation between the immediate posttest
scores and the number of times subjects accessed help was also positive but not statistically significant, \( r(130) = 0.05, p = 0.56 \). Students who attained higher test scores also accessed help more often. Similarly, the correlation between the immediate posttest scores and the number of visits to the Plan page was positive but not statistically significant, \( r(130) = 0.12, p = 0.16 \). Students who visited the Plan page more often had higher test scores than those who visited less.

The correlation between the delayed posttest scores and total time to completion was negative but not statistically significant, \( r(130) = -0.08, p = 0.355 \). Higher delayed posttest scores were not associated with longer time to complete the learning task. The correlation between the delayed posttest scores and the number of times subjects accessed help was positive but not statistically significant, \( r(130) = 0.105, p = 0.23 \). Students who attained higher delayed posttest scores accessed help more often. Similarly, the correlation between the delayed posttest scores and the number of visits to the Plan page was positive but not statistically significant, \( r(130) = 0.095, p = 0.28 \).

The correlation between total time to completion and the number of times subjects accessed help was negative but not statistically significant, \( r(130) = -0.14, p = 0.11 \). The correlation between total time to completion and the number of visits to the Plan page was also negative but not statistically significant, \( r(130) = -0.089, p = 0.31 \). More use of help and more visits to the Plan page were related to less total time to complete the task. However, the correlation between the number of times subjects accessed help and the number of visits to the Plan page
was positive and significant, $r(130) = 0.60, p < 0.01$. Subjects who accessed help more also visited the temple Plan page more often. Table 14 below summarizes the correlation findings.

Table 14

**Correlations Among the Immediate Posttest Scores, the Delayed Posttest Scores, Total Time to Completion, the Number of Times Subjects Accessed Help, and the Number of Visits to the Plan Page**

<table>
<thead>
<tr>
<th></th>
<th>Sig. (2-tailed)</th>
<th>Immediate posttest scores</th>
<th>Delayed posttest scores</th>
<th>Total time to completion</th>
<th># of times subjects accessed help</th>
<th># of visits to the Plan page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate posttest scores</td>
<td>Pearson Correlation</td>
<td>1</td>
<td>-</td>
<td>0.098</td>
<td>0.050</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td></td>
<td>132</td>
<td>-</td>
<td>132</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td>Delayed posttest scores</td>
<td>Pearson Correlation</td>
<td>-</td>
<td>1</td>
<td>-0.081</td>
<td>0.105</td>
<td>0.095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td>Total time to completion</td>
<td>Pearson Correlation</td>
<td>0.098</td>
<td>-0.081</td>
<td>1</td>
<td>-0.140</td>
<td>-0.089</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.266</td>
<td>0.355</td>
<td>0.108</td>
<td>0.312</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td># of times subjects accessed help</td>
<td>Pearson Correlation</td>
<td>0.050</td>
<td>0.105</td>
<td>-0.140</td>
<td>1</td>
<td>0.604**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.565</td>
<td>0.233</td>
<td>0.108</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td># of visits to the Plan page</td>
<td>Pearson Correlation</td>
<td>0.122</td>
<td>0.095</td>
<td>-0.089</td>
<td>0.604**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.164</td>
<td>0.276</td>
<td>0.312</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
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Summary

This chapter presented the results from the data analysis of the study. A one-way ANOVA revealed significant differences among the four treatment groups (W, WG, AG, and WAG) on the immediate posttest scores, delayed posttest scores, and total time to completion. The written text only group (W) had the highest scores on the immediate comprehension posttest, followed in order by the written text with graphics group (WG), the written text with audio and graphics group (WAG), and the audio only with graphics (AG) group. Further analysis revealed that the W group scored significantly higher on the immediate comprehension posttest than the AG group. Although not statistically significant, the WG and WAG groups also scored higher than the AG groups.

The results for the delayed comprehension posttest were different. The WAG group had the highest scores, followed by the WG, the W, and the AG groups. Further analysis revealed that the WAG group scored significantly higher than the AG and the W groups. Moreover, the WG group scored significantly higher than the AG group. Although not significant, the WG group also scored higher than the W group.

In terms of total time to complete the learning task, the W group spent the least amount of time on average, followed by the WAG, the WG, and the AG groups. Further analysis revealed that the W and WAG groups spent significantly less time than the AG and the WG groups. In addition, the WG
group also spent less time completing the learning task than the AG group, but the difference was not significant.

In the next part of the analysis, a one-way ANOVA did not yield significant differences among the four treatment groups for the number of times subjects accessed help. Similarly, a two-way ANOVA did not find interaction effects between gender and the number of years participants had studied Lanna history for the immediate and delayed posttests. The main effects for gender and the number of years participants studied Lanna history were not significant.

Correlation analysis revealed that there were positive though not statistically significant relationships between the immediate posttest scores and total time to completion, the number of times subjects accessed help, and the number of visits to the Plan page. The relationship between the delayed posttest score and total time to completion was negative but not statistically significant. Furthermore, there were negative though not statistically significant relationships between total time to completion and the number of times subjects accessed help, as well as the number of visits to the Plan page. Finally, there was a positive and significant relationship between the number of times subjects accessed help and the number of visits to the Plan page.

The final chapter discusses these findings, draws conclusions based on the findings, addresses the limitations of the study, and recommends potential areas for future research.
CHAPTER 5
DISCUSSION AND RECOMMENDATIONS

This chapter is organized in five sections: overview of the study, discussion of the findings, conclusions based on the findings, limitations of the study, and recommendations for future research.

Overview of the Study

The availability of modern technology promised new ways of developing and integrating multimedia into classroom learning. Information in multimedia presentations should be presented in both text and graphics modes (Mayer, 2001; Mayer & Moreno, 1998; Overbaugh, 1994). Students who have difficulty with text only information may learn better from graphical presentations (Clark & Mayer, 2003; Mayer, 2001; Merrill, 1983). Furthermore, audio can be used to gain learners' attention or provide directions to learners while text directions are often ignored (Alessi & Trollip, 2001).

Nonetheless, a concern was raised whether multimedia could produce better learning than a text only presentation (Hamilton, 2003; Kinnamon, 2003; Wallen, 2002). The results of multimedia studies have been inconsistent. Moreover, most of the multimedia studies were conducted with US college
students on scientific subjects such as how lightning works or how the automobile brake system works. The results shown from the cited studies might vary with younger populations (Mayer, 1999), other cultures, and/or different content. The specific problem for this study was that no research had been conducted regarding the impact of multimedia on Thai seventh-grade students’ learning, specifically in social studies.

The purpose of this study was, therefore, to investigate and compare Thai seventh graders’ comprehension of a social studies text under four different multimedia presentation formats.

Setting and Participants

This study took place in a secondary school in a suburban area in Chiang Mai Province, Thailand. The K-12 curriculum in Thailand is mandatory and standardized. In addition, students are required to take an entrance examination before they are accepted into seventh grade. Thus differences among schools in Thailand are minimal. The selected school was co-ed and had three computer labs: a mathematics lab, a science lab, and an English lab. All labs were equipped with computers, Internet access, and headphones.

The participants for the study were 132 seventh-grade students. There were significantly more female participants than males. One hundred and three participants (78%) indicated that they did not have background knowledge about the history of Lanna, the content area for the experiment. A chi-square test
showed no significant difference in knowledge of Lanna history by gender. In addition, 129 participants (97.7%) reported that they had never heard about Krati-jak-kra-wan, the temple building principles that are the main subject of the lesson.

Data Analysis

A one-way ANOVA and a post hoc test were used to analyze immediate and delayed comprehension test scores, total time to completion, and the number of times subjects accessed help. A two-way ANOVA was used to analyze the relationships among participants' gender, the number of years participants studied Lanna history, and their comprehension posttest scores (immediate and delayed). Correlation was used to examine possible relationships between the comprehension posttest scores and total time to completion, the number of times subjects accessed help, and the number of visits to the Plan page, a diagram of the temple.

Discussion of Findings

The following sections discuss the findings of the study based on the seven research questions and their hypotheses.

Learning Environment and the Immediate Posttest Scores

Question 1: What is the relationship between learning environment – a written text (W), a written text with graphics (WG), an audio text with
graphics (AG), or a written text with audio and graphics (WAG) - and learners' scores on an immediate comprehension test?

The mean scores for the immediate comprehension posttest (see Figure 10, Chapter 4) were 7.70, 7.21, 7.15, and 5.94 for the W, WG, WAG, and AG groups respectively. The mean score for the AG group was almost 2 points less than the W group and more than one point lower than the WG and WAG groups. The ANOVA results in Table 5 (Chapter 4) showed that this difference pattern was statistically significant with a medium effect size \( F = 3.244, p = 0.024, \eta^2 = 0.07 \). Based on this analysis, the null hypothesis that there was no significant relationship between learning environment and learners' scores on an immediate comprehension posttest was rejected. Post hoc analysis determined that students in the W, the WG, and the WAG groups scored significantly higher, almost two points, than the AG group. No other group differences among the W, WG, and WAG groups were found.

According to the modality principle proposed by Mayer (2001), students learn better when audio and graphics are presented than when on-screen text and graphics are presented. Mayer conducted extensive research with college students to test the modality principle. His studies yielded consistent results that students in the auditory and graphics group learned better than those in the on-screen text and graphics group. The results from Severin’s study (1967) with seventh-grade students comparing six sets of conditions, i.e., audio only, text only, audio with text, audio with related pictures, audio with unrelated pictures
of the same category, and audio with unrelated pictures of a different category, yielded similar results. Students in the audio with related pictures group learned better than those in the audio with text group.

The results from the current study differ from Mayer’s and Severin’s studies. The participants in the audio with graphics group (AG) did not appear to benefit from their multimedia learning environment, and in fact had the lowest scores on the immediate posttest. On the other hand, the participants in the written text only (W) group earned the highest scores on the immediate posttest. Pattern recognition of the information in short-term memory (STM) may explain this result. Presenting text only on the screen is similar to reading from a textbook, thus participants in the W group may have been able to organize and retain the information better than students in the AG, WG, and WAG groups.

Although the scores were not quite as high as those in the W group, the participants in the WG and WAG groups also had significantly higher scores than the AG group. These findings appear to support the multimedia principle of the cognitive theory of multimedia learning (Clark & Mayer, 2003; Mayer, 2001), which states that learning can be more effective when text and graphics are presented together. The current study shows some consistency with Wiedenbeck’s study (1999), which found that an icon (graphic) and text group and a text only group performed better on an immediate recall test than an icon-only group in terms of correctness of tasks, time, and the use of help.
Learning Environment and the Delayed Posttest Scores

Question 2: What is the relationship between learning environment – W, WG, AG, and WAG – and learners’ scores on a delayed comprehension test?

The mean scores on the delayed comprehension posttest (see Figure 11, Chapter 4) were 6.73, 6.49, 5.28, and 4.76 for the WAG, WG, W, and AG groups respectively. Again, the mean score of the AG group was almost 2 points less than the WAG and WG groups, but only 0.5 points less than the W group. The ANOVA results in Table 7 (Chapter 4) showed that this difference pattern was statistically significant with a medium to large effect size ($F = 5.128, p < 0.05, \eta^2 = 0.107$). Based on this analysis, the null hypothesis that there was no significant relationship between learning environment and learners’ scores on a delayed comprehension test was rejected. Post hoc analysis determined that students in the WG and the WAG groups scored significantly higher than the AG group. In addition, the WG and the WAG groups also scored significantly higher than the written text only group (W). No significant difference was found between the W and the AG groups.

The results from this study show that the participants in the WAG and WG groups retained the information after two weeks better than those in the W and AG groups. Although students in the W group scored higher than the other groups on the immediate posttest, they did not perform as well on the delayed
posttest. The AG group still had the lowest score on the delayed test. One possible explanation is dual coding theory (Paivio, 1971, 1986, 1991), which states that learning is better when information is coded visually and verbally. Another explanation could be the multimedia principle of the cognitive multimedia learning theory (Mayer, 2001), which states that students learn better from words and pictures than from words alone. Moreover, presenting text and graphics simultaneously, as in this study, rather than successively may have contributed to the higher scores in the delayed posttest for the WAG and WG groups. This effect is referred to as the temporal contiguity principle of the cognitive multimedia learning theory.

Prior knowledge is another factor that may have an effect on the relationship between multimedia use and learning (Ausubel, 1968). According to the individual differences principle of the cognitive multimedia learning theory, a multimedia presentation has a greater effect on students with low prior knowledge than on those with high prior knowledge. The demographics data from this study showed that 103 of 132 participants had no background knowledge about the history of Lanna. Although a chi-square test showed no significant difference (chi-square = 3.45, df = 3, p = 0.33) across the four groups in prior knowledge, the WG and WAG groups had the largest number of participants who reported no prior knowledge (WG = 30/33; WAG = 29/33; AG = 26/33; W = 18/33). Therefore, relative lack of prior knowledge may have
enabled the WAG and WG groups to achieve higher scores than the W and AG groups on the delayed posttest.

A study by ChanLin (2001) on the effects of three presentation formats and learners' prior knowledge on descriptive learning and procedural learning of a computer-based physics lesson yielded similar results. The novice learners who used still graphics had higher scores than those who used text for descriptive learning and procedural learning. Similarly, Mayer and Anderson (1992) found that students with low prior knowledge learned more efficiently when verbal and visual information were presented simultaneously. In addition, the results from a study using college students by Zhu and Grabowski (2006) comparing the instructional effects of static graphics with two web-based animation strategies - to gain attention and to gain attention and provide elaboration - were also consistent with the aforementioned studies. Their results showed that students with low prior knowledge performed equally as well as those with high prior knowledge of human physiology in a drawing test, identification test, terminology test, and comprehension test. In other words, low-prior-knowledge subjects learned comparatively more.

**Learning Environment and Total Time to Completion**

*Question 3: What is the relationship between learning environment and learners' total time to completion?*

The mean total time to completion (see Figure 12, Chapter 4) was 18.30, 19.40, 21.55, and 25.58 minutes for the W, WAG, WG, and AG groups.
respectively. The mean for the AG group was 7.28 minutes greater than the W group, 6.18 minutes greater than the WAG group, and 4.03 minutes greater than the WG group. The ANOVA results in Table 9 (Chapter 4) demonstrated that differences were statistically significant with a large effect size ($F = 24.199, p < .001, \eta_p^2 = 0.362$). Based on this analysis, the hypothesis that there was no significant relationship between learning environment and learners’ total time to completion was rejected. Post hoc analysis determined that students in the written text only group spent significantly less time, about 3.25 minutes, completing the learning task than the WG group. The WAG group also spent significantly less time, about 2.15 minutes, completing the learning task than the WG group. In addition, the W, WAG, and WG groups all spent significantly less time, about 4 – 7 minutes less, completing the learning task than the AG group.

Although the human brain can process information over two or more channels (Dwyer, 1978), only two or three elements can be dealt with simultaneously before cognitive load interferes with the task (Garner, 2001; Miller, 1956; Sweller, 1994). Since there was only one element (written text) for the W group, the participants did not have to cope with any element interaction. In other words, the participants in the W group could understand and learn the material without any reference to other items, such as graphics or audio. Nonetheless, the result for this research question is not consistent with other studies. For example, Martin-Michiellot and Mendelsohn (2000) investigated the effects of cognitive load while learning from three different types of computer
manuals: a conventional manual (sections of instructions only) and a computer, a manual with juxtaposed screen images (computer screen images and juxtaposed sections of instructions) with no computer, and integrated screen images (computer screen images with arrows connecting to the corresponding sections of instructions) with no computer. They found that groups that used a juxtaposed manual and an integrated manual learned faster than the group that used a conventional manual.

Learning Environment and the Number of Times Learners Accessed Help

Question 4: What is the relationship between learning environment and the number of times learners accessed help?

The mean number of times learners accessed help (see Figure 13, Chapter 4) was 0.12, 0.15, 0.27, and 0.30 for the W, WAG, WG, and AG groups respectively. The ANOVA results in Table 11 (Chapter 4) revealed that the F-ratio of 0.682 for the number of times learners accessed help had a probability of 0.564, $\eta^2_p = 0.016$. This means that learning environment was not statistically related to the number of times learners accessed help. Based on this finding, the null hypothesis that there was no significant relationship between learning environment and the number of times learners accessed help was not rejected.

The demographic data from this study show that 107 out of 132 participants were quite familiar with computers, i.e., they used computers 3-5 hours per week. Since their main purpose for using computers was to play games, participants were comfortable with computer interfaces. In addition, this
group of participants also used computers to listen to music and to do research from the Internet. This may explain why the number of times participants accessed help in the study did not yield any significant differences among the four learning environments. Furthermore, the mean number of times subjects accessed help was very low with small variance, making significant differences difficult to detect. The data confirm the initial belief that participants in this study were relatively familiar with the computer and that there was no novelty effect with the technology.

Relationships Among Gender, the Number of Years Learners Studied Lanna History, the Immediate and the Delayed Comprehension Posttest Scores

Questions 5 and 6: What are the relationships among gender, the number of years learners studied Lanna history, the immediate comprehension posttest scores, and the delayed comprehension posttest scores?

The two-way ANOVA results for the relationships among gender, the number of years learners studied Lanna history, and the immediate comprehension posttest in Table 12 (Chapter 4) revealed that the interaction effect was not significant ($F = 0.58, p = 0.45, \eta^2_p = 0.005$). The main effect for gender was not significant ($F = 1.16, p = 0.30, \eta^2_p = 0.009$) and the main effect for number of years participants studied Lanna history also was not significant ($F = 0.16, p = 1.0, \eta^2_p = 0.005$). Based on this analysis, the hypothesis that there were no significant relationships among gender, the number of years participants...
studied Lanna history, and the immediate comprehension posttest scores was not rejected.

Similar to the above result for the immediate posttest, the two-way ANOVA results for the relationships among gender, the number of years learners studied Lanna history, and the delayed comprehension posttest in Table 13 (Chapter 4) revealed that the interaction effect was not significant \((F = 0.40, p = 0.53, \eta_p^2 = 0.003)\). The main effect for gender was not significant \((F = 1.0, p = 0.32, \eta_p^2 = 0.008)\) and the main effect for the number of years participants studied Lanna history was also not significant \((F = 0.45, p = 0.75, \eta_p^2 = 0.015)\). Based on this analysis, the hypothesis that there were no significant relationships among gender, the number of years participants studied Lanna history, and the delayed comprehension posttest scores was not rejected.

Despite initial concerns about a significant gender imbalance in the subjects compared to provincial and national data, gender does not appear to be a factor in this study. Although there were significantly more female than male participants, no interaction effect was found between gender and the immediate posttest scores \((F = 0.58, p = 0.45, \eta_p^2 = 0.005)\). T-test analysis confirmed that overall there was no significant difference by gender \((T = -1.04, p = 0.3)\) for the immediate posttest scores. T-test results for the W group, which had the most extreme imbalance, also showed no difference \((T = -0.089, p = 0.93)\). Similarly, no interaction effect was found between gender and the delayed posttest scores \((F = 0.42, p = 0.53, \eta_p^2 = 0.003)\). T-test analysis also showed that overall there was no
significant difference by gender \((T = 0.86, p = 0.39)\) for the delayed posttest scores. T-test results for the W group again showed no difference \((T = 1.14, p = 0.26)\). In addition, the number of participants who had prior knowledge about the history of Lanna and Kra-ti-jak-kra-wan was very low. Therefore, no interaction effects between the number of years participants studied Lanna history and the immediate or delayed posttest scores were found.

**Relationships Among the Comprehension Posttest Scores (Immediate and Delayed), Total Time to Completion, the Number of Times Learners Accessed Help, and the Number of Visits to the Plan page**

*Question 7:* What are the relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page?

Correlation results in Table 14 (Chapter 4) revealed that the correlation between the immediate posttest scores and total time to completion was positive but not statistically significant \((r = 0.098, p = 0.27)\). The correlation between the immediate posttest scores and the number of times learners accessed help was also positive but not statistically significant \((r = 0.05, p = 0.56)\). Finally, the correlation between the immediate posttest scores and the number of visits to the Plan page was positive but not statistically significant \((r = 0.12, p = 0.16)\).

In contrast, the correlation between the delayed posttest scores and total time to completion was slightly negative but not statistically significant \((r = -0.08, \ldots)\).
The correlation between the delayed posttest scores and the number of times learners accessed help was positive but not statistically significant ($r = 0.105, p = 0.23$). The correlation between the delayed posttest scores and the number of visits to the Plan page also was positive but not statistically significant ($r = 0.095, p = 0.28$).

The correlation between total time to completion and the number of times learners accessed help was negative but not statistically significant ($r = -0.14, p = 0.11$). The correlation between total time to completion and the number of visits to the Plan page was also negative but not statistically significant ($r = -0.089, p = 0.31$). The correlation between the number of times learners accessed help and the number of visits to the Plan page, however, was positive and significant ($r = 0.60, p < 0.01$).

Based on these analyses, the hypothesis that there were no significant relationships among the immediate comprehension posttest scores, delayed comprehension posttest scores, total time to completion, the number of times learners accessed help, and the number of visits to the Plan page can be rejected partially.

The results for this research question show that participants who had high scores on the immediate posttest tended to spend more time on the learning task. In addition, they also accessed help more than those who had low scores on the immediate posttest. Furthermore, participants who visited the Plan page more often had higher immediate posttest scores than those who visited less.
Similarly, higher delayed posttest scores were not associated with longer
time to complete the learning task. This may be a function of the learning
environment. Participants in the W group took the least time and had higher
scores on the immediate posttest than the WG, AG, and WAG groups. On the
other hand, participants in the WAG group had the second shortest time but had
higher scores on the delayed posttest than the other groups. The group with the
combination of all media retained their learning better.

The use of help and the number of visits to the Plan page were also related
to total time to complete the learning task. More use of help and more visits to
the Plan page were related to shorter total time to complete the task. Subjects
who accessed help more also visited the temple Plan page more often, which is
logical because the Plan page is itself a form of help.

Conclusions

Do humans use both audio and visual channels to receive and process
information? Does multimedia have any impact on learning? If the answer to
both questions is yes, then which type of multimedia presentation is the most
effective? Does the benefit of multimedia only accrue to college students
learning scientific or technical subjects? Are there other factors such as cognitive
load and prior knowledge that should be taken into consideration when
designing multimedia presentations? The results from this study may help
answer these questions and thus contribute to multimedia learning research.
First, information processing theory (IP), or how human memory works, plays an important role in designing a multimedia presentation. When pattern recognition occurs, the information is sent to short-term memory (STM). STM serves as temporary storage and can only hold five to nine chunks of information (Miller, 1956). A chunk of information, according to Miller, refers to organizing or grouping the information such as a name or a telephone number into a familiar unit. Since the information presented to the participants in the W group was text only, they may have been able to achieve higher scores on the immediate posttest than the WG (written text with graphics), AG (audio with graphics), and WAG (written text, and audio with graphics) groups. However, if the information has not been repeated, it will be lost, according to the theory. This may partially explain the lower scores for the W group on the delayed posttest.

Second, multimedia does appear to have an impact on learning as evidenced by the delayed comprehension test. Presenting written text with audio and graphics appears to have helped students learn better; that is, they retained their learning better over time. This suggests that multimedia may help students recall information better than written text with graphics, written text only, and audio with graphics. The results of this study support the dual coding theory and cognitive multimedia learning theory. The participants in the WAG group achieved higher scores than the other experimental groups on the delayed posttest.
Third, multimedia benefits not only college students, but also younger students, in this case seventh graders. The results from this study were consistent with previous studies, for example, a comparison of different types of multimedia with seventh graders by Severin (1967), a study of the effect of cognitive load and different types of multimedia on eighth- and ninth-grade students by ChanLin (2001), and studies using how lightening forms and how a car’s braking system works as the content for college students by Mayer and Moreno (1998). In addition, the results from this study also confirmed that subjects such as social studies in addition to science or technical content can benefit from multimedia presentations.

Fourth, the time to complete the learning task depends on the cognitive load. The lower the element interactivity, the less time it will take students to complete the learning task. The W group in this study, the condition with the lowest cognitive load, completed the learning task in a shorter time than the other experimental groups.

Finally, prior knowledge should be taken into consideration when designing multimedia presentations. The results from this study showed that multimedia had an effect on retention. Low-prior-knowledge students (Tables 12 & 13, Chapter 4) learned more effectively (that is, they retained the knowledge longer) when they learned with multimedia.
Limitations of the Study

One limitation is that there was no pretest for prior knowledge in this study. The only measure of prior knowledge in this study was years of studying Lanna history reported on a questionnaire. Moreover, the sample size of the study was small, only 132 participants. A larger number of participants may yield different results. Furthermore, the time between the immediate and delayed posttest was only two weeks. A longer period might alter the findings. Finally, the methodology used did not reveal why the AG subjects took significantly longer to complete the learning task.

Recommendations for Future Research

Because only some of the results in this study are consistent with previous studies, more studies are still needed. The same experiment should be conducted with other schools and with other grade levels, both younger and older (high school) participants. The number of female and male students could be more nearly equal or studies could focus only on one gender. A larger number of participants would also be beneficial. In addition, further multimedia research using social studies and other content areas besides science should be conducted. Moreover, studies with more variation in prior knowledge are needed to investigate the prior knowledge variable. For example, Samaras, Giouvanakis, Bousiou, & Tarabanis (2006) suggested that low-prior-knowledge
students should be engaged in deeper active processing such as think-aloud protocols while learning through multimedia environments.

In addition, the time between the experiment and the delayed posttest could be increased or the test could be given at more than one later time to investigate whether the retention patterns from this study remain consistent over a longer time. Furthermore, a qualitative element should be added to future studies to help clarify findings such as why the participants in the AG group took a much longer time to complete the learning task than the other groups, including the WAG group, which also had audio materials. In addition, the software should be redesigned to measure actual audio use, which may explain differences among the groups.

Finally, future research should address globalization, a trend that has been emphasized in instructional design for training and learning materials. Culture issues (D. Taylor, 1992) such as use of colors, icons, placement of graphics, and word order should also be incorporated into future studies.

The results of this study contribute to and broaden the line of multimedia research by showing that multimedia helps not only adult learners learn better but also younger learners. Moreover, appropriate content of multimedia materials is not limited to science, mathematics, or how-to subjects, nor do the benefits of multimedia learning materials impact only research participants whose language is English.
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APPENDICES
APPENDIX A:

SCHOOL PERMISSION FORM (THAI AND ENGLISH VERSIONS)
The effects of using different types of multimedia presentations on Thai seventh-grade learners' understanding of a social studies text

The research question of the study was to determine the effects of using different types of multimedia presentations on Thai seventh-grade learners' understanding of a social studies text. The research hypothesis was that students who were exposed to multimedia presentations would have a better understanding of the social studies text than those who were not. The research design was a quasi-experimental design with a pre-test and post-test. The sample consisted of 120 seventh-grade students from two schools in the province of Nakhon Pathom. The two schools were randomly assigned to the experimental group and the control group. The experimental group was exposed to multimedia presentations, while the control group was not. The results of the study showed that students in the experimental group had a significantly better understanding of the social studies text than those in the control group. The researchers concluded that multimedia presentations are effective in enhancing students' understanding of social studies text.
Dear (principal of ________________)

My name is Rosarin Adulseranee, a doctoral student majoring in Instructional Technology in the Department of Educational Technology, Research and Assessment, Northern Illinois University, DeKalb, Illinois, USA. I would like to ask for permission to use your school and computer labs for conducting my study titled, "The effects of using different types of multimedia presentations on Thai seventh-grade learners' understanding of a social studies text." The study will involve social studies teachers and seventh-grade students only.

The purpose of my study is to investigate and compare Thai seventh graders' comprehension of a social studies text under four different multimedia presentation formats. A specific unit in social studies, focusing on local historical places, Wat Phra That Lampang Luang, and the philosophy, Kra-ti-jak-kra-ivan, behind building sacred place such as the temple will be used as content for this study. I understand that social studies lessons focusing on local subjects, places, and things are new to the curriculum. The results of this study may help increase student interest in local study and social studies in general through effective use of multimedia.

The study involves two phases. Phase one will last one hour for the learning task and half an hour for completing the posttest. The students also will be asked to complete a brief questionnaire regarding their demographic data. Phase two will last half an hour, during which participants will take the posttest again, and will be conducted two weeks after the first phase. All of the study will be done after school in a computer lab where the social studies teachers and the researcher are present at all times.

To recruit participants for the study, the researcher will meet with seventh-grade social studies teachers to explain the purpose of the study. After that, the researcher will ask the teachers for permission to attend their classes with them. Once in the class, the researcher will introduce herself and inform students of the purpose of visiting their class. The researcher will ask for volunteers for the study and will give those who volunteer an envelope with a parental permission form to take home. Students will not be allowed to participate in the study if their parents do not return the signed parental permission form. Times for
conducting the study will be arranged to fit the participants' schedules and the availability of computer lab space in your school.

Any questions about the study should be addressed to Rosarin Adulseranee at 16 Sai Namphung 3 Sirimunkarajarn Road, Muang, Chiang Mai. Telephone: (053) 213-497.

If you wish further information regarding your rights, you may contact my advisor, Dr. James Lockard, at (815) 753-8368 or the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

If you agree to allow the researcher to use your school and computer labs for conducting the study, please read the statement below and indicate your agreement by signing on the line provided. Please keep a copy of this form for your records.

I acknowledge that I understand the purpose of this study and I hereby give permission to Rosarin Adulseranee to conduct her study in my school.

______________________________
School Principal

______________________________
Rosarin Adulseranee, Researcher

______________________________
Date

______________________________
Date
APPENDIX B:

MODEL (LAB) SCHOOL, THAILAND
Model (Lab) School

The model or lab school is one of the projects initiated by the government to extend the support for talented and gifted students in rural areas. This project is an attempt to insure that in every district there is at least one school of national standards (Ministry of Education, 2006). The main purposes of a model school are to enhance the quality of district schools, to encourage students to remain in local schools, to mobilize the support of the communities, and to gain the confidence of the public.
APPENDIX C:

PARENTAL PERMISSION FORM (THAI AND ENGLISH VERSIONS)
ใบอนุมัติผู้ปกครองสำหรับเข้าร่วมในงานวิจัย

เรียนผู้ปกครอง

บุตร/ธิดาของท่านได้รับสิทธิ์เข้าร่วมการทดลองในงานวิจัย ที่ชื่อ The effects of using different types of multimedia presentations on Thai seventh-grade learners’ understanding of a social studies text โดย นางสาว รสริน อุดมฤทธิ์ เป็นผู้ทำวิจัย

จุดประสงค์ในการทำกิจกรรมดังกล่าวคือ เพื่อศึกษาและปรับปรุงความเข้าใจของนักเรียนชั้นปที่ 1 เกี่ยวกับวัฒนธรรมสู่การคิดและผลที่ได้ใช้ในการสร้าง หรือ คลิกแล้วกด ยังไม่ได้

การทดลองนี้จะทำในห้องปฏิบัติการคอมพิวเตอร์โรงเรียนเล็ก โดยบุตร/ธิดาของท่านจะได้รับแบบสอบถามเบื้องต้น ถูก เพศ ความรู้เรื่องประวัติศาสตร์ล้านนา ความรู้ของคำสำคัญ คลิกแล้ว จำนวน ชั้นในที่บุตร/ธิดาของท่านใช้คอมพิวเตอร์ด้านนี้สูงสุด และวิเคราะห์ในการใช้คอมพิวเตอร์ของบุตร ฆลาของท่าน หลังจากที่บุตร/ธิดาของท่านได้ทำการทดลองแล้ว นักเรียนทุกคนมีการทดลองแล้ว บุตร/ธิดาของท่านจะได้รับแบบสอบถามเพื่อรับความเข้าใจในเรื่องที่ได้มีการทดลองทั้งหมดจะใช้เวลาหนึ่งชั่วโมงครึ่ง คลิกแล้วเลือก ศึกษาเนื้อหา ชั้น ป.1 ของ และทดลองอีกครั้งที่ชั่วโมง หลังจากนั้นจะกลับไปยังบุตร/ธิดาของท่านจะทำแบบทดสอบอีกครั้งหนึ่งเป็นเวลาครึ่งชั่วโมง ที่น้องภูมิคุณทักษะคอมพิวเตอร์โรงเรียนเล็ก การทดลองทุกครั้ง ครั้งจะมีผู้ทำวิจัย และ อาจารย์ที่สอนวิชาสังคมศึกษารวมอยู่ด้วย

การเข้าร่วมการทดลองนี้จะไม่มีผลต่อการเรียนรู้วิชาสังคมศึกษาของบุตร/ธิดาของท่าน หรือเกิดความเสียหายใด ๆ ต่อสุขภาพใดๆทั้งสิ้น

ประโยชน์ที่บุตร/ธิดาของท่านจะได้รับจากการเข้าร่วมการทดลองครั้งนี้คือความรู้เกี่ยวกับประวัติศาสตร์ ราคาไม่แพง และหลักที่ใช้ในการสร้าง เพื่อให้

ข้อมูลทั้งหมดที่เกี่ยวกับบุตร/ธิดาของท่านและการทดลองครั้งนี้ จะถูกเก็บเป็นความลับ และไม่มีการเปิดเผย รายละเอียดใดๆทั้งสิ้น

ลงชื่อนี้ หากไม่ได้รับอนุมัติจากท่าน บุตร/ธิดาของท่านไม่มีสิทธิ์ที่จะเข้าร่วมการทดลอง แต่ถ้าท่านอนุญาตให้บุตร/ธิดาของท่านเข้าร่วมการทดลองแล้ว บุตร/ธิดาของท่านยังมีสิทธิ์ขอย้อนกลับ ถ้า หรือ/และ ระหว่าง การทดลองโดยไม่ความผิดหรือได้รับการโทษใดๆ

 หากท่านมีคำถาม หรือ สงสัย กรุณาติดต่อ ผู้ทำวิจัย นางสาว รสริน อุดมฤทธิ์ ที่เบอร์โทรศัพท์ (053) 213 497

ขอขอบคุณ และหวังว่าท่านคงให้ความร่วมมือในการทดลองงานวิจัยครั้งนี้

นางสาว รสริน อุดมฤทธิ์ ผู้ทำวิจัย

วันที่ / เดือน / พ.ศ.

ชื่อพ่อ/แม่ ผู้ปกครอง

เบอร์โทรศัพท์

เข้าร่วมการทดลอง

วันที่ / เดือน / พ.ศ.
PERMISSION FORM FOR PARENTS/GUARDIANS OF MINORS

Your child is invited to participate in a research study titled the effects of using different types of multimedia presentations on Thai seventh-grade learners' understanding of a social studies text being conducted by Rosarin Adulseranee, a graduate student at Northern Illinois University, USA.

The purpose of this study is to investigate and compare Thai seventh graders' comprehension of a social studies text under four different multimedia presentation formats.

Your child's participation in this study will last one hour for the learning task and half an hour for completing the posttest. He or she will also be asked to complete a brief questionnaire regarding their demographic data. Two weeks later your child will participate again for half an hour to retake the posttest. All of the study will be done after school in a computer lab where the social studies teachers and the researcher are present at all times.

There are no foreseeable risks and/or discomforts that your child could potentially experience during this study.

The benefit your child may personally receive from participating in this study is to gain knowledge about a local historical place, Wat Phra That Lampang Luang, and the philosophy behind building sacred place such as the temple.

Although Northern Illinois policy does not provide for compensation for treatment of any injuries that may result from participation in research activities, this should not be construed as a waiver of any legal rights or redress you or your child might have as a result of participation in this study.

Information obtained during this study may be published in educational journals or presented at educational meetings, but any information which could identify your child will be kept strictly confidential. In addition, only the researcher will have access to these data and the findings will be reported only in the aggregate. Individual participant data will not be reported.

Participation of your child this study is voluntary. Your decision whether or not to allow your child, as well as his or her own assent to participate, will not negatively affect you or your child. Your child will be asked to indicate individual assent to be involved immediately prior to participation, and will be free to withdraw from participation at any time without penalty or prejudice.
Any questions about the study should be addressed to Rosarin Adulseranee at 16 Sai Nampfung 3 Sirimunkarajarn Road, Muang, Chiang Mai. Telephone: (053) 213-497.

If you wish further information regarding your rights or your child’s rights as a research subject, you may contact my advisor, Dr. James Lockard, at (815) 753-8386 or the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

If you agree to allow your child to participate, please read the statement below and indicate your agreement by signing on the line provided.

I agree to allow my child ____________________________________________, to participate in this research study and acknowledge that I have received a copy of this consent form.

__________________________________________  _________________________
Signature of Parent/Guardian                Date

__________________________________________  _________________________
Rosarin Adulseranee, Researcher               Date
APPENDIX D:

QUESTIONNAIRE (THAI AND ENGLISH VERSIONS)
แบบสอบถาม

กรุณาตอบคำถามดังต่อไปนี้

1. เพศ (เพศ)
   ________ ชาย ________ หญิง

2. อายุ __________________________

3. ให้นักเรียนวงกลมจำนวนปีที่เรียนประวัติศาสตร์แล้วมา
   น้อยกว่า 1 ปี 1 ปี 2 ปี 3 ปี มากกว่า 3 ปี

4. นักเรียนเคยได้ยินคำว่า ศัลเจษวธรรม หรือไม่
   ________ เคย (ไม่ขอ 5)
   ________ ไม่เคย (ไม่ขอ 6)

5. ให้นักเรียนอธิบายความหมายของคำว่า ศัลเจษวธรรม ถาม 1 หรือ 2 ประโยค หากไม่มีทราบให้เขียนว่า
   ข้าพเจ้าไม่ทราบ

   ________________________________________________________
   ________________________________________________________
   ________________________________________________________
   ________________________________________________________

6. ให้นักเรียนวงกลมจำนวนชั่วโมงในการใช้คอมพิวเตอร์ต่อหนึ่งสัปดาห์
   น้อยกว่า 1 ชั่วโมง/สัปดาห์ 1 ถึง 3 ชั่วโมง 3 ถึง 5 ชั่วโมง มากกว่า 5 ชั่วโมง/สัปดาห์

(ไม่ห้ามลั่นไป)
7. ให้นักเรียนบอกอุปกรณ์ในการใช้คอมพิวเตอร์ (เลือกได้มากกว่า 1 ข้อ)

__________ อีเมล
__________ ท่องเวป
__________ ค้นหาข้อมูลเกี่ยวกับเรื่องเรียน
__________ ฟังเพลง
__________ ใช้โทรศัพท์ทางอินเตอร์เน็ต
__________ ดาวน์โหลดโปรแกรม
__________ เข้าแชทกุรูหรือใช้instant message
__________ ดูหนัง
__________ อ่านหนังสือพิมพ์หรือนิตยสารทางอินเตอร์เน็ต
__________ เล่นเกม
__________ อื่น ๆ (กรุณาระบุ) _______________________________________

__________________________________________
QUESTIONNAIRE (in translation)

Please fill out the form about yourself.

1. Gender (Please check):
   ______ Male  ______ Female

2. Age _________________________

3. How many years have you studied the history of Lanna?
   Less than 1 year  1 year  2 years  3 years  More than 3 years

4. Have you ever heard about “Ka-ti-Jak-kra-wan?”
   ______ Yes  If yes, go to No. 5
   ______ No  If no, go to No. 6

5. Explain in one or two sentences the meaning of “Ka-ti-Jak-kra-wan.” If you do not know the meaning, write down, “I do not know.”

   _______________________________________________________
   _______________________________________________________

6. How many hours per week do you use a computer? (Please circle one)
   Less than 1 hour/week  1 to 3 hours/week  3 to 5 hours/week  more than 5 hours/week

7. What are your purposes for using computer? Please check all that apply.
   ______ E-mail
   ______ General surfing
   ______ Gather research info
   ______ Listen to music
   ______ Internet phone
   ______ Others (please specify) _____________________________
   ______ Read online newspaper or magazine
   ______ Download software/files
   ______ Chat/instant messaging
   ______ Watch movies
   ______ Play games

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APPENDIX E:

MAP OF LAMPANG PROVINCE, THAILAND AND

MAP OF KO KHA DISTRICT, LAMPANG PROVINCE, THAILAND
Map of Ko Kha district, Lampang Province, Thailand
APPENDIX F:

LESSON CONTENT: KRA-TI-JAK-KRA-WAN (THAI AND ENGLISH VERSIONS)
คติจาระวัล

บทนำ

ข้อรำคำตามความเชื่อของสมุคนคืออะไร นักเรียนทราบไหม แนวคิดเรื่องคติจาระวัล หรือ ถั่วบันหนึ่ง คือ การสร้างสมุดย่อของสมุคนเกิดขึ้นมาเป็นสมุบรม หรือ การจุ่มตุ่งหยาหารวัล ได้รับการเผยแพร่มาจาก ลาเช่นจารกับปุ่มขั้น พื้นที่ที่ถูกกำหนดให้เป็นสมุดย่อจาระวัลจะเป็นสถานที่ศักดิ์สิทธิ์สำหรับใช้ในการประกอบ ทิพธาร และเป็นที่อยู่รวมความเชื่อมันของคนในชุมชน

รูปแบบการจาระวัล

รูปแบบการจาระวัล คือ บั้นคัดเลือกเป็นสมุดย่อกลาง วิหารทัศน์ ๘ ที่ศร วางตามแนวแนวที่สัมพันธ์กับ องค์เจดีย์ โดยมีอาคารหลัก คือ วิหารหลวงอยู่ฝั่งตะวันออก สำหรับปัจจุบันเป็นที่ประกอบสีพิธี ในที่ศร เรียงตามที่ศรเนื่อง ๘ ที่ศร อาจจะเป็นห้องแห่งหนึ่งของวิหาร ไล่ละ ยะละครึ่ง หรือประดิษฐา ดังนั้น โปรดมา บั้นคัดเลือก ที่ตั้งที่ตั้งของอาคารและสิ่งก่อสร้างแล้วจะอยู่บนทรัพย์

ความหมายของลาพพา

ลาพพาในความหมายของคติจาระวัลคืออะไร ลาพพาเป็นที่ที่อยู่แบบมหัศจรรย์ทั้งหมด และมีพพา แต่ละเรื่อง ถ้ามีความหมายที่เห็นได้และเห็นไม่ถึงมหัศจรรย์ทั้งหมด ดังนั้น ทุกอย่างก้าวไปตามลาพพาได้ก็เรา ด้วยฝั่งเดินอยู่บนบนมหัศจรรย์ทั้งหมดในวัสดุจาระวัล อันมีเขาประโยชน์และพรีดา ๆ ตลอดอยู่เป็นกำลัง

ด้านการปฎิบัติ

คติจาระวัลจักรกิจสมบูรณ์ตามแนวคิดจาระวัลภาษาไทยในประเทศต่อไปที่ ๑๑ พบได้ในวัสดุประกอบที่เป็น วิหารทางหนึ่ง วิหารหลวงคู่พระใหญ่ แต่ไม่จาระวัล มีเพียงวิหารหลวงลำปางหลวง ที่ อ.เกาะดง จ.ลำปาง ท่านั้นที่สมบูรณ์อยู่ ดังที่นักเรียนจะได้เรียนในหน้านี้ถัดไป

วัฒนธรรมลำปางหลวง

วัฒนธรรมลำปางหลวง จึงทรงลำปาง อยู่ทางด้านทิศเหนือของวัฒนธรรมล้านนา ทางจากตัวเมืองลำปางไป ประมาณ ๑๓ กิโลเมตร ต่อถึงอยู่ในเขาเอียงไปขวา คือ เมือง สี่แยกผาป่าน ที่ส่งผลถึงการเป็นที่พื้นที่เดิมที่มีการอยู่อาศัยอยู่มาเป็นเวลานาน อยู่ตามลำน้ำ แต่เป็นที่อยู่อาศัยของชุมชนนับตั้งแต่สมบูรณ์ที่ ๑๗ เกิดตัวมา เป็นวัฒน์ไก่สมบูรณ์ที่ดุของประเทศ ปัจจุบันนี้เป็นที่ประดิษฐกรรมครั้งแรกคลอดออกมา

ลักษณะของวัฒนธรรมลำปางหลวง

งานออกแบบทางสถาปัตยกรรมกระเบื้องด้านอร่อย ที่ตัดความเชื่อในจาระวัลภาษาไทยพระศาสนา ซึ่งเชื่อว่า ภาษาพระสมบูรณ์เป็นหลักของจาระวัล ปัจจุบันเป็นที่ตั้ง เช่น ในหัวใจของทุก ๆ ๘ ที่ศร แต่ละขั้นเป็นที่ตั้ง ๘ ภายใน ทางที่ผ่านซึ่งเป็นที่อยู่อาศัย ที่บ้านเพียงต้องรองรับจาระวัล บรรดาที่เป็นที่อยู่อาศัยในเขต จาระวัล หรือคู่มือมหัศจรรย์ทั้งหมด ดังนั้น การจุ่มตุ่งหยาหารวัล จึงเป็นการพยายามเสริมความมหัศจรรย์ ทั้งหมดให้ดูอยู่ตลอดไป

นอกจากนี้ บรรณาธิการพระยาวัลภาษาไทยพระศาลลำปางหลวง ยังกล่าวตอบไปด้วยวิหารหลวงปุ่มศีลเจดีย์ ซึ่งสมุดย่อ ซึ่งถูกเริ่มต้นทรัพย์จาระวัล ยื่นบรรด์อย่าง ๓ ทาง ด้านที่ผ่านไปทางทิศตะวันออก เป็นทางลาด ผ่านโดยปากเป็นผืนน้ำบานตาดอยู่ดีฝนที่ตั้ง และเต็งสิ่ง อันเป็นสีสันในการพัฒนาแต่ละอยู่ที่ตั้ง ด้วยอุทิศ จาระวัล แสดงที่อยู่อาศัยขึ้นมาได้ดีที่สุด นิยมใช้คำว่าจุ่มตุ่งหยาหารวัลในแนวทิพธาร และปัจจุบัน ทิพธาร ลำปางหลวง
ผังพัฒนาสาวัตพรประเทศลำปางหลวง

1. พระเจดีย์

ตามข้อบัตรประจำตัวในที่ประดิษฐานพระสมภพจริยาคุณพระพุทธเจ้าส่วนพระมหากาฬ (หน้าแรก) ข้างขวา
พระอัษฎางค์พระพรหม (ลำาค) ต้นนวามาดั่งบันธพลและเสิร์ฟพระเจ้า พระเจดีย์นี้ สิ่งก่อสร้างกันว่า สอง
ซึ่งมานานแล้วและมีการบูรณะซ่อมแซมในสมัยพระเจ้าติโลกราช พุทธศักราชที่ ๑๑

ลักษณะของพระเจดีย์
เป็นทรงกลมแบบต้นเมืองด้านนอกสมัยยุคคลาสสิกยุคใหม่ ก่ออิฐถือปูบ ฐานกว้างด้านละ๒๕
เมตร สูง ๕๕ เมตร มีก้านแก้วลูกครึ่งสูงหุ้นสุดยอดบัวล้อมเป็นรูปสี่เหลี่ยมจุรัส องค์พระเจดีย์
ภายในหุ้นล้อมแน่นที่สุดในแต่ละด้านองค์ บูชาว่า ทรงตรงที่ มีเดินแบบมาจากเจดีย์วัด
หัวขวัญ วัดท่าวังแสงเมืองหลวง อ. เมือง จ. เชียงใหม่

2. วิหารหลวง

เป็นวิหารประจำ มีอยู่ด้านทิศตะวันออกขององค์พระเจดีย์ มีการวางฝั่งอยู่ในแนวตะวันออก-
ตะวันตก ซึ่งเป็นแนวเดียวกับประตูใหญ่และองค์พระศรีดี ภายในมีเจตนาปราสาททรงเหลือง
ประดิษฐานพระพุทธเจ้าลำปางหลวง คือพระบรมมหาราชวันวิถี พ.ศ. ๒๕๒๖

ลักษณะของวิหารหลวง
เป็นวิหารทรงกระบอกในรูป ทรงสี่เหลี่ยมสมบัติ กว้าง ๒๗ เมตร ยาว ๒๐ เมตร หรือตามความชัดเจน
ด้านหน้า ๙ ชิ้น ด้านหลัง ๓ ชิ้น โครงสร้างขึ้นได้ คือ ทำจากไม้ทุกหมด หล่อลงมุกแก้วดีบังตน
รูปแบบที่ดีที่สุดในการออกแบบอุทิศกงผนวชจาก杨欢来自ด้าน เรียกว่า แผ่นดินลอง หรือ แผ่น
ทอนลง ด้านในของแห่งต้องมีการเขียนภาพเป็นเรื่องราวในภาค

3. วิหารหน้าเดิม

มีชื่อเรียกอักษรค่อนว่า วิหารภาพเขียน (คำว่า นาเดิม หมายถึง ภาพเขียน) ต้องอยู่ที่พื้นที่เหนือของ
องค์พระธาตุ สิ่งประดิษฐาน ส่วงเข้มข้นในสมัยพระเจ้าติโลกราชประมาณพ.ศ. ๒๗๔๗ – ๒๘๓๘ ภายใน
พระประดิษฐานพระประสม เป็นพระพุทธศรีสันติ นามว่า พระเจ้าสมุห์ท่านหลวง ขนาดหน้าตั้งกว้าง
๔๘ นิ้ว

ลักษณะของวิหารหน้าเดิม
วิหารหน้าเดิมเป็นวิหารทรงกระบอกสี่เหลี่ยม มีลักษณะเป็นรูปสี่เหลี่ยมผืนผ่า กว้าง ๔ เมตร ยาว ๒๐ เมตร สูง
๓๗ เมตร หรือตามความจริงมีด้านหน้า ๓ ชิ้น ด้านหลัง ๒ ชิ้น ตามแบบวิหารสันติ โครงสร้างเป็น
เครื่องไม้ หล่อลงมุกแก้วดีบังตนไม่มีฝ้าพื้น

4. วิหารหลังเก่า

ต้องอยู่ที่พื้นที่เหนือขององค์พระธาตุ หรือ อยู่ทางทิศเหนือของวิหารหลวง มีแบบ
คลาสสิกน่าจะไม่ได้เปรียบเป็นปูที่อยู่จริงและในที่การสร้าง ภายในมีพระพุทธปริศนา
พระพุทธเจ้าสุวรรณ สร้างจากไม้ที่ผ่าออก เป็นพระพุทธศรีสันติของพระรูปจันทน์ ๑๙ ส่วน สร้างโดยเจ้า
หน้าที่ที่สร้าง มีการทำหูยุคในลักษณะภูคโลกที่ ๑ ได้วิหารพุทธและตรงข้ามในปี พ.ศ. ๒๕๑๐

5. วิหารพระพุทธ

ต้องอยู่ที่พื้นที่เหนือขององค์พระธาตุดุคกับวิหารหน้าเดิม ภายในประดิษฐานพระประสมเป็นพระพุทธปร
ิศนาวิรุฬห ขนาดหน้าตั้งกว้าง ๒๗ นิ้ว สูง ๓๗ นิ้ว ในด้านบนและนวมที่พระพุทธเจ้าองค์หลวง
เชิงกันว่า พระพุทธปริศนา สร้างในสมัยเจ้าแต่น้ำพระเกศ พ.ศ. ๒๗๑๒ วิหารพระพุทธนี้มีลักษณะเป็นรู
พื้นแบบเดียวกันกว้าง ๑๐ เมตร ยาว ๒๕ เมตร เป็นวิหารแบบพื้นแบ่งที่มีหน้าบิด มีประตู หน้าต่าง
สิ่งประดิษฐานกว้างเดิมเป็นวิหาร.orig แต่มีการบูรณะภายใน

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6. วิหารละวิ

ยึดอยู่รัฐวิถีอย่างว่า วิหารพระเจ้าอิลีหรือวิหารเจ้าพ่อ ตั้งอยู่ทางทิศตะวันออกขององค์พระธาตุ
สร้างเมื่อประมาณปี พ.ศ. ๒๔๐๐ โดยเจ้ากรุงละวิวิหารราชบัลลังก์ของพระนครเจ้าพ่อ เป็นอาคารเปิด
โล่ง ภายในประดิษฐานพระพุธรูปปางมงคลสมโภชพระ สร้างจากหินสีขาว หน้าตึกกว้าง
๖๐ นิ้ว สูง ๗๒ นิ้ว

7. หลวงพระพุทธบาท

ตั้งอยู่ทางด้านหลังของวิหารพระพุทธบาท สร้างขึ้นในสมัยเจ้าพระยาที่อยู่ในพ.ศ. ๒๔๒๗ เพื่อครอบบอย
หลวงพระพุทธบาท หลวงพระพุทธบาทนี้ มีลักษณะเป็นอาคารทรงแทแหนก กลิ่นเป็นต้นทิพย์ ตั้งอยู่บนฐาน
สูงกว่า ยาว ประมาณ ๓.๕๐ เมตร หลังคาจั่ว มีชายตัวชิ้น ภายในหลวงพระพุทธบาทนี้ จะ
สามารถมองเห็นแสงที่มาจากเป็นแสงพระธาตุและวิหารหลวงลำบวนกลับ

8. ผูกผ้า

ตั้งอยู่ทางทิศตะวันตกเฉียงใต้ของพ่อพุทธภาค เป็นอาคารทรงสไตล์ ไม่มีประดิษฐ์ว่าสร้างขึ้นใน
สมัยใด แต่เดิมสันนิษฐานว่า ใช้เป็นที่อยู่หลัก เพราะมีป่าอยู่ด้านหน้า

9. ปลากฉาก

เป็นต้นไม้ใหญ่ ตั้งอยู่ทางทิศตะวันออกเฉียงใต้ของพ่อพุทธภาค เป็นต้นไม้ที่มีเรื่องราวเกี่ยวกับ
การล่าสัตว์ของพระพุทธบาท ณ ต้นเด 시간 ตามฐานพระธาตุกล่าวว่า มีลักษณะต่างชิ้นข้อว่า อธิษฐาน
เอาไว้ประจำวัน ตลอดปีนี้ก็จะกระทบกั้นให้ไปถึงพระพุทธบาท กลับภายในวัน พระพุทธบาท
ปลากฉากปักไว้ที่นั่น ดังปรากฏกันเองมันโดยยืน

10. ภูเขา

ภายในเขตพุทธรวดของวัดพระธาตุลำปางหลวง พบการก่อสร้างภูเขา ๒ ด้าน ด้านเหนืออยู่พระ
ธาตุเด่นชัดหน้า ด้านตะวันออกอยู่หน้าพระธาตุ เชื่อกันว่า เป็นรู opinapหลังพระธาตุ หรือไม่เชื่อปี ภู
อาจเป็นความเชื่อเดิมของท้องถิ่นที่ถูกปรับให้เข้ากับตึกพุทธศาสนา

11. กำแพงและประตู:

กำแพงเหล่านั้นเด่นชัดของวัดพระธาตุลำปางหลวงใช้กำแพงเป็นสิ่งกันที่ ปัจจุบันมิ
ปรากฏอยู่แล้ว ๓ ด้าน คือ ประตูทางทิศตะวันออก ซึ่งเป็นทางเข้าหลักสุวรรณารามหลวง มี
ลักษณะเป็นชั้นประดับฉนวนหลังโกรธี บี่เรียก ประตูใหญ่ หรือ ประตูที่ ประตูทางทิศตะวันออก
แต่แล้ และประตูทางทิศใต้เข้าทางวิหารพระพุทธบาท

บทสรุป

จะเห็นได้ว่า ลักษณะการจัดวางพื้นที่อาคารและสิ่งก่อสร้างต่าง ๆ ในวัดพระธาตุลำปางหลวง เป็นแบบอย่าง
แสดงให้เห็นถึงศาสตร์การวางของพระธาตุนาฏศิลป์ไทย กล่าวคือ มีองค์พระธาตุเป็นองค์ประธานและ
ศูนย์กลาง องค์พระธาตุจึงมีปริมาณที่มีขนาดใหญ่ของชั้นวาง ด้านเหนือขององค์พระธาตุ
จะอยู่ในแนวเดียวกับวิหารหลวงซึ่งเป็นวิหารหลักหน้าทางทิศตะวันออก

นอกจากนี้ ยังมีวิหารครบถ้วนที่สำคัญ ๔ ห้อง วิหารพระพุทธบาท ปรับเปลี่ยนกับภูเขาใหญ่สิ่งศิริที่ล้อมรอบพระธาตุ
โดยมีขนาดใหญ่เป็นที่มีอยู่ที่สำคัญที่สุด เนื่องจากเป็นที่ที่เป็นที่พระพุทธบาท ประดิษฐ์ ตรรปลุ และพระพุทธบาท
และยังเป็นหนึ่งในที่ที่บรมศิริสิ่งศิริ ดังนั้น การสร้างวิหารหลวงให้มีขนาดใหญ่กว่าวิหารซึ่ง ๆ จึงเป็นการทำงานให้
เห็นถึงความเข้าใจในเรื่องจรรยาของชั้นของพระธาตุในสมัยก่อน
Kra-ti-jak-kra-wan (lesson content -- in translation)

Kra-ti-jak-kra-wan is the way of building a sacred place on an empty sand space. According to Kra-ti-jak-kra-wan, sand space represents the Sri-tan-dorn ocean and sand itself means a drop of water. To build a sacred place, the pagoda (chedi) must be placed on the center of the space with four temples (viharn) on the north, south, east, and west. These buildings can be surrounded by small temples, building of Buddhist scriptures, belfry, Footprint-of-the-Buddha chapel, trees, ponds, and pagoda protectors (jak). The principal temple, which is always on the east side of the pagoda, is the place for ritual practice.

During the 21st Buddhist era, there were few places in Chiang Mai (Wat Phra Singh), Lampoon (Wat Phra That Haripunchai), and Lampang (Wat Phra That Lampang Luang) that ideally applied Kra-ti-jak-kra-wan. At present, only the structures at Wat Phra That Lampang Luang, Lampang, followed Kra-ti-jak-kra-wan.

Wat Phra That Lampang Luang is located in Ko Kha district, Lampang province. The Wat itself was an ancient city called Lam Pa Kap Pa. The structures of Wat Phra That Lampang Luang are listed below.

1. Pagoda (chedi), covered in gilded copper sheets known as chang-go. The original date of construction is not known. The size is 45 meters high and 24 meters at the base. The design of the pagoda is quintessentially Lanna, with a high redented square base above which the prominent circular moldings, bell and spire taper smoothly to the finial (Freeman, 2001). It is the place where a piece of Lord Buddha's left forehead and neck bone are enshrined.

2. Principal Temple (Viharn Luang) is located in front of the pagoda on the east. Built in 1476, this temple is open-sided and is the most exceptional large wooden structure of its type in Lanna. The size is 36 meters long and 17 meters wide. There is an image of the principal Buddha named Phra Chao Lan Thong, cast in 1563, inside the temple.

3. Nam Tam Temple (Viharn Nam Tam) is located on the north side of the pagoda and in line with the Ton Kaeo temple. It is the open-sided temple dating from the early 16th century and believed to be the oldest extant wooden religious building in the country (Freeman, 2001). The size of the temple is 20 meters long, 8 meters wide, and 7 meters high. There is an image of the principal Buddha named Phra Chao Sam Muan Thong inside the temple.

4. Ton Kaeo Temple (Viharn Ton Kaeo) is located on the north east side of the pagoda. The original date of construction is not known. There is an
image of the principal Buddha that represented the Na Lampang family inside the temple.

5. Phra Put Temple (Viharn Phra Put) is located on the south side of the pagoda. The date of construction is around the 13th century and rebuilt in 1802 with beautiful colored glass inlay work covering the entire façade in rectangular panels (Freeman, 2001). This is a close-sided temple (it has a door, windows, and walls) with the size of 25 meters long and 10 meters wide. There is an image of the principal Buddha named Phra Putta Chao Ong Luang inside the temple.

6. Phra La Wo Temple (Viharn Phra La Wo), also called Viharn Phra Sao Sila, is located on the west side of the pagoda. The original was, according to legend, built by Queen Chamathewi’s father in 657 to enshrine a stone image, the Phra Nak Pok (Freeman, 2001).

7. Footprint of-the-Buddha Chapel (Ho Phra Putthabat), built in 1449, is located behind Phra Put Temple.

8. Ubosot, dating from 1476 and rebuilt in 1924, is located on the south west side of the pagoda and has a pond in front of it.

9. Ancient Indian elm tree (Kachao tree) is on the south east side of the pagoda. According to the legend, it was planted at the time of the Buddha’s visit two and a half thousand years ago (Freeman, 2001).

10. Pagoda protectors (Kummapan), one of them stays in front of the pagoda and the other stays behind the pagoda. Their purpose is to protect the pagoda.

11. Walls and entrances are used as the territory of Wat Phra That Lampang Luang. The main entrance is on the east and leads the way to the Principal Temple. The other two entrances are on the north and on the south and lead to Nam Tam Temple and Phra Put Temple respectively.

One can see that all the buildings, trees, ponds, and ogres found at Wat Phra That Lampang Luang followed the idea of Kra-ti-jak-kra-wan. That is, the pagoda is on the center of a sand space and has the four main temples on the north, south, east and west. The Principal Temple or Viharn Luang is the largest and the most important temple. It also represents Chom Pu Taweeb (the capital city of Buddhism) where Lord Buddha was born, enlightened, and proclaimed his words.
Kra-ti-jak-kra-wan

Sand space

- Nam Tam Temple
- Ton Kaeo Temple
- Phra La Wo Temple
- Principal Temple
- Indian elm tree
- Phra Put Temple
- Ubosot
- Footprints of the Buddha Chapel
- Main entrance
- Door

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APPENDIX G:

SCREEN DESIGN AND NAVIGATIONAL ICONS
Screen 1: Title
_screen 2: Objectives
คิดจิตรวัลาย >> วิธีใช้โปรแกรม

หลังจากที่นักเรียนกดที่ปุ่ม เริ่มบทเรียน จะมีหัวข้อทั้งหมด ๑๓ หัวข้อ และปุ่มสามปุ่มอยู่ด้านล่าง
โปรแกรมจะเริ่มที่หัวข้อต่าง ๆ เพื่อเรียนรู้เรื่องหัวข้อราว  จะมี
เครื่องหมาย ✔ ปรากฏในช่องสีเหลือง  ของหน้าหลัก
เมื่อเลือกความทุกหน้าแล้ว จะมีเครื่องหมาย ✗ อุ้มทะลุมุมฉาข้อของหน้าหลัก ให้นักเรียน
กดที่ปุ่ม ออกจากโปรแกรม ที่หน้าหลักเพื่อออกจากรายงาน

หากครุย์แล้วปุ่มที่ปุ่มเริ่มบทเรียนใดเลย

Screen 3: How to use the program
Screen 4: Main menu
APPENDIX H:

IMMEDIATE AND DELAYED COMPREHENSION POSTTESTS (THAI AND ENGLISH VERSIONS)
แบบทดสอบ

จงอ่านคำถามต่อไปนี้เกี่ยวกับเรื่องที่นักเรียนพ่วงอ่าน แล้วเลือกคำตอบที่ถูกต้องที่สุด โดยทำเครื่องหมาย X หัวข้อ ก, ข, ค, หรือ ง

1. คลื่นจักรวาลเป็นแม่คิดที่ได้รับมาจาก __________
   ก. กับผู้
   ข. รายเกียรติ
   ค. ป้าหมาน
   ง. มานานที่สิ่งที่ค้น

2. รูปแบบการวางแผนทุทธาศาสที่ถูกต้องคือมีองค์เจตย์ __________
   ก. เป็นสูญกล่าว
   ข. อยู่ทางทิศใต้
   ค. อยู่ทางทิศตะวันออก
   ง. อยู่ทางทิศตะวันตก

3. ในวิทยาศาสตร์บางหมวด วิหารโดยอยู่ทางทิศตะวันออกขององค์เจตย์
   ก. วิหารดินแก้ว
   ข. วิหารหลวง
   ค. วิหารพระพุทธ
   ง. วิหารน้ำเดิม

4. วิหารโดยอยู่ทางทิศเหนือขององค์เจตย์
   ก. วิหารดินแก้ว
   ข. วิหารหลวง
   ค. วิหารพระพุทธ
   ง. วิหารน้ำเดิม

5. ความคลื่นกระจค เสียงกล่อมหรือเสียงดังอยู่บนลานทรรศยพระ __________
   ก. ทรงเป็นเสียงที่ปรากฏและไม่แก่ความชื่น
   ข. ทรงเป็นเสียงที่ปรากฏเป็นมาทางสัณหีดฝั่งคู
   ค. ทรงเป็นเสียงออกจิตอย่างพระสุนทร
   ง. ทรงเป็นเสียงออกจิตอย่างความละเอียดอ่อน

6. ข้อใดคือความหมายที่ถูกต้องของเม็ดทรรษอตามลำกล้าของคลื่นจักรวาล
   ก. ทรัพี
   ข. เกาะ
   ค. หยดน้ำ
   ง. มหาสมุทร

7. วิหารพระศูนย์กลางต้องอยู่ในชายเมืองโบราณเรียง __________
   ก. กุ้มครั่ง
   ข. สิ่งที่ใหม่
   ค. เบี้ยสะพัก
   ง. เคลื่อนสะพักไป

8. พระเจดีย์ที่วิหารพระศูนย์กลางเรียง __________
   ก. เป็นคลื่นวลเล่นรายสมุทร
   ข. เป็นคลื่นวลเล่นรายสมุทร
   ค. เป็นที่ประดิษฐานพระพุทธ
   ง. เป็นที่ที่พระพุทธเจ้าปักป้อมเจริญไว้
9. ไปบริการทั้งหมดหรือพี่ชุมชนโดยพิจารณาอยู่
  ก. พระพุทธรูป
  ข. พระเจ้าล้านหอง
  ค. พระเจ้าสมุห์แห่ง
  ง. พระพุทธรูปเจ้าองค์หลวง

10. พระพุทธรูปที่สำคัญของพระสุกิตร่อสิ่ง 3 ลำปาง ประดิษฐานอยู่ในวิหารใด
  ก. วิหารด้านตะวันออก
  ข. วิหารนิมิต
  ค. วิหารหลวง
  ง. วิหารพระพุทธรูป

11. วิหารใดเป็นวิหารแบบเปิด
  ก. วิหารหลวง
  ข. วิหารนิมิต
  ค. วิหารพระพุทธรูป
  ง. วิหารพระตะวัน

12. วิหารคนเป็นสิ่งลักษณะของ
  ก. ปราบพิษณุโลก
  ข. ปราบเครื่อง
  ค. คำแห่งจักรวาล
  ง. วิหารของทุกท่าน

13. สิ่งใดต่อไปนี้อยู่ด้านหลังของวิหารพระพุทธรูป
  ก. อุโบสถ
  ข. กุฏิภักดิ์
  ค. ต้นหารจารวัล
  ง. หลวงพระพุทธรูป

14. ประดิษฐานข้ามเอกวัดพระธาตุล้านยอดมี 4 ด้าน
  ก. หน้า
  ข. ด้าน
  ค. ด้าน
  ง. ด้าน

15. ประดิษฐานที่ต้องเป็นทางข้ามหลักสูตรในวิหารหลวง
  ก. ชุมชนทางด้านที่ติด
  ข. ชุมชนทางด้านที่ติดเหนือ
  ค. ชุมชนทางด้านที่ติดตะวันตก
  ง. ชุมชนทางด้านที่ติดตะวันออก

16. ไม่มีข้าวต้นอยู่ทางทิศใดของผ้าพยาบาล
  ก. ที่ติดตะวันออก
  ข. ที่ติดตะวันตกเหนือ
  ค. ที่ติดตะวันตกใต้
  ง. ที่ติดตะวันออกเหนือ

17. ภาพเนื้อพระธาตุของวัดพระธาตุล้านยอดใช้สิ่งใดเป็นตัวกำหนดขบวนเขต
  ก. กำหนด
  ข. กำหนด
  ค. กำหนด
  ง. หลวงพระพุทธรูป
18. ผู้เขียนกล่าวว่าหน้าที่ วิหารที่ราษฎรมิตรภาพจะเป็นปัจจุบันกับทวีปсонมิตรภาพ ที่ล้อม เขาพร้อมสุนทรีย์
ข้อใดไปยัง วิหารทั้งสิ่งนี้
ก. วิหารระดับ
ข. วิหารสันติ
ค. วิหารพระยา
ง. วิหารพระพุทธ

19. วิหารใดเป็นปัจจุบันกับทวีป
ก. วิหารนามเดิม
ข. วิหารหลวง
ค. วิหารพระยา
ง. วิหารพระพุทธ

20. เหตุใดผู้เขียนจึงกล่าวว่าทางล้านนาในสมัยก่อนมีความเข้าใจเรื่องจักรวาลเป็นอย่างดี
ก. จากลักษณะของวิหารหลวง
ข. จากการวางผังพระธาตุทางล้านนา
ค. จากการวางแปลงเจดีย์ วิหารหลวงและประดิษฐาน
ง. จากความเข้าใจที่มีการสร้างกุฏิขึ้นมาเป็นเจดีย์
Comprehension Test (in translation)

Read the questions and select the best answer by marking an x in front of choice a, b, c, or d.

1. Kra-ti-jak-kra-wan is the concept received from _________
   a. Cambodia.
   b. Ra-ma-ya-na.
   c. Him-ma-pan forest.
   d. Sri-tan-dorn ocean.

2. According to Kra-ti-jak-kra-wan, the correct position of the pagoda (chedi) has to be in the _________
   a. center.
   b. south.
   c. east.
   d. west.

3. Which temple is on the east side of the pagoda (chedi) in Wat Phra That Lampang Luang?
   a. Ton Kaeo Temple (Viharn Ton Kaeo)
   b. Principal Temple (Viharn Luang)
   c. Phra Put Temple (Viharn Phra Put)
   d. Nam Tam Temple (Viharn Nam Tam)

4. Which temple is on the north side of the pagoda (chedi) in Wat Phra That Lampang Luang?
   a. Ton Kaeo Temple (Viharn Ton Kaeo)
   b. Principal Temple (Viharn Luang)
   c. Phra Put Temple (Viharn Phra Put)
   d. Nam Tam Temple (Viharn Nam Tam)

5. According to Kra-ti-jak-kra-wan, all the buildings must be built on sand because _________
   a. sand is easy to find and does not hold moisture.
   b. sand represents the Sri-tan-dorn ocean.
   c. sand represents the center of the universe in Buddhism.
   d. sand represents tidiness.
6. Which of the following is the correct meaning of sand in Kra-ti-jak-kra-wan?
   a. Continent
   b. Island
   c. A drop of water
   d. Ocean

7. Wat Phra That Lampang Luang is located in an ancient city called
   __________
   a. Ku-kut-na-korn
   b. Sing-hon-na-wat-na-korn
   c. Sri-ha-pa-lo
   d. Lam-pa-kap-pa

8. The pagoda (chedi) at Wat Phra That Lampang Luang ____________.
   a. is the art of Lanna and Su-kho-thai.
   b. is the art of Lanna and La-wo.
   c. is the place where a piece of Lord Buddha’s left forehead and neck bone are enshrined.
   d. is the place where Buddha planted the ancient Indian elm tree (Kachao tree).

9. Which Buddha image is placed inside the principal temple?
   a. Phra Put-ta-sai-yat
   b. Phra Chao Lan Thong
   c. Phra Chao Sam Muan Thong
   d. Phra Putta Chao Ong Luang

10. An image of the principal Buddha that represented the Na Lampang family is inside which temple?
    a. Ton Kaeo Temple (Viharn Ton Kaeo)
    b. Nam Tam Temple (Viharn Nam Tam)
    c. Principal Temple (Viharn Luang)
    d. Phra Put Temple (Viharn Phra Put)

11. Which temple is a close-sided temple (has a door, windows, and walls)?
    a. Principal Temple (Viharn Luang)
    b. Nam Tam Temple (Viharn Nam Tam)
    c. Phra Put Temple (Viharn Phra Put)
    d. Phra La Wo Temple (Viharn Phra La Wo)
12. Viharn Kot represents the ______________
   a. Him-ma-pan forest.
   b. Kong-ka river.
   c. wall of the universe in Buddhism.
   d. heaven in Buddhism.

13. Which of the following is located behind Phra Put temple?
   a. Ubosot
   b. Pagoda protectors (Kummapan)
   c. An ancient Indian elm tree
   d. Footprint of-the-Buddha Chapel (Ho Phra Putthabat)

14. How many entrance ways are there in Wat Phra That Lampang Luang?
   a. one
   b. two
   c. three
   d. four

15. Which entrance way leads to the Principal temple?
   a. The entrance way on the south
   b. The entrance way on the north
   c. The entrance way on the west
   d. The entrance way on the east

16. According to Kra-ti-jak-kra-wan, an ancient Indian elm tree is located on
    which side?
    a. West
    b. Southwest
    c. Southeast
    d. Northeast

17. Wat Phra That Lampang Luang uses which of the following to indicate its
    borders?
    a. Walls
    b. Pagoda protectors (Kummapan)
    c. An ancient Indian elm tree
    d. Footprint of-the-Buddha Chapel (Ho Phra Putthabat)
18. Which of the following temples is not considered one of the main temples in Kra-ti-jak-kra-wan?
   a. Nam Tam Temple (Viharn Nam Tam)
   b. Ton Kaeo Temple (Viharn Ton Kaeo)
   c. Phra La Wo Temple (Viharn Phra La Wo)
   d. Phra Put Temple (Viharn Phra Put)

19. Which temple represents Chom Pu Taweeb (the capital city of Buddhism)?
   a. Nam Tam Temple (Viharn Nam Tam)
   b. Principal Temple (Viharn Luang)
   c. Phra La Wo Temple (Viharn Phra La Wo)
   d. Phra Put Temple (Viharn Phra Put)

20. Which of the following is true about building the sacred place and understanding the meaning of Kra-ti-jak-kra-wan?
   a. From the size of Principal Temple
   b. From the Plan page of Wat Phra That Lampang Luang
   c. From the placement of the pagoda, Principal temple, and the entrance ways
   d. From the belief of having Pagoda protectors (Kummapan)
APPENDIX I:

ASSENT FORM (THAI AND ENGLISH VERSIONS)
แบบฟอร์ม การทดลองเข้าร่วมงานวิจัย

ข้าพเจ้า ____________________________ ได้รับอนุญาตให้เข้าร่วมการทดลองใน
งานวิจัย หัวข้อ The effects of using different types of multimedia presentations on Thai seventh-
grade learners’ understanding of a social studies text โดย นางสาว ธรรม อุดมเยศรี เป็นผู้ทำวิจัย

ผู้ทำวิจัยได้สัญญาจดประสงค์ในการทำการทดลองครั้งนี้ว่าจะมีเนื้อหาเท่ากับ วัตถุประสงค์ล่างอย่างลง และหลักที่ใช้ในการสร้าง หรือ คัดจูงวิจารณ์ โดยใช้ภูมิปัญญาที่มีอยู่ในการทำการทดลอง

การทดลองนี้จะทำในห้องปฏิบัติการคอมพิวเตอร์หลังโรงเรียนแลก ข้าพเจ้าจะได้รับแบบสอบถามเกี่ยวกับ
ประวัติของข้าพเจ้า ความรู้เรื่องประวัติศาสตร์แผ่นดิน ความหมายของคำว่า ศิลปะ และความนิยมที่
ข้าพเจ้าใช้คอมพิวเตอร์เรียนรู้เรื่องสังคม และจุดประสงค์ในการใช้คอมพิวเตอร์ของข้าพเจ้า หลังจากนั้นจะ
เนื่องแบบคอมพิวเตอร์ ข้าพเจ้าจะได้รับแบบทดสอบเพื่อวัดความเข้าใจเรื่องที่อ่านไป การทดลอง
ทั้งหมดจะใช้เวลาหนึ่งชั่วโมงครึ่ง คือใช้เวลาศึกษาเนื้อหา 1 ชั่วโมงและทดสอบอีกครึ่งชั่วโมง หลังจากนั้นถึง
ผลงานสิ้นท้าย ข้าพเจ้าจะทำแบบทดสอบอีกครั้งเป็นเวลาครึ่งชั่วโมง ที่ห้องปฏิบัติการคอมพิวเตอร์หลังโรงเรียน
แลก

การเข้าร่วมการทดลองนี้จะไม่มีผลใดๆ ต่อการเรียนรู้รายบุคคลของศิษษ์ของข้าพเจ้า แต่อาจทำให้ความ
สนุกและความรู้ของข้าพเจ้าที่มีต่อการสอนเกิดในลักษณะเดียวกัน

ผู้ทำวิจัยได้สัญญาให้สัญญากับข้าพเจ้าว่า ข้อมูลทุกอย่างที่เกี่ยวกับข้าพเจ้าและการทดลองครั้งนี้จะถูกเก็บเป็น
ความลับและไม่มีการเปิดเผยต่อผู้ร่วมของข้าพเจ้า

ทั้งนี้ ข้าพเจ้ามีสิทธิ์ที่จะไม่เข้าร่วมการทดลอง และหากข้าพเจ้าเข้าร่วมการทดลองแล้ว ข้าพเจ้ายินยอมขั้นตอนดังกล่าว และ/หรือ ระหว่างการทดลองโดยไม่ได้มีความคิดหรือได้รับการกระทำใดๆ นอกจากนี้ข้าพเจ้ายัง
สามารถบอกคำตกลงที่เกี่ยวกับการทดลอง และข้อตกลงของข้าพเจ้าได้รับการทดสอบจากผู้ทำวิจัยก่อนที่จะเข้าร่วม
การทดลอง

ข้าพเจ้านั้นได้เข้าร่วมการทดลอง

__________________________________________

ผู้เข้าร่วมการทดลอง วันที่ / เดือน / ป.ศ.

__________________________________________

ผู้ปกครอง วันที่ / เดือน / ป.ศ.

__________________________________________

นางสาว ธรรม อุดมเยศรี ผู้ทำวิจัย วันที่ / เดือน / ป.ศ.

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I, ____________________________, have been asked to participate in the study titled, The effects of using different types of multimedia presentations on Thai seventh-grade learners' understanding of a social studies text, which has been explained to me by the researcher, Rosarin Adulseranee.

I have been told that the purpose of this study is to learn more about local historical places, Wat Phra That Lampang Luang and the philosophy, Kra-ti-jak-kra-wan, behind building sacred places such as the temple using four different multimedia presentation formats.

This study will be performed in a school computer lab after school using multimedia software. I will be given a questionnaire to answer about my gender, age, prior knowledge about the history of Lanna, the meaning of Kra-ti-jak-kra-wan, hours per week I use a computer, and the purpose of using computer. I will also be given a paper-based comprehension test after using the software. It will take me one hour for the learning task and half an hour for the test. Two weeks later I will be asked to do the test again in a school computer lab after school. It will take me another half an hour to do the test.

I understand that this study will not affect my grade in social studies. It may increase my interest and knowledge about local historical places.

I have been promised that anything the researcher learns about me in this study will be kept confidential.

I have been told that I do not have to participate in the study. If I do participate, I understand that I may stop at any time without penalty. I have been allowed to ask questions about the study, and all of my questions were answered.

I willingly agree to be in this study.

_________________________________  _______________________
Participant                          Date

_________________________________  _______________________
Rosarin Adulseranee, Researcher    Date