

The Impact Of Multimedia and Redundancy on the Efficiency of History Presentations

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Abstract

The use of educational technology to create classroom presentations is already commonplace in American history classes. Therefore, this study focuses on how multimedia presentations can promote efficient instruction specifically, can the employment of the multimedia and redundancy principles (Mayer, 2009) improve the efficiency of student learning in high school history. The goal is to identify methods of multimedia presentation design that maximize the efficiency of instruction, as a gap in literature exists when referencing the performance of adolescents in a public high school and in the study of history. Keeping the focus on efficient learning, this study uses a quasi-experimental post-test only control group design to determine if more learning occurs during a presentation that incorporates either the multimedia or the redundancy principle.

Keywords: Cognitive load theory, 12 Principles of Multimedia Learning, Efficiency Learning, Multimedia Principle, Redundancy Principle

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Chapter 1: Introduction

This dissertation examines the potential impact of employing the multimedia and redundancy principles of the cognitive theory of multimedia learning in designing high school United States history instructional media in the State of Maine as a means for improving learning efficiency.

Background

Understanding the purpose of this research first requires an exploration of the term learning efficiency. Clark, Nguyen and Sweller (2006) state, in their book entitled *Efficiency in Learning* that the cognitive load theory describes efficient learning in terms of two variables: the performance of the learner and the amount of effort exerted by the learner during the process (p. 19). A classroom that enables learners to expend minimal effort and achieve maximum performance is, by this definition, considered to be efficient. Teachers then, could feasibly make their lessons more efficient by either mitigating the required effort to achieve a desired performance level, such as a content standard, or elevating the amount of effort used by the student to achieve a higher level of performance.

In a practical sense, the promotion of efficient learning must not be limited to a discussion of student effort and performance, but must also consider the reality that several natural obstacles within the learning environment, such as time and available resources, can inhibit student achievement and decrease learning efficiency. For instance, every school must operate on a time schedule within which the desired level of learning must occur. When the performance level of the students falls short of the desired goal, efforts are made to improve the efficiency of learning. Many of these reforms fail for a variety of reasons. According to John Sweller's (2006) description of learning efficiency, when a student is overloaded the required effort must be decreased often by adding more time requirements through strategies such as segmenting. But what if there is no more time available? This study attempts to consider this and other limitations, along with Sweller's definition of efficiency as key components in a more thorough and practical approach to learning efficiency. On a broader scope, in

public education a definition of learning efficiency needs to consider time and financial resources expended, in addition to the measure of student learning.

The Cost of Education. Directly speaking, K-12 education is expensive. In Maine, as it is throughout the nation, public schools are under increasing pressure to improve the level of performance without the benefit of additional financial resources. As demands for improving student achievement escalate, Maine schools are experiencing a decrease in student enrollment and a decline in financial commitments from the local, state, and federal governments. Reduction of government spending on the state level cannot occur without sacrifices from K-12 education. In addition, the majority of school spending is tied up in salaries, insurance and heating costs that generally cannot be adjusted. The cost of health insurance alone has increased as much as 20% in any given year for the past decade and in that same time period the cost of heating and diesel fuel has more than doubled (Hermon, 2010). This means that maintaining level education funding has put a strain on curricular aspects of schools such as class sizes, course offerings and extra-curricular activities.

With the high costs involved in education, the simple addition of more funding to help improve instruction is not likely. According to the State of Maine (2010), nearly 32% of the 2010-11 supplemental state budget is for public K-12 education and in most communities, such as Hermon (2010), nearly three-quarters of local tax dollars are dedicated to schools. The rural nature of Maine communities and the steady decline of the natural resource-based economies of lumber, paper, potatoes, and fishing make raising education funds more difficult with the passing of each year. The current financial condition of the state makes any reforms or efforts to improve student achievement entirely dependent upon doing more within the limits of current financial resources.

Despite the high costs, financial efficiencies are already a reality. For example, highly paid teachers whose students underperform could be considered inefficient; while using the same rationale, poorly paid teachers who have high performing students can be seen as highly efficient. The Maine

Education Association (2010), the major labor union representing Maine teachers, points out that Maine educators, despite being highly experienced and generally at the top of their local pay scales, rank 43rd in the nation in average teacher salary and according to teacherportal.com (2010), Maine ranks 47th on a salary comfort index, a scale designed to measure the purchasing power of teacher salaries. Despite Maine's low salary ranking, an average sized school district in Maine will spend as much as 90% of its budget on salaries, health insurance, professional development, transportation and energy (Hermon.net, 2010). The fact that Maine teachers are among the lowest paid in the nation but state and local education expenditures are extremely high suggests that the exploration of financial efficiencies to make learning more efficient has already been exhausted. These factors make the reduction of school budgets as they currently exist or the addition of new programs or staff virtually impossible. The inability of the schools to acquire additional revenue adds urgency to the need to find other ways to improve learning efficiency.

Curricular and Time Demands. While this research is not meant to be an examination of political expectations or economic conditions, these factors are paramount to the genesis of the study. When government leaders stress the need for better performance from schools at a lower cost to the taxpayer the result is a catch-22 that promotes a stagnant status quo in education. How can public schools in Maine, particularly high schools, be more efficient in the use of funds and improve learning results? The two concepts do not seem to be compatible as efforts to improve learning usually translates into increased education spending. Likewise, lowering costs usually means either decreasing pay and benefits or cutting programs, which is typically perceived to be detrimental to student performance.

The problem with a required course like U.S. History is that every student must take it, and the knowledge that students are expected to possess on the history of the United States is constantly growing, while the time to teach it and the available resources are not. To illustrate this point, the

Bangor High School United States history curriculum guide identifies 20 units of study that are to be covered during the 11th grade year. When reducing the 175 student days in a school year to account for time lost to testing, school-wide assemblies and fire drills, there are roughly 140 instructional days remaining to learn new content. This leaves about 7 instructional days for each unit. Can a unit such as the American Revolution or the Civil War be adequately covered in seven 40-minute lessons? The goal of higher student achievement is in danger of becoming a pipe dream if educators are forced to cut significant chunks of content from the curriculum in the interest of time.

Existing Technology. In Maine, a high priority is placed on the use of technology in the classroom. In 1995, Governor Angus King and the 112th Maine Legislature began the Maine Learning Technology Initiative (MLTI), which pioneered one-to-one computing for all 7th graders in the state. A contract with Apple Computer has supplied multimedia laptops for the program. Over the past 10 years, despite tough economic decisions in other areas, the MLTI laptop program has expanded to 8th graders and, on a voluntary basis, to high schools. In addition to all students, all middle and high school teachers also receive a MacBook laptop and every school in Maine has been upgraded to include wireless capabilities (Maine.gov, 2010). Maine schools are more “wired” than most states in the nation, so the question becomes what kind of instructional innovation is coming from the availability of the most up-to-date technology? Is the technology used to make education more entertaining and engaging? What about making learning more efficient? Can educational multimedia instructional strategies be used to help students learn more information in less time, or at least learn more information with no additional time?

Anecdotal evidence seems to suggest that teachers are using the MLTI laptops to a greater extent every year, especially to make and deliver multimedia presentations. However, Clark (2008) cited the fact that more use of technology does not necessarily improve the quality or efficiency of instruction. The availability of the laptop computers is generally appreciated by teachers and most are

utilizing them for instructional purposes, but professional development opportunities are rare and few have analyzed the implications that the technology might have on teaching and learning. Many teachers view the use of technology as necessary in a techno-savvy world where students, now called “technology natives” are comfortable with multimedia, but they are unable to delineate between the use of technology and the *effective* use of technology and its impact on student learning.

As research can confirm, the incorporation of one-to-one computing has not significantly improved student performance in Maine (www.ed.gov). While Maine does typically do well comparatively speaking, there is no evidence to suggest that the very expensive MLTI program has anything to do with it. From an efficiency perspective, one could realistically argue that the MLTI program has decreased learning efficiency by making it costlier to achieve the same test scores. The problem has evolved into how to make learning efficient, as time and money are limited. Maine schools are at risk of losing the laptop program due to its price tag unless something can be done to prove that it truly does help improve student performance. In this sense, the level of learning efficiency caused by the availability of multimedia computers needs to increase in order to justify the expense.

The Solution

Within the realm of learning efficiency, the teaching of United States history poses a unique problem that has not emerged in other required courses in Maine's public high schools. To illustrate, during a December 2010 school committee meeting, Hermon School Committee Chairman Ralph Carr, a former social studies teacher, stated that he taught United States history 40 years ago and even then there was too much content to teach in one year. With the passing of every era in American history, the volume of necessary content grows, but the time and financial constraints demand that the content still be taught in one school year. A major question posed by this study is, can multimedia technology and a rethinking of how it is used help make teaching all of United States history in one year possible?

Teachers and their school leaders need to begin the effort to make learning more efficient by

focusing on things they can control, such as instructional methodology. If time runs out before everything in the curriculum is taught and learned, then attention should be given to finding ways to fit everything in instead of deciding what to skip. The major goal of this study is to find out if the use of very specific instructional strategies can make learning more time efficient. Essentially, can students learn more subject area content without additional time and expense if teachers develop a pedagogy that takes learning efficiency into consideration? If more learning can occur without adding more time or money to the process, then public education can realistically move toward the achievement of both demands--more results for less (or at least no more) money.

The problem now becomes finding a way to improve student learning and reach curricular goals given the reality of limitations from existing technology, financial and material resources and time. Reflecting back on the definition of efficient learning, an efficient classroom allows for maximum learning with minimal effort. The problem with this theoretical definition is that it does not adequately address the realistic obstacles to efficiency, time, and money. For example, a common method for reducing effort is to allow more time. What if there is no more time to give? High schools are governed by a rigid structure of bell schedules and calendars, and additional time allowances may not be realistic.

As a result, for the purposes of this research the definition of efficiency will be modified somewhat from the one forwarded by Sweller (2006); however, the main concepts will remain. The goal is still to maximize the level of student learning but the research will measure how much learning will occur within the confines of time and readily available resources. The reason for this is that students are expected to be in class and on task for a prescribed amount of time, and it is safe to assume that efficient instruction will maximize the use of that time. If students can improve their performance without extending the boundary of time, then the learning that occurs can be considered more efficient. This is not a total abandonment of Sweller's (2009) definition of efficient learning. His focus was to

get the student to learn the same amount of desired content with less effort, while this study suggests that it is also possible to learn more content with a consistent degree of effort. The alteration of the theory is a simple application of it to the reality of the high school classroom. Educators are not interested in getting students to learn with less effort or to finish their work in less time, but instead are concerned with being as productive as possible within the allotted time frame.

Rarely are learning efficiency and multimedia learning the focus of a study that involves high school students in a traditional classroom environment, nor does such a study generally address the learning of social studies content. Typically, the subjects in a study on these topics are found on a college campus and the nature of the learning task is usually skill-based “how to” knowledge rather than content knowledge. The problem posed by this situation is that educators still need to know if instructional design using strategies from these theories will work when the desired learning is content-based. Any research on the theories behind instructional design should address who the learners are and what is to be measured when evaluating the learner's performance.

In summation, improved learning gained by using the multimedia and redundancy principles centers on the efficiency of a lesson. Efficiency can take many different forms, such as learning more information with less effort or, within the framework of a public school calendar, learning more information without the addition of more time or resources. For example, if educators expect students to learn 10 specific content items per 30-minute lesson, is it possible to expect students to learn 15 or 20 items in the same amount of time? Getting more learning out of a consistent amount of time reflects greater learning efficiency. Even though the 12 principles of multimedia learning, particularly the multimedia and redundancy principles, address issues of effort and performance it is desirable to use the principles to determine if they can be effectively employed in a high school history classroom to help students increase their performance within a prescribed amount of time.

The Multimedia and Redundancy Principles

The cognitive theory of multimedia learning was created through extensive research by Richard Mayer (2009) and his colleagues and is based primarily on the concepts derived from John Sweller (2006) and the cognitive load theory. The twelve principles in the theory embrace David Paivio's concept that the human brain encodes information through two channels, visual and verbal, and that to maximize the efficiency of effort, students learn better when they are exposed to both deliveries. Sweller's cognitive load research examined how much information people could process in working memory at any one moment and found ways to optimize the use of verbal and visual information during the learning process. He and his colleagues discovered that exposure to a high level of information without overloading working memory maximized learning efficiency. The effort then became an attempt to discover how to fill working memory with relevant information, reduce distractions, and maximize the benefit of both encoding channels (Clark, Nguyen & Sweller, 2006). Expanding upon Sweller's work, Richard Mayer (2009) led research efforts to describe how to use multimedia presentations that maximize the efficiency of the learning process. The twelve principles represent aspects of multimedia presentations that work toward that goal. While the application of all twelve principles allows them to work in concert with one another, it is difficult to measure the effectiveness of each principle when they are used simultaneously. This study will examine two of the principles, multimedia and redundancy.

Multimedia Principle. Four of the principles in the cognitive theory of multimedia learning are aimed at fostering generative processing (Mayer, 2009, p. 221), which is defined as a cognitive process that helps a learner make sense of the material and includes organizing the incoming material into coherent structures and to integrating these structures with one another and with prior knowledge. In other words, it is the process of coding information into long term memory so that it can be recalled. The first of these three principles is the multimedia principle which states that people learn better from words and pictures than from words alone (p. 223). This is effectively the definition of multimedia

learning. All eleven of the studies cited by Mayer support the concept that more learning occurs when students are able to construct verbal and visual models.

Redundancy Principle. The fact that people learn better from graphics and narration than from graphics, narration and on-screen text is the definition of the redundancy principle provided by Richard Mayer (2009, p. 118). He argued that presenting information with images, on-screen text and narration creates an overload of extraneous processing. The student is forced to compare two sources of verbal information (written and spoken) when, theoretically, it is easier to just focus on one verbal source at a time. The inclusion of text along with images in the visual portion of the presentation creates a similar form of competition for working memory space by increasing extraneous load. The empirical support for this principle is strong, as all five of the studies cited by Mayer show statistically significant gains by students who viewed presentations without redundancy. Mayer also pointed out that redundancy can be reduced in several ways, such as shortening on-screen text to include fewer words or by locating the text next to an appropriate image.

Problem Statement

The problem being examined in this study is that inefficient use of time, resources, and available technology inhibits content learning in a high school United States history curriculum.

As mentioned earlier, a serious problem exists in United States history instruction. The growing body of content that is expected within the curriculum, not to mention the increased demands for time spent on reading, writing, research, and critical thinking skills, without the addition of more time is making desired content learning a more difficult goal to achieve. History educators continually search for ways to cover all of the material. Professional development, in an attempt to improve learning, explores many teaching strategies that can increase student performance. The problem with many of the current popular strategies is that increasing student engagement and learning is more time consuming, and thus, inefficient and eventually abandoned. History teachers are by nature lecturers,

not necessarily because it is the only way they know how to teach, but because it is perceived to be the most efficient way to teach, even though it may not be the most efficient way to learn. The teacher needs to cover all of the content, and in the process he or she abandons established and proven learning theories. From the student's point of view, they are instructed, but material is thrown at them in such a rapid manner that very little content knowledge is retained. Somewhere along the way, a disconnect emerges between the teaching of United States history content and the learning of United States history content.

Purpose Statement

The purpose of this study is to determine if the application of either the multimedia principle or the redundancy principle from the cognitive theory of multimedia learning, to multimedia-based United States history lessons will improve the efficiency of learning in the study of high school United States history content.

There is a great need to combine schools of thought. How can history teachers be more efficient in their instruction, *and* how can history students be more efficient in their learning? To do this, the term “best practice” may need to be replaced by “most efficient practice.” In other words, students need to be able to learn more information in the allotted time given to instruction. For decades, proponents of traditional methods have clashed with those who support constructivist methods over which strategy is best, but the reality probably lies somewhere in the middle. Generally speaking, literature suggests that constructivist methodology promotes better learning, but the studies usually ignore certain realities that face public education, especially time constraints. Old-school lecturers feel justified when they rely on the most traditional methods, and, in fact, a good lecture is probably still better than a poorly designed collaborative activity, especially when you consider how much curricular content is not covered.

An inconvenient truth is that public education is governed by a stopwatch, and the reality is that

we cannot easily change the boundaries in which the system operates. Learning must occur in a prescribed amount of time and with a limited amount of resources. Therefore, the time conservationists that remain loyal to the lecture need to combine thought with the constructivists who embrace multiple modalities of learning, student engagement and meaningful experiences and the multimedia and redundancy principles can help. Each of the principles has its roots in the opposing ways of thinking. These two principles of multimedia learning can bring student engagement and motivation into play and allow constructivist approaches to be used in lecture-based instruction.

While attempting to find out if the application of the multimedia and redundancy principles will improve the efficiency of United States history instruction, this study will also seek to determine if any improvement in learning can be attributed to student attention. It can be assumed that student attention will be lost if a presentation is boring to the viewer or if it has distractions that draw attention away from the desired content. These principles imply that distractions can be mitigated, but can they also improve attention spans? This study attempts to show that there will be a positive impact on the attention span of students who are exposed to multimedia instruction using the multimedia and redundancy principles and that student attentiveness will be the reason for improved learning.

Significance of the Study

The body of knowledge on the use of the multimedia and redundancy principles of multimedia learning is extensive. The advent and proliferation of online learning environments have caused an explosion of new literature that examines all facets of the use of multimedia instruction. The cognitive load theory, on which the multimedia and redundancy principles are based, is also well researched from a best practice perspective that argues that students learn more of what is taught when the theory is applied. When all prior known research is considered, a gap in the literature exists in three significant areas dealing with adolescent students, a public high school classroom, and the study of history content. This study is concerned with traditional classroom instruction of high school history students. The

review of the literature shows that the vast majority of research is centered on higher education, online education and in corporate training, for the most part excluding adolescents, classroom teachers, and history content. The ultimate goal of this study is to provide practical direction for high school history teachers to deal with time constraints and curricular demands in an efficient and practical manner. This study achieves this goal by taking strong, well-researched theories and applying them specifically to high school history students in their regular learning environment.

Research Questions

1. Will students outperform a control group on a test of United States history content when the multimedia principle is incorporated in the design of multimedia instruction?
2. Will students outperform a control group on a test of United States history content when the redundancy principle is incorporated in the design of multimedia instruction?
3. If 11th grade US history students outperform a control group on a test of United States history content after a presentation that incorporates the multimedia principle, will the difference occur closer to the end of the presentation?
4. If 11th grade US history students outperform a control group on a test of United States history content after a presentation that incorporates the redundancy principle, will the difference occur closer to the end of the presentation?

Research Hypotheses

H₀₁: There will be no statistically significant difference in student performance on a test of United States history content terminology when the multimedia principle is incorporated into a multimedia-based lesson.

H₀₂: There will be no statistically significant difference in student performance on a test of United States history content terminology when the redundancy principle is incorporated into a multimedia-based lesson.

Ho₃: 11th grade United States history students will not show a statistically significant difference in content learning that is introduced closer to the end of a multimedia presentation designed using the multimedia principle.

Ho₄: 11th grade United States history students will not show a statistically significant difference in content learning that is introduced closer to the end of a multimedia presentation designed using the redundancy principle.

Identification of Variables

Independent Variable (IV): The three multimedia presentations administered to the treatment and control groups. The participants in the control and treatment groups in this study viewed multimedia presentations that covered identical information about the Berlin Airlift. The narration of the presentations was scripted and was identical in length, content, and tone for the control group and both treatment groups. The control group presentation consisted of a variety of multimedia components including on-screen text (phrases, bullet-points, full sentences, and captions), pictures, maps, charts and graphs. The essential function taken into consideration when constructing the control group presentation was that it provided a thorough coverage of all content that would appear in the post-test. No consideration was given to the management of extraneous load or essential processing. In essence, the control group focused on what was being taught and not on what was being learned.

The first treatment group was an edited version of the control group in which the instructional design focused on the cognitive processing of essential content through the inclusion of the multimedia principle. The alterations made to the presentation included strategies such as introducing images in sync with the narration and using the “build” function of Apple *Keynote* to add elements to a map or image while it was being explained in the narration. Likewise, the second treatment group was an edited version of the control group in which specific attention was given to the reduction of extraneous load by including the application of the redundancy principle. When considering the cognitive load

theory and the cognitive theory of multimedia learning, the extraneous load in the control group was caused by on-screen text being repeated by the narration. The design of the redundancy group eliminated a significant amount of the redundant verbal content, giving the pictures, maps, graphs, and charts a significant portion of the visual aspects of the presentation.

Dependent Variable (DV): Student grades on a post-test. The post-test consisted of 24 multiple-choice questions, each focusing on one content element, in the order in which they appeared in the presentations. An identical test was given to all three groups one day after the presentation. For the first and second hypotheses, that students will demonstrate better learning when viewing the treatment presentations as compared to the control group, scores on the test were compared using a two-tailed independent sample t-Test. Attempts to control for external threats to validity, such as students studying or talking to one another about the presentation, included using a randomized sample of students and having a large sample size ($n = 136$).

For the third and fourth hypotheses, that any increases in student performance on the post-test would be attributed to longer attention spans, improved performance would show up when students were tested on information that appeared closer to the end of the presentation. To test this, three t-Tests were used to determine if students mastered the content terminology to a greater degree at the end of the multimedia treatment group presentation when it was pitted against the control group presentation. Three more t-Tests were run to make the same comparison between the redundancy treatment group and the control group. The first test sought to find out if there was a significant difference during the first third of the presentation, the second test looked at the middle third and the final test examined the last third of the presentation. The hypothesis would be accepted if there was a significant difference during the last third of the presentation, but not during the first or second portion.

Assumptions and Limitations

Assumptions.

1. Careful, scientifically-based, research-supported instructional design will produce more efficient learning. Many history teachers take a survival approach to instruction by resorting to the presentation of content without developing schema or context in the interest of time. While the teacher may be able to teach all of the material, very little attention is given to how much the students actually learn.
2. Improvements in student learning can be achieved by making improvements to instruction. As history teachers fret about the need to teach more material with no additional time, the emphasis seems to be focused on the quantity of teaching (i.e. length of school day, length of school year, and 2-year vs. 1-year courses) and not on the quality of teaching. More is not always better and better can sometimes be less.

Limitations.

1. This study is an examination of 1 day in a 175-day school year. To be certain that multimedia learning-based strategies in instructional design is a best practice, it needs to be studied for an entire school year and not concentrated in 1 day in the life of a history student. It can be argued that just about any strategy can work for 1 day, especially when it has a novel appeal that may wear off over time.
2. The construct of the presentations is subjective. The study assumes that the presentations shown to the experimental and control groups accurately represent what is and what is not representative of the multimedia and redundancy principles. For this reason, other researchers or experts may argue that the presentations are flawed.
3. The students who participated in this project were aware that they were part of a study, and this knowledge could have caused them to exert more effort. However the opposite is also a potential issue. Some of the participants may not have taken the activity seriously and may not have attempted to answer the questions accurately. These two phenomena may have caused an inordinate number of outliers in the study making it difficult to measure.

4. A fourth concern is the validity of the test instrument. In order to customize the test instrument to a unique lesson, a test had to be constructed specifically for this experiment, potentially raising questions about what the results of the test indicate. Nine teachers were asked to evaluate the post-test for content validity and unanimously determined that the questions on the test accurately measured the content that was in the presentations.

5. The effort to protect the validity of the study eliminates many aspects of the real world classroom learning environment such as individual teachers, peer interaction, classroom management, and discipline. The goal of this study was to find a method of instruction that maximizes efficiency in the study of United States history in a regular high school classroom. The actual study pulled students out of a classroom and put them into a computer lab then used recorded narration instead of actual teacher dialogue. The question is how well will the findings of the study be transmitted to the classroom?

Summary

Public schools in the state of Maine have already skimmed their budgets to create financial efficiencies and the public will to increase education spending to improve student achievement is lacking. The inability to increase funding for education means that reforms to improve student achievement such as lengthening school days or adding new teachers are not realistically part of the discussion. It also means that extending United States history classes from 1-year to 2-year programs to deal with the overload of curricular content will not happen. Therefore, history teachers need to find ways to be more pedagogically efficient. Students need to learn more without using additional time or resources. The application of the multimedia and redundancy principles to content-based presentations has the theoretical potential to improve learning without the use of additional time or resources. This study attempted to find out if the theoretical potential can become reality.

Chapter 2: Review of Literature

Introduction

The debate over whether instructors should or should not use multimedia software such as Microsoft *PowerPoint* is at this point irrelevant. The concern now, given the fact that a vast majority of secondary educators already use multimedia in their classrooms, is how effective the technology can be in improving the quality of instruction and the efficiency of learning. Arguments such as the popular stance by Edward Tufte (Mackiewicz, 2008, p. 150) in which he states that “*PowerPoint* makes us stupid,” no longer push us away from using multimedia. However, it does help educators reflect on their instructional designs and begin searching for ways to make their multimedia presentations better. Amare (2006, p. 305) agrees that arguing for or against *PowerPoint* is a waste of time because it is here and it is generally accepted as an essential part of quality instruction. Even though both of these studies argue that there is no evidence that multimedia improves learning, they do suggest that there are ways to make multimedia presentations better.

The road to making better presentations began with the development of the cognitive load theory by John Sweller at the University of New South Wales in Australia (Clark et al., 2006). For two decades, he and many of his colleagues have refined the theory, making it practical for educators to use the theory to improve their instruction. The cognitive load theory has advanced the study of the learning process by leaps and bounds, but new research within the theory has slowed in recent years. Much of the value that the cognitive load theory can add to multimedia learning has been absorbed by researchers such as Richard Mayer, Jeroen van Merriënboer, and Roxana Moreno who have advanced the cognitive theory of multimedia learning. These and other researchers have narrowed several facets of cognitive load theory to be applied specifically to multimedia learning, which represents the focus of this study.

John Sweller and Jeroen van Merriënboer (2005) in developing a roadmap for future research in

the study of the cognitive load theory and the cognitive theory of multimedia learning, determined that trends in education suggest a priority needs to be given to its application in real-life tasks. The efforts of most researchers conducting the most recent studies seem to be following the father of the cognitive load theory into the realm of complex learning, such as action-based problem-solving and long-term training programs not explicitly relevant to classroom-based multimedia presentations. Studies on multimedia learning however, have continued to refine the concepts of cognitive load theory and have made great strides in offering valid applications for educators as they develop multimedia material for their classrooms (Moreno & Valdez, 2005).

PowerPoint Presentations: Good or Bad? As stated earlier, the use of multimedia during lecture-based instruction has increased rapidly (Blalock & Montgomery, 2005), but has it improved student learning? Research seems to suggest that the use of technology in itself does not improve learning, but it does open the door for individual lecturers to make improvements to their practice. According to many students, traditional lecture can be notoriously boring and inefficient because it inundates students with massive amounts of information, usually because time is limited and teachers choose methods that are the most expedient (Feldon, 2010, p. 15), but the amount of content that is actually learned is usually far less than what is taught. The negative findings, such as those by Amare (2006) and Mackiewicz (2008) regarding the use of *PowerPoint* during lectures, are more likely to be a reflection of lackluster or ill-informed implementation of the multimedia and not a condemnation of the technique itself (Feldon, 2010, p. 16).

Feldon went on to suggest that multimedia lectures can be inspiring and transformative, but 3 key properties are essential to making the presentations work well in a classroom. First, good lectures show the learner the relevance of the material being taught, second, that the content must have explicit connections to the learners goals and interests. Finally, the presentations must activate the prior knowledge of the learner (p. 16). In this sense, *PowerPoint* can become a bridge between direct and

constructivist learning models, and they are not doomed to be passive activities that rapidly disengage students. Jennifer Clark (2008) agrees with Feldon that multimedia presentations can encourage a greater degree of constructivist learning within the lecture format and can be used to illicit an emotional response. If so, how?

Putting the Principles Together. The cognitive load theory and, more central to this discussion, the cognitive theory of multimedia learning provide principles that can be employed to make lecture-based multimedia presentations more efficient and effective learning activities. As educators study the cognitive load theory, they will find several principles such as the split-attention principle and the modality principle, that address certain problems in the learning process. The principles help the instructor in the design process to keep attention on how the student learns rather than what the teacher wants to teach (Merrienboer and Sweller, 2005 ; Reed, 2006; Tabbers, Martens, and Merrienboer, 2004). In the cognitive theory of multimedia learning there are even more concepts such as coherence and spatial contiguity that add more thought specifically to the construction of presentations (Mayer, 2009).

Theoretical Literature

Dual coding system. Extensive study by Allan Paivio at the University of Western Ontario culminated in the writing of *Mental Representations: A Dual Coding Approach* (1986), which explained a comprehensive theory on the way human brain architecture defines how learning occurs. Paivio's cognitive theory postulates that people learn by receiving stimuli through the senses and then are able to remember the information by coding it in either of two channels, visual or verbal. The two channels are used to organize the information so that it can be attached to other relevant information already in memory and can be easily retrieved for recall. He referred to the visual channel as an analogue code, or a message that directly replicates the input. For example, if a person sees a cow, he or she has an analogue, or exact, representation of a cow. The verbal channel on the other hand is

referred to by Paivio as a symbolic coding channel in which stimuli receive a representative code, such as a word or a number (Reed, 2006). The example here would be a text description of the same cow, such as, it has four legs and horns.

Paivio explained that there are limitations in human learning and memory that are caused by the dual coding process. The biggest problem is that people have a limited capacity to attend to multiple stimuli at any one time. A good way to explain this concept is to imagine one of the 24-hour news stations on cable television. On the screen is a split image of a host in the studio and a reporter at a remote location having a conversation about one event while a text line is tracking across the bottom of the screen with random information that is unrelated to the conversation. The viewer is simultaneously processing two visual codes (the host and the reporter in two separate locations) and two verbal codes (the spoken words of the people on the screen and the scrolling text at the bottom of the screen). Paivio would explain that it is impossible for a person to attend to all of the stimuli and would likely describe it as distracting.

Alan Baddeley (1987) expanded on the cognitive theory of dual coding, providing a concept map that is useful in understanding how the theory is involved in working memory. Baddeley identified the two channels by the names visuospatial sketchpad and phonological loop, and then in 2000 he added a third system to the original model called the episodic buffer. The episodic buffer, according to Baddeley, is responsible for combining visual and verbal information into single representations so that a person can see the word cow and recall the visual representation of a cow. The buffer also adds concepts such as chronological order or rank to the coded material.

Cognitive Load Theory. The dual code model of working memory quickly became the most accepted version of how the brain processes, organizes and recalls information. In the late 1980s, research in the area of learning began to concentrate on dual coding, and with a greater understanding of the process, research began to examine how people could improve their learning. This is where John

Sweller from the University of New South Wales in Australia began his life mission to offer practical understanding of the dual coding theory and a means for potential application of the theory in learning environments. The result of over two decades of work by Sweller and some of his closest colleagues, such as Ruth Colvin Clark and Frank Nguyen, resulted in the publication of *Efficiency in Learning: Evidence-based Guidelines to Manage Cognitive Load* in 2006.

The theory developed by Sweller became known as the cognitive load theory, because the central focus is not on how learning occurred but instead on how efficient the process can become. The theory begins with the assumption that Paivio and Baddeley are right. Cognitive load theory builds upon the theoretical interpretation of brain architecture by focusing on methods that can maximize the efficiency of the learning process. Essentially the cognitive load theory begins with the question, how much can a person learn at any one time? Since a person may be exposed to multiple stimuli simultaneously, how can irrelevant information be weeded out, making room in the limited working memory described by Miller with his 7 +/- 2 concept? How can the effort and focus of the learner be concentrated on the relevant information or the desired content? The answers lie in the definitions of three forms of cognitive load that fully explain Sweller's theory; intrinsic load, germane load, and extraneous load.

Intrinsic Load. The intrinsic load imposed upon working memory is a static amount of effort required by the learner which cannot be altered. It represents the actual content that is the desired focus of the learning process and the level of difficulty that it imposes upon the learner (DeLeeuw & Mayer, 2008). For example, if the target of an exercise is to learn how to start a snowblower, there is a set number of steps in the process. The level of difficulty depends upon how much prior knowledge, or schema, the learner has about operating small engines. For example, one learner may already know what a choke is while another learner may need some extra explanation.

Intrinsic load can be managed by altering the method of instruction, which is the main idea

behind the cognitive load theory. The theory is based upon the effort to find out how much information the learner can process in a dual-coded working memory at one time. To help a person learn the skill of operating a snowblower, using pictures or video to go along with a narrated description of what is going on in the pictures can activate the maximum effort of both forms of working memory. The improvement in learning occurs when the instruction is adjusted to activate more working memory. A set of instructions that were verbal, but without visual representations, only takes advantage of half of the working memory capacity and actually causes overload. Likewise a visual description without verbal explanations will also cause overload and a lack of learning (DeLeeuw & Mayer, 2008).

The overload is what causes learning to become inefficient. Inefficient learning is generally thought to be content that is taught but not learned because too much information is being crammed into a short amount of time. This inefficiency is explained by continuing to pour information into instruction even though the learner's working memory is full and unable to process the stimuli. It can also be that the pace of information processing is too slow and the full capacity of working memory is not being utilized. Sweller's cognitive load theory, though, concentrates on the failure to use both coding systems equally in the teaching and learning process. It attempts to help the teacher and the student to avoid overloading one channel while underutilizing the other. In other words, the most efficient learning, in which the student can learn the most material in the shortest amount of time, requires a balance of visual and verbal material (Brunye and Taylor, 2006).

Germane Load. A second type of cognitive load that absorbs a significant amount of space in working memory is germane load. It is defined by Sweller (2006) as the load devoted to the processing, construction, and automation of schemas. Germane load is an essential part of learning, and it is required in order for a person to process because it is the thinking that is required to make sense of new content and to help organize it and connect it with already existing schemas that a person has in his or her long-term memory (DeLeeuw & Mayer, 2008). For example, learning about a list of

20th century presidents requires learners to activate a significant number of schemas that they are required to attach to new material. Dwight Eisenhower needs to be added to the Cold War, Franklin Roosevelt to World War II and the Depression, Theodore Roosevelt to the Progressive Era, and so forth. In this exercise the amount of germane load may be high because of so much prior knowledge that needs to be recalled at one time. A way of shrinking the germane load may be to make the exercise two separate lessons, such as pre-World War II and post-World War II.

Extraneous Load. The third type of cognitive load is extraneous load, which demands the greatest amount of attention by the application of the cognitive load theory. Extraneous load is the working memory load experienced by learners as they interact with instructional materials. It includes everything that is involved in the learning environment from the temperature of a classroom, the lighting, and the number of students in the room to the medium of instruction, the actions of the instructor, and the chair in which the student sits. Extraneous load demands attention by the theorists because it is the type of load that the teacher wants to eliminate from the learner's working memory because it distracts the learner from paying attention to the desired content (Merriënboer & Ayres, 2005).

Most of the principles of multimedia learning are based on the idea of reducing extraneous load. For example, if students are required to do a webquest activity to learn about the Berlin Airlift, the airlift itself represents the intrinsic load, the knowledge of how to use a computer and to navigate through the internet is the germane load, while items such as advertisements in the sidebar of a webpage represent extraneous load (Van Merriënboer & Sluijsmans, 2009). The student is easily distracted by a groundbreaking new strategy to lose 20 pounds in one week, which takes up space in working memory and limits the amount of space that could be used to understand why Captain Gail Halvorsen dropped candy to German children from the window of his C-54 cargo plane.

Principles of the cognitive load theory relevant to this study.

The split-attention principle. In a practical sense, the cognitive load theory provides guidelines that can be employed to promote more efficient learning. One of these guidelines is the split-attention principle, which focuses on the elimination of extraneous load by using methods that direct attention toward relevant content and away from distractors. When using multimedia strategies to deliver content, the split-attention principle calls for strategies such as aligning relevant pictures with correlating visual text (Clark et al., p. 92) so that the learner's eyes are not required to wander across the page or screen. Simple concepts such as using bolding or italics to draw attention to relevant information also reduces the negative aspects of the split-attention effect (p. 84). An interesting aspect of this principle centers around note-taking and argues that taking notes during dynamic instruction is a distraction. It stresses that when taking notes is necessary, lectures should be signaled (p. 102). Finally, split-attention concepts disclaim the idea that more is better. The rationale that delivering content in dual modes offers twice the learning opportunity is false and, in fact, acts as a distractor (p. 108).

The modality principle. A second relevant principle is the modality principle, which has the most research support of all of the cognitive load and multimedia learning principles. It requires the presenter to limit the words and descriptions of the content to audio narration and not present it as on-screen or visual text. The foundation of the modality principle is that words that are heard do not need to be written and seen visually. The combination of written and spoken words wastes precious space in working memory and the repetition is unnecessary (Clark & Mayer, 2008, p. 102).

A limitation that often must be dealt with in the application of the modality principle is the fact that technology-based presentations are bounded by the demands of the hardware or the location of the student (Clark et al, 2006, p. 103). In a classroom that employs *PowerPoint* with an LCD projector, for example, the teacher can be the narrator, eliminating the need for visual text, but if the lesson is web-based or if the learner is at a satellite location, recorded narrations may be difficult, necessitating more

visual text (Tindall-Ford & Sweller, 2006).

The redundancy principle. A third major example of relevant cognitive load principles is the redundancy principle. It points out that multiple content expressions actually overload working memory and depress learning (Jamet & LeBohec, 2006). For example, adding on-screen text that replicates the audio narration create a redundant expression of content and a decrease in learning efficiency (Clark et al., 2006, p. 122). As students read visual text, they read at a different speed from that of the instructor, and simply reading from a PowerPoint can cause split-attention issues, but it is also a waste of working memory space. In essence, students are filling up their working memory by doing the same task twice (Clark & Mayer, 2008, p. 123).

Cognitive Theory of Multimedia Learning. Maintaining an understanding of the cognitive load theory is essential when attempting to make learning more efficient as it forms the basis for the cognitive theory of multimedia learning. Ruth Colvin Clark and Richard Mayer (2008); have added to the body of knowledge relevant to the application of cognitive load theory based upon the concept of multimedia learning, that learners can better understand new information when it is presented in words and pictures (p. 1). The case for cognitive-based multimedia learning theory is supported by the idea that instructional messages should be designed in light of how the human mind works (p. 6). Based on this theory, Clark and Mayer stated that meaningful learning outcomes depend on the cognitive activity of the learner during the learning process rather than on the learner's behavioral activity during learning (p. 3).

Verbal modes of presentation dominate the way instructors convey explanations to their students. Similarly, verbal learning is usually the major focus of educational research, in spite of the fact that the advent of computers has created an explosion in the availability of visual ways of presenting material (p. 6). Emphasis in schools across the nation continues to stress the importance of reading and writing skills; instructional skills in multimedia have generally been ignored, though they

also are important and in need of improvement. These facts reinforce the reality that more research is necessary in the area of multimedia learning strategies.

The term multimedia learning is often misunderstood when considering the focal point of instructional design. Should instructors design lessons based upon the availability of technology, or should lessons be focused on the learner with technology serving to support the learning needs? This debate is explained by three views of multimedia instruction: the delivery-media view, the presentation-modes view, and the sensory-modality view. The delivery-media view emphasizes that multimedia instruction should include at least two devices to present new material (i.e., visual and verbal). The focus that this view puts on how material is presented fails to consider the learning process and assumes that learning will improve simply by including visual and auditory instruction (Wiebe & Annetta, 2008). Although it is impossible to say for sure, it is likely that the delivery-media view of multimedia instruction is probably the most common of the three views used in K-12 education.

The first of two views of multimedia instruction that employ a student-centered approach rather than a technology-centered approach is the presentation-modes view, which extends the delivery-media view to include a consideration of how material is presented within the context of the delivery devices. It stresses the fact that technology is only useful if it assists students in learning and does not merely assist the teacher in instruction. This view asks the instructor who is designing the multimedia presentation to consider how the student hears and views the material instead of how the instructor will present the material.

The third view of multimedia learning is called the sensory-modality view. It states that two or more sensory systems (i.e., eyes and ears) are involved in the process. This view is most in line with the cognitive load theory because it explicitly demands that both channels of working memory be utilized in the learning process. For example, a *PowerPoint* presentation that introduces the causes of the Civil War in bullet-point format does not require anything more than the learner's eyes. Even if the

presentation is narrated by an instructor, the student may tune out the teacher's voice and just read the slides or copy them into a notebook. The sensory-modality view requires the learner to listen to the teacher and view the slide in order to attain the desired content knowledge.

Assuming that multimedia presentations follow the sensory-modality view, several studies, including one by Blalock and Montgomery (2005), demonstrate that multimedia presentations can improve student test scores significantly especially in students who have already proven themselves to be above-average academic performers; these findings lend support to the dual-coding theories (p. 5). The same study also recommends that instructors carefully match their use of technology with the overall degree of technological savvy of the students and to make sure that the presentation complements the lesson and does not replace it.

Some studies have shown that multimedia instruction does not improve student achievement such as one conducted by Ricer, Filak and Short (2005) at the University of Cincinnati. They compared what they called a high tech presentation (computer-based, animated *PowerPoint*) to a low tech presentation (black and white overhead projection) and found that there was no noticeable difference in retention of learning (p. 108). The purpose of this study, however, is not concerned with the difference between use or lack of use of multimedia. Instead it focuses on the assumption that multimedia is being used and on how it can be used efficiently and effectively.

The Multimedia and Redundancy Principles. In *Multimedia Learning* (2009), Richard Mayer outlines the 12 principles of multimedia learning that enable practitioners to easily employ them in the design of their own presentations. The principles each have one of three purposes: to promote essential cognitive processing that can facilitate learning, to reduce extraneous cognitive processing that can interfere with learning, or to provide social cues that can make learning more meaningful and memorable. In this study, the focus will be on two of these principles, the multimedia principle, which is designed to promote essential cognitive processing, and the redundancy principle, which is meant to

eliminate extraneous cognitive processing. By examining one principle from each of these categories, the findings of the study will not only isolate the impact of one principle, but will also indicate the importance of an entire category within the theory itself. In other words, is it more important to improve essential processing or eliminate extraneous processing to improve learning?

Multimedia principle. Simply put, people learn better from words and pictures than from words alone (Mayer, 2009, p. 223). While this principle may sound like a general description of the entire theory, it has a more specific point. It is based on the concept that the images in a presentation, even though they may be supplemental, are still important to the learning process. Students are not participating in an efficient learning activity if they are only required to listen. It also stresses the importance of not rushing through a multimedia presentation because students will become frustrated if the activity outpaces their own processing ability, and student satisfaction is drastically increased when they are allowed to have an appropriate amount of time to view a screen (Blalock & Montgomery, 2005, p. 6). Supporting the studies, Maxwell (2007) posited that students should have multiple sources of academic stimulation including visual, spatial, verbal, auditory, and kinesthetic to ensure that the full capacity of working memory is being utilized. He suggests that it is better to err on the side of over-stimulation, rather than risk boring repetition (p. 43).

Redundancy principle. Richard Mayer (2009, p. 118) defines the redundancy principle with the statement that people learn better from graphics and narration than from graphics, narration, and printed text. The concept is simple when consideration is given to how fast and how well students can read silently as compared to the narrator's spoken words. Attention is lost when learners are asked to read text on a screen while a narrator reads it as well, and the text also distracts the viewer from the images on the screen. Kalyuga, Chandler and Sweller (2004, p. 578) demonstrated in three experiments that presenting on-screen text that is read aloud by a narrator does create a redundancy effect, causes an overload in cognitive processing, and, as a result, produces lower student test scores.

In Malaysia, Sii Ching Hii and Soon Fook Fong (2010, p. 123) found similar results in history lessons, one of the only studies that directly relates cognitive load theory or the cognitive theory of multimedia learning to high school history lessons.

The lack of bullet points enables a presentation to enhance and support a lecture-based class because the visual representations complement the lesson without being redundant. *PowerPoint* presentations intended for in-class activities should be designed so that they cannot stand alone. A good presentation, if it were posted on a website, would not be able to teach the entire lesson without the benefit of the instructor. Otherwise students will become increasingly inattentive or even physically absent from the class if they know that they can just look it up online (Bozarth, 2008; Maxwell, 2007, p. 48).

Empirical Literature

The theoretical literature seems to support three concepts that make up the basis of this study. First, the use of cognitive load theory and multimedia learning theory addresses inefficiencies that, when corrected, can improve instruction. Second, the improvements that come will also be accomplished without the addition of more time or resources to the instructional methods already employed in the classroom. Third, these theories can lead to improvements in the learning environment by emphasizing the attentiveness given to the learner, which in turn helps the learner be more attentive to the desired content or skill to be learned.

Efficient Instruction. A number of the methods that instructors try in their classrooms are done badly (Maxwell, 2007, p. 39). The materials such as reading assignments, activity sheets, maps or *PowerPoint* presentations are the work of textbook publishers who emphasize flair in order to make a sale, or technology personnel, who know the technology but not necessarily the content of the lesson. The result is a loss of efficiency in the desired area of learning. On the other side of the spectrum, bullet-point presentations give learners little incentive to listen to the lecturer (p. 41), and a similar

experience of inefficient learning occurs. Instructors can often fall into these traps that lead to inefficient learning because they are concerned about appealing to the interests of the students, about keeping learning fun, or about combatting apathy toward the content. The multimedia and redundancy principles, as representative segments of the entire cognitive theory of multimedia learning, keep the focus of the instructional design on the psychological process of learning and help the instructor to avoid fads that are common in the education environment.

Instructional settings that are efficient result in learning that is faster and/or better than settings that are inefficient (Clark & Mayer, 2008, p. 6). Defining efficiency in an educational context illuminates four things: the available time, the available resources, the amount of content that is to be taught, and the difficulty of the content. Tailoring guidelines to the unique situations in each classroom will make the learning environment more efficient (p. 28). Conversely, instruction is often the victim of various fads, such as edutainment and discovery learning, wasting time and resources and decreasing productivity. Evidence-based research in multimedia learning supports grounding decisions about the development and deployment of learning programs on the basis of valid evidence, not fads, fables, or folk wisdom (p. 16).

The cognitive load theory defines efficiency in terms of two variables, learner performance and learner mental effort (p. 19). The teacher must keep as a central focus how much the learner is expected to know, how much the learner is expected to do, and how much mental effort the learning activity requires. If the focus strays from the learner, then the development of lessons and learning materials will not be attentive to the learning process. The application of cognitive load theory goes hand-in-hand with the multimedia learning theory and the development of efficient lessons. For example, as instructors move toward the goal of eliminating irrelevant mental effort in order to free space in limited working memory (p. 33), the use of dual modalities can accelerate learner expertise (p. 48). In the studies by John Sweller, Richard Mayer, Roxana Moreno, and other cognitive load and

multimedia learning researchers, there are numerous suggestions forwarded to improve the learner-centered approach to instruction.

Some of the suggestions include the following. When content or skill elements are presented in a visual presentation, all elements can be viewed, and therefore learned, simultaneously (p. 53), unlike information that is embedded in sentences. The use of a visual requires fewer sentences and frees up more time, making that time available for other material. Therefore learning becomes more efficient. Visual material that does not require a verbal explanation should be left to stand alone, and verbal material should not simply repeat visual text; both suggestions save time and cognitive load (p. 73). Audio explanations aided learning only when the tasks were more complex and only for visuals that were not self-explanatory (p. 125). Explanations should also be concise; extraneous visuals, text, and audio should be omitted (p. 115). Careful attention should be given the inclusion of interest-based content to be sure that it does not interfere with the goals and objectives of the lesson. Evidence shows that adding motivational content—even content topically related to the lesson, depresses learning. (p. 116)

One concern that may prevent instructors from employing the 12 principles in their multimedia design is the amount of time it would consume in preparation, but evidence suggests that the preparation of the presentations is not time consuming (Urbanova & Ctrnactova, 2009, p. 208). The survey of teachers in this study did find other positive effects of cognitive-based, student-centered design of multimedia presentations; for example, teachers found the activity made their work more interesting for them. They also found that the development of these presentations, in the long run, saved time.

Efficient Learning. Information overload syndrome, a term coined by British psychologist Dr. David Lewis in 1996 in his *Reuter's* report entitled *Dying for Information*, illustrates the need for student-centered efficiency learning strategies. Dr. Lewis indicated that overloading people with

information causes mental anguish and physical distress (p. 4), erodes the quality of work (p. 7), and diminishes learning efficiency. In addition, Dr. Lewis claimed that when overload gets large enough, the learning system shuts down altogether (p. 29).

This philosophy emphasizes the fact that students are facing cognitive overload in their studies to a greater extent every day. The general assumption is that students are unprepared and that schools are failing to show progress in student achievement. Here is where an understanding of cognitive load and the cognitive theory of multimedia learning can direct efforts in the right direction. During their learning activities, students are constantly being bombarded by extraneous load, such as “edutainment” exercises, intercom interruptions and extracurricular activities, not to mention the more notorious stressors of adolescent life, such as friendships, drugs and sex. The cognitive-based learning activity first examines the learner, proceeds to the desired content, and then designs an activity that maximizes intrinsic and germane load while mitigating extraneous load. To do this, the teacher makes the student feel comfortable, keeps the learning environment predictable and free of uncertainty, and keeps the activities on task and focused on the necessary learning. Essentially it is about the stress that Dr. Lewis spoke about in his article.

Conclusion

There are two glaring gaps in the existing literature that are being filled by this study. First, there has been a lack of research on virtually every aspect of the cognitive load theory and the cognitive theory of multimedia learning in public high schools and examining the multimedia and redundancy principles is a good start. Gaining site access to high schools is difficult for researchers who are typically based at universities, and privacy laws add layers of bureaucracy to the research process, not to mention that many of the leading researchers are not based in the United States. Second, current data is typically collected in a laboratory environment that ignores any potential discrepancies between the lab and the natural environment of the high school student. Existing research in the literature tends

to be conducted either in the college setting, with young adults as the subjects, or in a laboratory setting, which is likely to change the behavior of the subjects as compared to their natural environment, and it does not include a true cross section of the student body. Even if adult learners and adolescents are impacted by cognitive load in an identical manner, and likewise for lab and real-world environments, the literature could use more direct research-based evidence that can remove any uncertainty on the value of these theories in public high schools.

Chapter 3: Methodology

Participants

Eleventh-grade students enrolled in a heterogeneous (unleveled) 1-year Social Studies class at two eastern Maine high schools made up the sample for this study. One of the schools provided 93 students and the second contributed 43 students, for a total of 136 students.

Setting

Both of the participating schools had computer laboratories that could accommodate an entire class of up to 25 students at one time. The participating students used the computer labs to access the assigned presentations and used earphones to eliminate outside noise and allow them to focus on the narration of their own presentation. On the day immediately following the presentation, the post-test was administered in the regular classroom.

Instrumentation

On the day the participants were given the treatment, all of the students were escorted from their regular classroom to computer laboratories. Once they were all in the computer labs, attendance was taken and students were assigned to one of the three treatment groups (Multimedia Principle, Redundancy Principle or Control Group) based on a random assignment from the alphabetical roster of the class. The regular classroom teacher instructed the students to log on to the correct website and to make sure that they all had earbuds that worked properly.

After the students were in position and ready to view the presentations, a set of instructions was read to make sure the students understood the activity. The students were told that the activity was an experiment to test different types of multimedia strategies and that their honest participation would make the results more accurate. They were urged to watch the entire presentation without skipping any section and that it was important that they watch and listen to every slide. The instructions stressed the fact that the participants should keep their attention on their own presentation because the presentations

being watched by their classmates were different. They were informed that they should try and remember as much content information from the presentation as possible because they would take a test during the next class session. Finally, the students were directed toward the correct presentation for the group to which they were assigned and instructed to begin watching the presentation.

The slide presentations were constructed using Apple *Keynote* and were recorded on *iMovie*. They were then made into a web movie and posted on the internet via a movie sharing website called *Vimeo*. The movies were then embedded into a website and labelled as “Presentation A,” “Presentation B,” and “Presentation C.” The students were assigned to one of the groups and were instructed to open the correlating movie. The students did have the ability to stop the presentation and to rewind it if they wanted to review something, but they were not instructed to do so. Without pausing or skipping, the presentations were 30 minutes in length.

The history content material contained in the slide presentations covered the Berlin Airlift of 1948-49. This topic was chosen because it was related to the curriculum being taught at the participating schools and would not radically interfere with their normal schedules. It was also likely that the students had some degree of background knowledge, such as the ending of World War II, that would help engage the students in the presentations. The content in the presentations was considered by all of the participating teachers to be very in depth and well beyond the scope of anything that they would normally teach in their survey history classes.

For two reasons, the construction of the presentations and the inclusion of the content followed a process that could be easily replicated by any teacher wanting to employ similar strategies in the future. First, to make this study practical for future use in the classroom, all of the materials needed to be accessible and readily available for teachers. Second, to ensure that the study was reliable and valid, there needed to be consistency between the three presentations. To accomplish these goals, the presentations used images that were available through a simple *Google* search and the content text was

borrowed from *Wikipedia*. The *Wikipedia* article on the Berlin Airlift formed the basis for the narration of the presentations. The same narration was used in all three presentations and only the visual aspects of each individual slide was modified between the groups.

Within the Berlin Airlift topic, 24 content items were chosen to be the basis of the post-test (see Table 1). The items included the names of key figures in the Berlin Airlift, code names of the different military operations during the crisis, geographic locations, and identifications of key objects such as types of aircraft and currency. The items were specifically chosen so that there would be 8 items in the first 10 minutes of the presentation, 8 items in the middle 10 minutes and 8 more in the final 10 minutes of the presentation. There was also a balance created in which approximately the same number of names, objects, and geography items appeared.

Control Group Presentation. The design of the control group presentation was based upon descriptions of commonly used *PowerPoint* procedures by Maxwell (2007), Bozarth (2008), and Feldon (2010). The slides maintained the integrity of the concept of multimedia by including images and text that were presented in conjunction with the narration. From a curricular standpoint, the presentation contained all of the desired material that would be a part of the assessment to be given at the end of the instructional period. The design of the control group did not adhere to any cognitive learning theories, but it did contain a few elements, common in multimedia presentations, that are contradictory to the cognitive theory of multimedia learning and, more specifically, the multimedia and redundancy principles. The control group followed a “teacher's notes” model that typically allows the presenter to read from the slides by including full sentences, phrases and bullet-points. The control group also did not use the transitions feature of Apple *Keynote* and instead presented multiple images and text at one time (see Illustration 6).

Treatment Group Presentations.

Treatment Group A: Multimedia Principle. The first treatment group applied the multimedia

principle to the control group by editing the visual aspects of the presentation in accordance with the specifications set forth by Richard Mayer (2009). The multimedia principle states that students learn better from words and pictures together than from either words or pictures alone. While all of the slides in all three presentations contained words, either visual or verbal, and pictures, the changes made in the multimedia principle treatment group focused on the interaction between the words and pictures.

In Appendix D, illustrations 6-8 demonstrate the multimedia principle in action during the multimedia principle treatment group presentation. Illustration 6 shows a blank map of West and East Germany during the post-World War II occupation by the allies (United States, Great Britain, France and The Soviet Union). While the narration explains the differences between the western allies and the Soviet Union there were no changes to the map. When the narration begins to explain the agreement to create separate zones of occupation, flags of the four countries move onto the map of Germany to indicate the geographic responsibilities of the Four-Power Allied Control Council. In illustration 8, the students were introduced to the problem of the Germany capital city of Berlin, which was also divided between the four powers. The narration explains that the western democracies were in control of a city that was located 100 miles inside Soviet communist controlled East Germany. The placement of the flags on the map and the highlighting of the distance between West Berlin and the rest of West Germany used a combination of verbal and visual instruction to make it clear that there was a problem in West Berlin.

A similar process takes place in the transition from illustration 10 to illustration 12 in Appendix D. In these images, the process that became known as “The Ladder System” was explained using a map with animations that were synchronized to the narration. In this series, it was explained that American planes flew into West Berlin on one air corridor, while the British planes entered along a separate corridor, and all planes exited through a third air corridor to avoid two-way air traffic. The narration was synchronized to the animations to create the link between the words and the pictures.

In Illustration 9, the introduction of the terms identifying German currencies during the Berlin crisis were accompanied by images. The Reichsmark and the Deutschmark were introduced as the old German currency that was debased by the Soviets and the currency that was introduced by the United States to create economic stability. On this slide, there were visual and auditory words that were linked to the images of the currencies. In Illustration 13, the term Deutschmark was linked to a map to show that it was introduced into West Germany and in Illustration 14, the Ostmark, which was the Soviet response to the Deutschmark was introduced. As was the case in Illustration 9, these slides had narration, on-screen text and images that were synchronized.

Treatment Group B: Redundancy Principle. The second treatment group applied the redundancy principle to the control group by editing the visual aspects of the presentation in accordance with the specifications set forth by Richard Mayer (2009). The redundancy principle states that listening to a narration while reading the same text on-screen causes extraneous load that interferes with learning. Like treatment group A, treatment group B was an edited version of the control group, this time incorporating the redundancy principle by eliminating a significant portion of the on-screen text. For consistency, the narration between the groups remained the same and only the visual aspects of the presentation were altered.

In Appendix E, Illustration 15 shows a slide in which Gail Halvorsen, “The Chocolate Pilot” was introduced. The slide contains images of Captain Halvorsen, his C-54 cargo plane landing, and groups of children gathered at the end of the runway as the plane approaches. The narration that occurs during the slide explains, with support from the images, what happened when Halvorsen dropped parachutes of candy to the children. Also contained in the control group slide, but absent from the redundancy principle group, is a large amount of on-screen text. Illustration 16 and 17 are also examples of the implementation of the redundancy principle. When these slides are compared to Illustrations 4 and 5 respectively in Appendix C, it can be seen that extraneous on-screen text that exists

in the narration is not present in the redundancy principle presentation.

Post-Test. On the calendar day immediately following the delivery of the presentations, members of the control group and the treatment groups completed identical 24-question multiple-choice tests to determine the amount of desired content material that was retained from the presentations. The paper and pencil test was administered by the regular classroom teachers, and the 24 questions were divided into three groups of 8 to represent the three chronological sections of the presentations: beginning, middle, and end. On the test, the students indicated which presentation they viewed (A, B, or C) and then answered the 24 content-based multiple-choice questions (see Appendix A).

Procedures

The initial step in completing this study was to gain approval from the Liberty University Internal Review Board (IRB) as well as from the appropriate personnel in the cooperating schools. In order to protect the juvenile students who were the subjects in this study, school administrators and parents were assured that the identities of the students would remain confidential. Likewise they were guaranteed that the data collected would be used for no other purpose than to determine the effectiveness of the application of certain learning theories. To use the data for any other reason would require further approval from the IRB.

School committees, superintendents, principals, and teachers were reassured that their schools, classrooms, and personal performance were not subject to consideration in the study and that they were not being measured against their peers. A face-to-face meeting with all cooperating parties was conducted to provide a clear understanding of the goals and objectives of the study. The meeting was an opportunity for participating teachers and school personnel to ask questions, as well as being a good chance for the researcher to trouble shoot any technological and logistical problems before running the study. To ensure that everyone who was in a position to grant permission (i.e. superintendents,

principals and teachers) knew and understood the nature of the study, all of them were required to sign a document stating that they were aware of and approved of their participation. Likewise, due to the fact that the participants were minors, the participants were required to supply signed documentation that they had the permission of their parents or guardians in order to participate.

On the day of the presentations, teachers accompanied the students to the computer lab and got them situated with computers and earphones. Each teacher passed out a one-page set of instructions for logging on to the correct website to access the presentation to which each individual had been randomly assigned. Once students logged on and were ready, the teacher instructed the students to put on their earphones and begin the presentation. At the completion of the presentation, the teacher instructed the students to leave the computer lab and return to class.

The content of the presentation was a chronological account of the Berlin blockade and airlift of 1948-49. One major concern expressed by school officials before the project began was that this study would potentially waste two days of instruction, so content needed to be as close to the curriculum as possible. While making the presentations to fit into the school curriculum, it was also necessary to make the content as novel as possible to avoid repeating content that had already been covered at an earlier date. The content went deeper into the historical event surrounding the Berlin Airlift than is typically covered in a survey course in American history, and all participating teachers indicated that they had not covered the finer details of the Berlin Airlift that were presented in this study. Table 1 shows the content items that were covered in the presentations and that were measured by the post-test.

Table 1

Content Items

<u>Beginning</u>	<u>Middle</u>	<u>End</u>
Josef Stalin	Deutschemark	Operation Little Vittles
4-Power Allied Control Council	Ostmark	Gail Halvorsen
Henry Morgenthau	5,000 Tons of Supplies Daily	Uncle Wiggly Wings
Socialist Unity Party	C-54 Skymaster	Jean Ganeval
George Marshall	Operation Vittles	Radio in the American Sector
Vyacheslav Molotov	The Ladder	The Easter Parade
Lucius Clay	William Tunner	Soviet News Agency (TASS)
<u>Little Airlift</u>	<u>Tempelhof Airport</u>	<u>NATO</u>

The day after viewing the presentations, the students completed the 24-question, multiple-choice (1 correct answer and 3 distractors) post-test. The students indicated the video that they watched, and it was then verified by the teacher and by the researcher using the class roster and the assignment list. Five students indicated their group assignment incorrectly on their answer sheet and were corrected by their teachers. The test included three 8-question sections based upon the order of material presented in the video. The 8-question sections of the post-test are designed to determine if any potential improvements in student performance in the treatment groups can be attributed to increased attention span.

The multimedia presentations and the test instrument were examined by 9 social studies for content validity, and they determined that the questions on the post-test were appropriate and were accurately matched to the content of the presentations.

Research Design

This experimental study utilized a randomized, control group, post-test only design. As will be

explained in greater detail in the procedural section of this chapter, several factors contributed to choosing this design. Concerning internal validity, the study design controlled for maturation, testing, instrumentation, statistical regression, differential selection, and the interaction of selection and maturation. The randomization of subjects controlled external validity issues such as influence of classmates, influence of the instructors, and the quality of presentation hardware and environment.

The post-test-only, control group design compared the performance of a treatment group that received a specific treatment with a control group that did not receive the treatment. The process was repeated for the second treatment group. The students in this study were subject to modified multimedia presentations of new content material that was not previously studied in their history classes. The control group watched and listened to a multimedia presentation that followed a traditional practice of displaying teacher notes along with a few visual aids, such as photos and maps. The audio and visual components for the control group were based upon current practice and came from existing classroom materials. The multimedia treatment group viewed and listened to a multimedia presentation that was a modified version of the control group, specifically designed to incorporate the rules of the multimedia principle. The same process of modifying the control group was followed to create the redundancy treatment group presentation.

Rationale for Post-test Only. There was a strong temptation to use a pre-test and a post-test to compare the differences in the scores between groups because the study was designed to demonstrate only the effect of the lesson and not other factors, such as prior knowledge and test-taking ability. However, the threats to internal validity caused by a pre-test, including a response-shift bias in which students will perform better on a post-test because of recall of pre-test questions proved to be greater than problems that were present without the pre-test. By using random assignment of students, the need for a pre-test was eliminated as students of differing ability, motivation, and prior knowledge had an equal chance of being in any of the three groups. This study also had the potential of having a very

large sample size, and when considered in conjunction with randomization, biases were easily controlled.

Data Analysis

A two-tailed independent sample *t*-Test was used to analyze the data for H₁ and H₂ because this study examined the difference between two mean scores (the average score on the post-test by the control and treatment groups). According to Gall (2007), *t*-Tests are used when three assumptions can be made about the obtained scores: that the scores form an interval or ratio scale, that the scores are normally distributed, and that the score variances for the populations are equal. Additionally, *t*-Tests have proven to be accurate in estimating the statistical significance even when there is substantial violation of these assumptions. This study expresses the scores on a ratio scale; the sample sizes for the treatment and control groups were close but not exactly equal, and it was assumed that a normal distribution would occur on the post-test due to randomization of participants. It was suggested by Gall that the sample size (*n*) for each group exceed 30 students, and with 136 subjects available there were no major concerns about power. On the first two research questions, a $p < .05$ level of significance was used for the analysis in this study to determine if the null hypotheses could be rejected.

The same system applied to H₃ because the post-test score for each chronological section of the test for the treatment group was compared directly to its match in the control group. Three two-tailed *t*-tests provided data that explained the degree to which learner attention was maintained during the treatment group presentations when compared to the control group. However, because there are fewer questions in each of the subsections as compared to the entire post-test, a $p < .025$ level of significance was used to determine if the null hypotheses could be rejected.

Summary

Students at two public high schools in central Maine were shown 30-minute multimedia presentations about the Berlin Airlift. There were three presentations, a control group and two

treatment groups. The control group mimicked a “teacher's notes” *PowerPoint* format that is traditionally seen in many high school classrooms. The first treatment group altered the control group based upon the multimedia principle to try and mitigate problems regarding essential cognitive processing. Finally, the second treatment group also altered the control group, but did so by including changes that addressed extraneous load problems and attempted to correct them by using the redundancy principle. Each of the 136 participating students viewed their randomly assigned version of the Berlin Airlift presentation on a computer with earbuds to listen to the narration. The next day, the students completed a 24-question multiple-choice post-test based upon the previous day's presentation to provide data that would determine if either the multimedia principle or the redundancy principle would improve learning efficiency and student attention spans when compared to the control group.

Chapter 4: Results

Introduction

The purpose of this study was to examine the significance of employing the multimedia principle and the redundancy principle from the cognitive theory of multimedia learning in the instructional design of multimedia presentations in high school social studies classes. Three research questions formed the framework of this study, all postulating that subjective improvement to the instructional design of the presentations by following the guidelines of the multimedia and redundancy principles would cause significant improvement in student performance and attention span.

The post-test only, randomized control group design was used to collect and evaluate data for this study. The sample of students began with a population of 186 high school 11th graders enrolled in one of 14 American history classes at two Maine public high schools. When each individual teacher administered the presentations, 17 students were either not present or did not participate in the project, 13 students did not complete and return consent forms, and 20 students were disqualified from participation because they were not in the 11th grade, leaving a total sample of 136 students (73% participation rate) (see Table 2).

Table 2

Breakdown of Participants

School	Available Students	Disqualified	Absent	Participants
School 1	130	26	11	93
School 2	56	7	6	43
Total	186	33	17	136

Demographics

Population. The individual subjects in this study were all 11th graders who were enrolled in an American history class. One of the participating schools identified the course as American History

while the other referred to the third-year required social studies course as World and American Studies III, but an examination of the curriculum indicated that a substantial strand of the course was American history. No advanced placement students were used, nor were any self-contained special education students. The general history courses used in this study are required by both schools, they are heterogeneously grouped, and they include any mainstreamed special education students and any gifted students who chose to not take AP U.S. History.

Demographic data such as race and sex were not included in this study, and student names were kept only long enough to verify that each student who took the test also submitted a consent form and that they watched the assigned presentation. Central Maine has a significant white population, in excess of 97%, and any examination of racial characteristics was not possible. It also seemed irrelevant, based on the stated purposes of this study, to disaggregate data based upon gender due to the fact that all students were regularly subjected to multimedia presentations and could benefit from improved instructional design of this nature.

Hypothesis Analysis

H₁: There will be a statistically significant difference in student test scores in 11th grade United States history classes following instruction designed using the multimedia principle. The first treatment group had a sample size of 48 students who viewed a presentation that included improvements, based upon the multimedia principle, and to find an answer for the first research question, they were then compared to the control group ($n = 45$). The goal of the experiment was to determine if the inclusion of the multimedia principle in multimedia instructional design could significantly improve the quantitative performance of the students.

Using a 95% confidence level ($p < .05$), the difference between the experimental group and the control group was statistically significant ($p = .0451$, $t = 2.032$, $df = 91$), and therefore the null hypothesis that there will be no difference between the performances of students in both groups was rejected. In

essence, the multimedia treatment group scored approximately 1.7 raw points higher than the control group on the 24-question post-test or a percentage increase of just over 7% (see Table 3).

Table 3

*Multimedia and Redundancy Effects**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	13.178	4.534
Multimedia Treatment	14.917	3.701
<u>Redundancy Treatment</u>	<u>14.256</u>	<u>3.606</u>

Note. * $p < .05$

H₂: There will be a statistically significant difference in student test scores in 11th grade United States history classes following instruction designed using the redundancy principle. The second treatment group had a sample size of 48 students who viewed a presentation that included improvements to the control group based upon the redundancy principle. The goal of this experiment was to determine if the redundancy principle could significantly improve the quantitative performance of the students. Using a 95% confidence level ($p < .05$), the difference between the treatment group and the control group was not statistically significant ($p = .2218$, $t = 1.231$, $df = 86$), and therefore the null hypothesis was accepted. The redundancy treatment group did slightly outperform the control group, and even though it is not statistically significant, it is noteworthy. The raw score difference between the redundancy treatment group and the control group was slightly higher than one point, or about 4.5%, which could be recognized in the realm of educational assessments to be a modest but good improvement.

H₃: If 11th grade US history students demonstrate a statistically significant difference in test scores following a presentation that incorporates the multimedia principle, the difference will occur closer to the end of the presentation. There are several ways in which this hypothesis could

have been measured. For example, each group could be measured within itself to determine if the level of decline in student performance due to loss of attention is significant in one group but not in another. However, there are several statistical problems with looking at attention span in this manner. First and foremost, the questions are different, making a comparison of performance unreliable. The best solution to determining if maintaining attention played a role in determining the impact of the treatments was for compare the beginning, middle and end of the multimedia principle treatment group to the corresponding sections in the control group. In this way, the questions would be the same and the timing of the instruction would also be the same.

Therefore, in searching for evidence of a difference in attention span between the multimedia principle treatment group and the control group, three t-Tests were used to determine if there was a difference in student performance. A t-Test was used to compare the student performance between the multimedia treatment group and the control group on the first eight content items as they appeared in the presentation and on the post-test. A second t-Test was used to compare the middle eight content items in the presentation, and a third test was used to do the same for the final eight items. A p-value that indicated that the treatment group statistically outperformed the control group on the middle and/or final section would support the hypothesis that the inclusion of the multimedia principle would improve the attention span of the students viewing the presentation.

When comparing the control group with the addition of the multimedia principle, using a confidence level of 97.5% ($p < .025$), the beginning of the presentation showed a statistically significant difference ($p = .005$, $t = 2.498$, $df = 91$). This result came as a surprise because the hypothesis predicted that the improvement in student performance would appear in the middle and/or end sections of the post-test. The statistically significant difference between the control group and the multimedia principle treatment group that was found in supporting the first hypothesis was assumed to be attributable to improved attention span and, thus, was expected to show up in the final section of the

test. However the significance was demonstrated to occur in the first section of the test, which suggests that student performance was not necessarily improved by increasing attention spans, but can also be improved by capturing the attention of students in the beginning (see Table 4). A further discussion of this issue will take place in Chapter 5.

Table 4

*Multimedia Effect (Beginning)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.311	1.807
<u>Multimedia Treatment</u>	<u>5.292</u>	<u>1.443</u>

Note. * $p < .025$

The middle of the multimedia treatment presentation did not show a statistically significant difference from the control group; in fact, it showed virtually no difference at all ($p = .9942$, $t = .007$, $df = 91$). Likewise, the end of the presentation did not show a significant difference ($p = .039$, $t = 2.100$, $df = 91$), but it is important to note that the final section of the test would have proven to be significant at the 95% confidence level. The null hypothesis is accepted because the data rejects the idea that the treatment group would demonstrate statistically significant improvement at the end of the presentation, but not necessarily at the beginning or in the middle (see Tables 5 and 6).

Table 5

*Multimedia Effect (Middle)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.711	1.961
<u>Multimedia Treatment</u>	<u>4.708</u>	<u>1.713</u>

Note. * $p < .025$

Table 6

*Multimedia Effect (End)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.156	1.894
<u>Multimedia Treatment</u>	<u>4.917</u>	<u>1.596</u>

Note. * $p < .025$

H₄: If 11th grade US history students demonstrate a statistically significant difference in test scores following a presentation that incorporates the redundancy principle, the difference will occur closer to the end of the presentation. The same process that was followed in measuring the three sections in the multimedia treatment group was then repeated to compare the redundancy treatment group to the control group. When comparing the control group with the addition of the redundancy principle, there was no significant difference at any of the three intervals of the post-test. These findings are consistent with the second part of this study in which it was found that the inclusion of the redundancy effect did not show a significant improvement in student performance on the post-test. Therefore, it is safe to assume that the null hypothesis would be accepted due to the fact that there would be no significant improvement to attention span if there was no significant improvement in overall performance.

While the hypothesis is rejected in this set of data, there are two items that are noteworthy. First of all, the middle section of the redundancy presentation did demonstrate better student performance than the beginning or end, which is unique to the rest of this study. Second, when taken separately, the multimedia principle and the redundancy principle may only make modest gains or no gains at all in student performance, but when put together they may work in concert to make more significant improvements in performance. If the multimedia principle works well at gaining student's attention in the beginning of a presentation, as suggested by the validation of the first hypothesis, and the

redundancy principle helps to keep attention through the middle third of the presentation, the positive effects are potentially compounded and could produce an overall increase in student performance that is statistically significant (see Table 7).

Table 7

*Redundancy Effect (Beginning)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.311	1.807
<u>Redundancy Treatment</u>	<u>4.674</u>	<u>1.554</u>

Note. * $p < .025$, $t = 1.009$, $df = 86$, $p = 0.316$

Table 8

*Redundancy Effect (Middle)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.711	1.961
<u>Redundancy Treatment</u>	<u>5.370</u>	<u>1.822</u>

Note. * $p < .025$, $t = 1.874$, $df = 86$, $p = 0.096$

Table 9

*Redundancy Effect (End)**

<u>Group</u>	<u>Mean</u>	<u>SD</u>
Control Group	4.156	1.894
<u>Redundancy Treatment</u>	<u>4.488</u>	<u>1.818</u>

Note. * $p < .025$, $t = 0.459$, $df = 86$, $p = 0.648$

Summary

This study examined the impact that the use of the multimedia principle and the redundancy principle have on the efficiency of student learning during multimedia presentations. When compared

to a control group, the addition of the redundancy principle did not have a statistically significant impact on learning, but the inclusion of the multimedia principle did show a statistically significant improvement. In conducting this investigation, the third hypothesis assumed that there would be improvements to the efficiency of student learning and that these gains would be due to the extension of student attention spans during the presentations and that this would be proven by showing that gains in performance would occur with greater significance near the end of the treatment presentation. The null hypothesis was accepted in this case because there was no statistically significant improvement in learning efficiency in the middle or end sections of the experimental presentations. However, the multimedia principle did show that there was a statistically significant gain as compared to the control group in the beginning section of the presentation, which, even though it still rejects the hypothesis, supports evidence that the multimedia principle does improve learning efficiency during multimedia presentations, just not in the way that had been anticipated.

Chapter 5: Discussion

Introduction

The original goal of this study was to find out if the use of the cognitive theory of multimedia learning, specifically the multimedia and redundancy principles, would improve student learning in a high school history class without requiring additional time or resources. To do this, content-based multimedia presentations, based upon these principles and a control group, were constructed to test the idea. As outlined in chapter 4, the results showed that the multimedia principle was more successful than the redundancy principle at causing improved student performance. The data also showed that neither principle demonstrated an impact on attention span, but the multimedia principle apparently does help to capture the attention of students at the outset of the presentation.

Summary of Findings

Environment. One of the most important factors in a good multimedia presentation designed for the classroom is the environment in which the presentation is delivered. Distractors such as noisy air circulators, classmate behaviors, and teacher quality can contribute to decreased student performance assessments of student learning during multimedia presentations. With that in mind, there were some flaws worth mentioning in this study that potentially undermined the desire to examine students in the natural environment of the regular social studies classroom. To mitigate the influence of individual teachers and to ensure the validity and reliability of this study, the presentations were shown on computers, and live presentations by teachers were not used. In a traditional scenario, a teacher who is delivering a multimedia presentation in person would be able to gauge student attention and could liven up a presentation accordingly or establish a pace that was best suited to the students. A teacher could also conduct periodic assessments of student retention of information throughout the presentation and could review more complex information or move more quickly past easier information that would more accurately manage cognitive load.

Second, to ensure reliability in the study, the computer-based model was used, but it can be argued that it did not accurately mimic the environment of the regular classroom. In the computer lab, where individuals were working at their own computer terminal with earbuds, there was an entirely different set of distractors that could have caused this study to fail in its attempt to replicate a regular classroom multimedia presentation. In the typical classroom, students are asked to pay attention to a presentation on a screen and to the voice of the teacher. Distractors, in this situation, that can cause extrinsic load include the behaviors of other students or ambient noises such as heaters and movement in the hallway. In the computer lab, students using earbuds were unable to attend to those distractors, but their set of extraneous load came from the temptation to peek at a neighbor's screen or to fidget with the computer equipment. In this situation, there were several reasons why the teachers could not attend to the individual as much as they could in the classroom for several reasons. First, the students had their backs to the teacher, facing computer screens, and there was no eye contact between student and teacher. Not being able to see the faces of the students, teachers were unable to get cues from expressive reactions to the presentation to determine if the students were understanding and retaining the material.

The biggest difference however, between a classroom presentation and the one shown to the individuals participating in this study was the ability of the teacher to control pace. In a perfect situation, students are able to control a multimedia presentation by stopping and reviewing content that they did not immediately understand, but the students in this study were more likely to just let the presentation play through than to review material that had already passed. A teacher-led presentation would better enable the instructor to control the pace of the presentation, ensuring a greater degree of content retention. This assertion does pose an interesting point for discussion, however, in that the stopping and starting of a presentation by a teacher could also have a negative effect by causing an increase in extraneous load.

Population. Conducting this study in public high schools with adolescent students was extremely valuable and contributed a significant aspect to the discussion of cognitive load theory and multimedia learning theory as applied to public education. The very nature of the public school as it relates to cognitive learning theories, is very intriguing as teens and the environment in which they are expected to work are important when attempting to apply the cognitive concepts. For example, this study was conducted in 11th grade history classes that are required for all students and they are not necessarily there because of a personal choice. Many of the students also lacked some of the motivators that typically drive college students or other people who volunteered for similar studies in the past. The students examined in these pages were not necessarily intrinsically interested in doing their best in an activity unless they knew it would impact their grade. Likewise they were not paying for the course, nor were they receiving payment for their participation.

Conducting this research in public high schools also enabled us to examine adolescents in as normal a situation as possible for the students. Even though the typical classroom experience was altered significantly by moving them from a regular classroom to a computer lab, the vast majority of typical cognitive load was still present. Students that participated in this project received instruction that was relevant to the subject area and was presented in PowerPoint format, making the delivery method of the content familiar to the students. The students were still with their regular classmates, friends, and teachers during the study so they had the same support system and a similar set of distractors, such as boyfriends/girlfriends or class clowns that might cause good and bad cognitive load on any given day at a public high school.

As data was collected, an interesting phenomenon became apparent, but it is likely that it happens in most studies of this nature. Because minors were being used in this study, it was required that permission forms, signed by parents, be procured before individual student tests could be included in the data set. Non-compliant students were still shown the presentations, and they took the post-test,

but if they did not submit a permission form, their tests were not included. The post-tests that were stricken from the data set due to noncompliance in attaining permission proved to be the lowest performing students in almost every case. While randomization ensured that these exempt tests were from each of the three test groups, it still does have the potential to alter the population sample and poses some interesting questions about the accuracy of the results.

The students who did not return their permission forms and who performed poorly on the post-test demonstrated apathy toward a school activity. The absence of these students from the study could have altered the demographics of the study. Who are they? Are these students poor? Do they lack supportive parents at home? What is their regular performance record in the class? These students obviously did not care to participate in the project. Do they behave this way during other multimedia presentations? If the purpose of this study was to improve the efficiency of student learning in United States history classes, then this population of apathetic students was, and still remains, a significant target for improving instruction, and it is important to note that they were not included in the results of the study.

Multimedia Principle. The multimedia principle presentation was the only hypothesis of the three that was proven to be statistical significant, apparently because it was able to do a better job at capturing student attention. Despite the assumption that the significance would appear closer to the end of the presentation than the beginning, the realization of significance at the beginning of the presentation can be seen as a positive result. Relating these results to the theory of Richard Meyer (2009), the conclusion that can be drawn from this is, that the early phase of the presentation was successful at activating prior knowledge, and that the new material was successfully integrated with existing schema.

The specific content material in the early section of the presentation was centered around an understanding of the Berlin crisis and how it was related to the end of World War II. It is likely that

students already possessed at least a modest schema regarding World War II, and the attachment of an unknown topic to a known schema aided learning in this instance. For example, all of the students who participated in this study had already studied World War II and it is safe to assume that they had a schema that included the joint occupation of Berlin by the Soviet Union and the United States at the conclusion of the war. To show how this would improve student performance on this part of the post-test, one of the terms in the first section of the presentation was the Morgenthau Plan, which was one of the American strategies regarding post-war Germany. Introducing the students to the fact that the Soviet Union strongly opposed American thought on this subject helped them understand the basics of the content of the presentation. However, using this logic, the students in the redundancy and control groups should have performed better on the first section of the post-test than they did on the middle or final sections as well, but that was not the case. This concern will be addressed in the discussion of the redundancy treatment group.

The decline in student performance in the middle of the multimedia principle treatment group, down to the level of the control group leads to an interesting question. If the presentation did a good job at capturing attention and activating prior knowledge, why did that trend not continue throughout the presentation? A strong explanation to this question lies in the nature of the content itself. The middle third of the presentation transitions to new content that does not depend upon existing schema that was likely discussed in the study of World War II. For example, understanding the concept of introducing new currency (the Deutschmark and the Ostmark) as an attempt to create economic dominion over the city of Berlin is more of an economics discussion than a geopolitical discussion. The students certainly recognized the physical presence of Soviet and American troops as part of a conflict, but they probably needed a deeper lesson on the impact of currency on political control and social stability to fully understand the concept. Without the ability to link the Ostmark to the existing schema, the students were then forced to learn the terminology as a random item on a list with no

apparent connection to the rest of the list. While the students might have been able to remember the Ostmark, they may not have been able to recall that it was the Soviet-introduced currency of East Germany. Aggravating the recall problem is the fact that the two post-test questions regarding the Deutschmark and the Ostmark included both terms, one as the correct answer and one as a distractor. The students may have recognized both terms, but could not recall which currency was introduced by the Americans in West Berlin and which one was introduced by the Soviets in East Berlin.

Sticking with the example of the Deutschmark and the Ostmark, there are two other issues that could have caused the decline in the middle of the presentation. First, the presentation moved along at quick pace, covering 8 content items in 10 minutes. This means that each item was given approximately 1 minute and 15 seconds of time to be introduced, explained and committed to long-term memory before moving on to the next term. The Deutschmark and the Ostmark were introduced simultaneously, were explained together, and presumably retained at the same time. The students may have in fact learned these two terms, but they may have also stored them in long-term memory in the same place with no distinction between the two items.

The second issue, that may have contributed to the decline in the middle section, was a potential contradiction between what the presentation taught and what the student was expected to learn. The presentation clearly taught that the United States and the Soviet Union, in an effort to control the entire city of Berlin, each introduced a new currency to the economic system. In this sense, it might have been appropriate to ask students to identify, in 1 question, the two currencies, but the post-test asked the students to attribute the two currencies to their respective regions of Berlin, east or west. With that in mind, the post-test question (see Appendix A) that asked the student to identify the Ostmark as the East German currency introduced by the Soviet Union included the Deutschmark as a distractor answer. Given the circumstances, this is a very difficult question, because it is likely that the students could recall the Deutschmark and the Ostmark, but could not recall which one belonged to which side.

While the post-test was a valid instrument for this study, its limitations, and the limitations of any post-test, have created a good discussion for teachers when they consider the construction of exams designed to measure what the students were able to learn from their instruction. Standards based assessments that are growing in popularity in high schools today need to take this issue into consideration. Was it acceptable for the students who participated in this study to know that it was the Deutschmark and Ostmark that were introduced in 1948 as means for winning the competition for control of Berlin? If so, then the question in the post-test, as worded, demanded that students exceed that expectation and be able to attribute the two currencies to the proper side.

To examine this issue, an analysis of the post-test answers could be conducted to find out how many students answered either Deutschmark or Ostmark on these two questions. Certainly this would improve the performance of the students in this section of the test. It would also presumably happen in the redundancy principle treatment and the control group as well and it would elevate the performance of all three groups in the middle section to a level that is comparable to the performance of the multimedia group during the first and final sections. In other words, changing the level of expectation on these two questions would probably have created a consistent performance throughout the presentation for the multimedia treatment group.

Table 10

Comparison of the Mean Scores of the Multimedia, Redundancy and Control Groups

<u>Group</u>	<u>Beginning</u>	<u>Middle</u>	<u>End</u>
Multimedia Treatment	5.292	4.708	4.917
Redundancy Treatment	4.674	5.370	4.488
<u>Control Group</u>	<u>4.311</u>	<u>4.711</u>	<u>4.156</u>

The multimedia treatment group lost over a half-point in the mean score from the beginning to middle sections while the redundancy and control groups both gained almost a half-point (see Table 5).

Another examination of the content in the middle section helps to explain the phenomenon that appeared in this study. The 8 content terms that appeared in the middle section included the following; Deutschmark, Ostmark, 5,000 tons of supplies per day, General William Tunner, C-54, the Ladder System, Operation Vittles and Tempelhof Airport. The reality is that some content terminology may have been more responsive to different instructional methods and it is entirely possible that these 8 terms were not as conducive to instruction based on the multimedia principle. In fact, it is also possible that the multimedia principle was counter productive to learning these terms.

If it could be assumed that the students should have been able to accurately attribute the Deutschmark to the United States and West Berlin, and the Ostmark to the Soviet Union and East Berlin, then the question becomes, why did the multimedia principle not help the students learn this material? It is possible that these terms are less likely to be learned with visual support and the visual aspects of the slide may have created extraneous load in the form of a distraction from the narrative explanation. In the slide, a picture of the Deutschmark appeared when it was mentioned in the narration and an arrow pointed from it to a map of West Berlin. Likewise, an image of the Ostmark appeared at the appropriate time and was pointed toward East Berlin. During the few moments that the images were on the screen, students may have been attempting to make the visual distinction between the two currencies, but the real distinctions between the two items was contained in the narration. It may have been more productive to just show the word Deutschmark on the screen instead of an image of a 10-Deutschmark note.

Redundancy Principle. The rejection of the hypothesis that the inclusion of the redundancy principle would significantly improve student learning during a multimedia presentation is interesting. While the data does show that the redundancy principle group outperformed the control group in a consistent manner throughout, it was not significant enough to make the claim that the application of this principle alone would guarantee improved student performance. As part of a larger strategy,

though, the redundancy principle can contribute to greater student performance when it is allowed to work in concert with other strategies such as the multimedia principle. This is suggested by the fact that there was a noticeable spike in student learning during the middle portion of the post-test by students who viewed the presentation that included the redundancy principle. If this effect was coupled with the significant difference noted in the first hypothesis regarding the multimedia principle, then student performance could likely be definitive and not marginal.

The redundancy treatment presentation may have reduced too much cognitive load and eliminated the need or desire to pay attention to the visual aspect of the presentation. John Sweller (2006) and Richard Mayer (2009) have both argued that cognitive load in working memory is similar to a container filled with water. It may be suggested that reducing cognitive load too much will actually allow extraneous load to fill the void and cause a distraction from the desired learning. In other words, the cognitive capacity of a student's working memory will always be full, but the real trick in education may be to reduce extraneous load by ensuring that intrinsic load fills working memory first. The task in managing working memory is to identify how much information at one time is just enough--not too much, but also not too little. The redundancy principle reduced the cognitive load as prescribed by Richard Mayer (2009), but it is possible that the void created by the reduction activated students to fill the remainder of their cognitive capacity with extraneous load such as fidgeting with earbuds or keyboards or turning attention to nearby screens or other movements in the classroom.

The visual presentation, when the redundancy principle is applied, is not typical when compared to what students commonly recognize in a PowerPoint presentation. They may be used to more visual text and in its absence did not see the importance of maintaining visual attention. During casual observation of students participating in the project, it was clear that many students were compliant by remaining attentive to the audio portion of the presentation, but many students lost interest in the visual presentation, as demonstrated by staring at the floor, peeking at a neighbor's screen, or even closing

their eyes. The students were not coached to pay close attention to the screen images, and they may not have understood the importance of the visual aspects. In support of what was stated earlier, a presentation led by a teacher could draw attention to the visuals during their lecture, something that was clearly absent during the redundancy principle treatment group. On a positive note, it highlights the importance of the presence of a teacher to direct student attention. An assumption that could lead to a hypothesis in a future study is that the redundancy principle is more effective in live presentations than in computer-based presentations.

A conclusion that was drawn about why the multimedia treatment produced a significant difference in the early section of the presentation was attributed to its ability to incorporate the material into previously existing schema about World War II and its aftermath. This conclusion poses a question about the redundancy treatment group and the control group. If the redundancy presentation contained the same material and the same narration as the multimedia and control presentations, why didn't these groups also demonstrate a strong influence in the early section of the presentation? To answer this question there has to be an examination of assumptions about the presentations, the post-test, and how they fit into a normal history lesson.

The multimedia treatment produced a significantly higher level of student performance on the post-test during the first section of the presentation when compared to the control group. The redundancy principle also produced an improvement over the control group, although it was not statistically significant. It is possible that all 3 groups responded to the existing schema equally, but what is being demonstrated in the results is the superior impact of the multimedia principle on the specific types of questions in the first section. In other words, the redundancy principle made some improvement, but the multimedia principle had a greater impact on the learning of the same 8 questions and it did not necessarily have anything to do with timing.

When the same logic is applied to the middle section of the presentation, the opposite is true.

The presence or absence of existing schema is equally applied to all presentations, but the redundancy treatment group outperformed the multimedia treatment, albeit only slightly, when it was compared to the control group. This brings the discussion back to the examination of the individual content items and the formulation of the test questions. It is safe to say that the multimedia principle did a better job in the first section and that they were both about relatively equal in the middle.

Attention Span. The third and fourth hypotheses in this study were that any significant improvement in student learning would be closer to the end of the presentation. As was stated earlier, the findings show that the only instance where there was a significant difference during the duration of the presentations, the opposite was true. The control group and the redundancy treatment group showed no significant difference during the middle or ending sections, but the multimedia principle treatment group demonstrated significantly better performance in the beginning section of the presentation. While the assumption that the multimedia treatment group would produce significantly better performance was accurate, it was a surprise for it to appear at the beginning of the presentation and not appear as significant at the end.

The multimedia presentation did a better job at capturing the attention of the students while the control group had a more balanced performance throughout. Essentially the data suggests that the multimedia principle was quicker at capturing student attention but it declined, at least to a level comparable with the control group, as the presentation progressed. As was earlier suggested, the application of the redundancy principle in this experiment may have actually invited extraneous load by reducing cognitive load too far, but the inclusion of the multimedia principle maintained a consistent level of intrinsic cognitive load that proved especially significant at the beginning when attention levels were likely at their highest point.

Attention span proved to not be a significant factor in the application of either principle as the control and treatment groups had no significant difference in either the middle or ending sections of the

presentations. This is a significant finding because it is typical for teachers to assume that an essential reason for low student performance is attention deficits. Addressing attention issues can easily follow the assumption that the duration of attention is central in designing lessons, but this study suggests that a critical focal point is what happens at the beginning of a presentation. In other words, the attention deficit caused by not using the multimedia principle is the inability of a presentation to quickly capture a student's attention rather than how long the attention can be maintained.

Another significant conclusion that can be drawn from this study is that attention span has nothing at all to do with student learning during a multimedia-based lesson. One of the goals of this study was to find out if improvement in student learning could be attributed to the impact of either the multimedia or redundancy principle on student attention spans. The simple answer, based upon the test results, is that it cannot. An assumption was made earlier that the multimedia treatment demonstrated a better ability to capture attention at the beginning, but the decline in that group in the middle section and then an upswing at the end causes one to question if attention span is really the issue.

The key word here is span. It may not be accurate to measure attention in generalized blocks of time, but instead should be looked at on an item-by-item basis. The study results do not make a strong argument that attention to three different blocks of time provides an explanation of the success or failure of the multimedia or redundancy principles to hold student attention. What it does suggest is how well the principles impacted each individual content item that appeared on the post-test. During the discussion of the multimedia treatment group it was postulated that the cognitive strategy may be better suited to specific content items. If this is true, then attention is constantly fluctuating throughout a lesson and the real art behind the science of the cognitive theory of multimedia learning may lie in knowing which principles apply best to specific types of desired content.

The post-test results may simply be showing anomalies in which the beginning and end groups given the multimedia principle treatment contained more items that were responsive to the multimedia

principle than the content in the middle group. As for the redundancy group, the results found in the beginning, middle and end groups were more consistent, but it showed improvement in the middle group while the multimedia group showed a decline. This suggests that the content in the middle group was more responsive to the redundancy principle.

Conclusions

Examining only 1 of the 12 principles of multimedia learning at a time allows researchers to isolate variables and focus on very specific aspects of multimedia-supported teaching and learning. However, it also causes the research to miss some of the facts of the big picture. In this study it is suggested that the multimedia principle is one of the most significant pieces in Mayer's entire theory while the redundancy principle has little effect, if any, on student performance. This conclusion is unlikely to be entirely accurate because of the failure to examine what happens to learning when all of the principles are employed simultaneously.

Seldom will an instructor choose to use just 1 of the 12 principles or to exclude a principle on purpose, as has been done in this study. Based upon the suggestions set forth in the theory, the maximum performance of students will appear when all of the principles are employed in designing multimedia instructional materials. This suggestion represents the fact that no single principle will produce a significant difference in student performance, but when they are all taken as a whole, student performance will show significant gains.

Knowing that the significant difference between the multimedia treatment and the control group materialized in the beginning of the presentation is encouraging in the sense that it may provide some extra validity, in a non-statistical sense, to the results. A criticism of the hypothesis, that attention span is measurable in this study, might be that students would always perform better on tests that measure information presented at the end of a lesson. The rationale is that older information would have interference during the recall process while the newer information would not. Knowing that the

students in this study did a better job recalling information at the beginning of the presentation helps support the notion that the multimedia principle is a good way to improve student learning.

Another question arising from this study is, could this significant improvement in learning efficiency continue throughout the school year? If so, the implications it could have on the social, political, and economic realms of public education are thought provoking. Consider just the 7% increase to the overall mean score added by the inclusion of the multimedia principle. What if even just half of the students in any given classroom could improve their general performance on tests by 7%? It is safe to say that this kind of improvement in student performance would open the eyes of parents, school administrators, and especially political leaders, who seem to rely so much on test scores to measure the success of a school. Also, economically speaking, these improvements would be coming at no additional cost to the taxpayer!

The construction of the presentations and how the strategies applied to the different content terms also deserves some reflection. It is apparent that not all desired learning responds equally to the inclusion or exclusion of either the multimedia principle or the redundancy principle. Some terms in the study of history do not need visual support to improve learning, and, in fact, attempts to force learning of certain content into the visual channel may actually impede learning. Likewise, it is possible to reduce redundancy to such a level where content is not given enough coverage or repetition to support meaningful learning.

To this end, it is important that teachers not attempt to create multimedia presentations that strictly follow one or both of these principles. The teacher must be aware of when a principle is appropriate and when it is not. He or she must also be aware of what is taught by the presentation to ensure that the questions on a post-test accurately measure partial learning, desired learning, or learning that exceeds expectations. For example, is it acceptable that students know that Deutschmarks and Ostmarks were the competing currencies in Berlin during the occupation crisis following World War II

or should they have been able to specifically attribute them to the correct side of the argument?

The discussion will always circle back to best teaching and evaluation processes. In a slide-by-slide or question-by-question analysis of the lesson and its assessment, this study helps to support the notion that teachers need to be aware of three concepts: what needs to be taught, how do students learn and how do educators accurately assess what has been learned. The presentations in this study were all designed based on what needed to be taught and the treatment groups attempted to examine how students learn. The post-test did detect a difference in desired learning, though it also created a set of data that could facilitate a valuable discussion of how well a test instrument provides realistic information. Essentially, the results show that a concerted effort to design lessons based on the cognitive process of the learner is an integral part of improving the efficiency of learning in the study of history in public high schools.

Based upon this study, the impact of the two principles on attention span is inconclusive. However, there is enough evidence to suggest further study regarding attention to specific types of content in the presentation and to content questions in the post-test. This would require the abandonment that attention occurs over spans of time and instead occurs from one item to the next. Because both treatment groups fluctuated in opposite directions throughout the presentations lends support to the notion that attention can be either gained or lost several times throughout the presentation and that different principles can be applied strategically to mitigate the loss of attention at any given point in time.

It has become apparent that the real issue here is not to apply one, or even both, of these principles to an entire presentation, but instead, it is how to know when it is best to apply a particular principle to a particular content item. The cognitive theory of multimedia learning should be adapted on a slide-by-slide basis to make significant improvement to an entire presentation. To do this a teacher should focus on 3 concepts: the exact content that is to be taught, developing the best strategy

to teach each individual item, and determining how to identify the desired amount of learning in the assessment that follows the lesson.

In the lesson there was no explicit identification of the items that students needed to know. The teacher and the developer of the presentations and the post-test knew what was going to be part of the assessment, but the students did not. Informing the students of what they need to gain from the presentation is more a part of the individual teaching and will certainly improve student performance on the post-test, but it was entirely appropriate to not include such information in the presentations because only the efficacy of the presentation was being examined in this study.

What can be determined from this and any future studies is how well the chosen principle was applied to the content items. An item analysis of the terms and how the students performed on each of the 24 questions on the post-test can provide some more insight into how well each of the principles apply to the different types of content questions. This analysis would also help provide some feedback into how much was expected of the student. The post-test did accurately link a content item to a question, but what it may have not done is set a fair level of expectations on how much a student should know.

Further Study

A clear conclusion in this study is the importance of the presenter, despite the effort to control for the impact of the teacher. Therefore, the next direction to go with this study is to put the teacher back in control of whole-class multimedia presentations. This can be achieved by measuring the impact of teacher training in cognitive load theory and the cognitive theory of multimedia learning. Teachers can be recruited to participate in a 2-year study in which they are given no instruction on how to use these theories to construct PowerPoint presentations. After 1 year, the teachers could then participate in a summer training program in which they were taught about using the theories to improve their presentations. During the second year, the teachers would construct new presentations, and a

comparison could be made to see if the new instructional strategies would improve the performance of their students on content-based assessments.

The general purpose of this study was to determine if the multimedia or redundancy principles could be used to improve the efficiency of social studies instruction. Holding true to this purpose means that a study needs to examine whether the theory could help individual teachers improve on what they already do in their individual classrooms. The 2-year study could begin with an introduction to all of the aspects of Microsoft *PowerPoint* or Apple *Keynote* and how to use them, but without any specific instruction regarding the specific multimedia strategies. The study would specifically guide teachers to create multimedia presentations on specific content addressed in the curriculum; then during the second year, after teachers have been trained to use the 12 principles, they would redesign their presentations in a workshop setting. Students would be given a post-test in the first year, and those scores could be compared to student scores after seeing the improved presentations in the second year.

Appendix A: Post-Test**The Berlin Airlift and the Beginning of the Cold War Multimedia Presentation
Post-Presentation Evaluation**

Name _____ Group (circle one) A B
 Gender (circle one) M F

Directions: Circle the choice that you think is the correct answer to each question. Please be sure to attempt to answer every question. Take your time and answer to the best of your ability. Thank you for your cooperation and participation!

1. Before the end of World War II, leaders from the Soviet Union, Great Britain and the United States met in Potsdam, Germany to set plans on how to govern post-war Europe once Adolf Hitler's regime had been defeated. The Soviet delegation refused to promise democratic elections in the liberated nations. Which of the following men represented the Soviet Union at this meeting?

- | | |
|----------------------|-----------------------|
| A. Harry S. Truman | C. Josef Stalin |
| B. Winston Churchill | D. Vyacheslav Molotov |

2. During the allied occupation of Germany following World War II, four victorious nations shared the responsibility to govern the nation. Under the plan, the Soviet Union, Great Britain, France and The United States divided Germany into four separate zones of occupation but formed an organization to foster cooperation in governing the post-war nation. What was the name of this organization?

- | | |
|---------------------------------------|-----------------------------------|
| A. North Atlantic Treaty Organization | C. Warsaw Pact |
| B. European Recovery Organization | D. 4-Power Allied Control Council |

3. As allied nations began preparations for post-war reconstruction of Europe, many world leaders feared that if Germany was permitted to rebuild its industrial capabilities it could cause another world war. One of President Franklin Roosevelt's top advisers developed a plan to reduce the industrial capabilities of Germany to 50% of its 1938 capacity. Who was this U.S. Adviser who wanted to reduce Germany to a second rate nation?

- | | |
|---|--|
| A. Secretary of the Treasury Henry Morgenthau | C. Secretary of War Henry Stimson |
| B. Secretary of State Cordell Hull | D. Secretary of the Navy James Forrestal |

4. At the completion of World War II the NAZI Party was banned in Germany. Britain, France and the United States favored creating a multi-party political system in which free elections were permitted, but the Soviet Union preferred to establish a one-party system. When the Soviet Union took control of East Germany they forcibly combined the German Communist Party and the Social Democratic Party and suppressed all other political activity. What was the name of the political party that was formed by the Soviet forces in East Germany?

- | | |
|---|---|
| A. Nationalist Socialist German Workers Party | C. Catholic Center Party |
| B. Socialist Unity Party | D. Fascist-Socialist Reconstruction Party |

5. After great debate over reducing Germany's industrial capabilities or rebuilding them, the United States decided that it would be better to restore Germany as a world economic power and to allow the reconstruction of its industry. In fact the U.S. decided to help aid all of Europe, including the Soviet Union, by committing \$13 billion in what was officially called the European Recovery Program. The plan was named after President Harry Truman's Secretary of State. Who was he?

- A. Henry Stimson
- B. Albert Weidemueller
- C. Henry Morgenthau
- D. George Marshall

6. What was the name of the Soviet Foreign Minister who predicted that a communist take over of all of Europe would begin by the abandonment of Berlin by the western powers of the United States, Great Britain and France when he said, "What happens to Berlin, happens to Germany. What happens to Germany happens to Europe."

- A. Vyacheslav Molotov
- B. Vasily Sokolovsky
- C. Ernst Reuter
- D. Yuri Gargarin

7. The man who was appointed to become the commander of the United States occupation zone in Germany was a general who spent the entire duration of World War II managing production and supply lines and did not get the chance to command an army in battle. He was also the first man to give a realistic thought to supplying the blockaded city of West Berlin by air. Who was he?

- A. William Tunner
- B. Gail Halvorsen
- C. George Marshall
- D. Lucius Clay

8. The Berlin Crisis began in earnest on March 25, 1948 when the Soviet Union ordered that all trucks and trains leaving or entering the City of West Berlin must be stopped and searched. Refusing to allow U.S. Military vehicles to be searched by Soviet forces, the U.S. Occupation commander ordered that all ground traffic to a U.S. Military base in Berlin be suspended and all cargo be shipped by air. The air shipments into Berlin by U.S. Military cargo planes were constantly harassed by Soviet fighter planes but were never fired upon. What was the nickname given to these tense moments early in the Berlin conflict?

- A. The Little Airlift
- B. The Last Stand
- C. The Prelude
- D. Operation Feed Berlin

9. One of the most important aspects in the effort to reconstruct Germany was the establishment of a valuable currency with which the German people could conduct trade. The problem was that the Western allied powers and the Soviet Union disagreed on who would control the currency during occupation. In an effort to force the issue, the United States organized the mass printing of what kind of currency, which quickly became the official currency of West Germany?

- A. Reichs Mark
- B. Ost Mark
- C. Deutsche Mark
- D. Euro Dollar

10. Post-war Germany was permanently divided into two nations (at least until 1989) when the currency crisis erupted in Berlin in 1948. After the United States flooded the market with a new German currency, the Soviet Union responded by introducing their own new currency, completing the division between West and East Germany. What was the name of the East German currency that was introduced by the Soviet Union?

- A. Ost Mark
- B. Rupies
- C. Reichs Mark
- D. Deutsche Mark

11. The British Royal Air Force and the United States Air Force combined data to determine that an airlift to support the two million starving people of West Berlin was possible. The British knew that it would take 1,700 calories of food for each person every day to keep the people alive and the Americans knew how much coal and gasoline it would take to keep the city warm and under power. What was the combined estimated tonnage of food and fuel that needed to be airlifted into Berlin every day for the airlift to be a success?

- A. 1,000 tons
- B. 2,500 tons
- C. 5,000 tons
- D. 10,000 tons

12. Even though they would be considered quite small by today's standards, the aircraft used to bring supplies and food to Berlin were the largest in existence in 1948. What kind of airplane flew most of the missions into Berlin during the airlift?

- A. C-49 Skytrain
- B. Vickers Viking 1B
- C. B-29 Superfortress
- D. C-54 Skymaster

13. On June 25, 1948 the allied commander in Germany gave the order to begin the Berlin Airlift with the delivery of 80 tons of food to the city. Every United States military operation is given a code name. What was the code name for the Berlin Airlift?

- A. Operation Vittles
- B. Operation Open Skies
- C. Operation Eagle
- D. Operation Manna

14. Because it was so difficult to deliver the massive amount of food and supplies by air it required a large number of airplanes to make the mission successful. The number of aircraft needed made air traffic in and out of West Berlin dangerously crowded. To solve this problem, a system was devised in which inbound aircraft flew at staggered elevations and at precise speeds to ensure safe arrivals. Likewise, all aircraft departed Berlin in a different direction to prevent collisions. What was this system called?

- A. The box
- B. The ladder
- C. The triangle
- D. The boomerang

15. After the Berlin Airlift dragged on for a month it became clear that it could go on indefinitely. With no end in sight it became necessary to increase the amount of food and supplies going into West Berlin. To accomplish this goal, the United States Air Force brought in a general who had experience doing airlifts across the Himalayan Mountains during World War II. It proved to be a wise choice as this man was able to make the Berlin Airlift more efficient, increasing the daily tonnage into West Berlin above the 5,000 ton mark. Who was he?

- A. Major General James Forrestal
- B. Major General William Tunner
- C. Major General Albert Wiedemuller
- D. General Paul Lykins

16. To successfully execute the Berlin Airlift, British and American planes flew from two air bases in West Germany, Rhein-Main air base and Wiesbaden. When the airlift began there were only two major airports in West Berlin into which the cargo planes could land. One of the airports was named Gatow airport. During the winter a third airport, Tegel airfield, was added. What was the name of the other Berlin airport that took inbound planes for the entire duration of the Berlin Airlift?

- A. Tempelhof
- B. Hamburg
- C. Lubeck
- D. Finkenwerder

17. One of the most memorable parts of the Berlin Airlift was when American pilots began dropping candy out of their cockpit windows to children who waited at the end of the airfield to greet the arriving planes. The good will gestures became so popular that the U.S. Air Force began to use it as propaganda and they gave the act its own mission code name. What was the code name of the candy bombings?

- A. Operation Hershey's Kiss
- B. Operation Just Desserts
- C. Operation Sweet Relief
- D. Operation Little Vittles

18. The candy bombings started when one of the American pilots gave two pieces of Wrigley's gum to some children near the airport in Berlin. He promised them more the next time he came to Berlin. The next day he dropped some candy bars in a home made parachute to the children who came to see if he would keep his promise. Who was this pilot?

- A. William Tunner
- B. Lucius Clay
- C. Gail Halvorsen
- D. Albert Weidemueller

19. To signal the children who gathered on the ground that candy was about to be dropped on them the pilots would wiggle their wings. To say thank you to the pilots for the nearly three tons of candy they dropped during the Berlin Airlift the children wrote letters to the American air base but they did not know the actual names of the pilots. What was the nickname that the Berlin children gave to the candy bombers?

- A. Uncle Wiggly Wings
- B. Uncle Candyman
- C. Candy Claus
- D. Willy Wobbly Wings

20. During the winter of 1948-49 it became very important to open a third airport in West Berlin and the responsibility to do so fell onto the French Army. French General Jean Ganeval could only build what would become Tegel Airport if he removed a Soviet-owned radio tower, which the Soviet leaders refused to move. How did General Ganeval solve the problem?

- A. He moved the airport to a different location
- B. He bribed the Soviets to remove it
- C. He blew it up
- D. He convinced Berliners to dismantle it

21. Throughout the Berlin Airlift, which lasted over 15 months, it was uncertain when it would end or if it would be successful. One of the most important aspects that was necessary to make it successful was to have the people of Berlin remain supportive of the Airlift. To help maintain the support of the people, the Americans opened a radio station to broadcast news and information to the Berliners, as well as to play music to keep their spirits up. What was the name of this radio station?

- A. Radio Free Europe (WRFE)
- B. Radio in the American Sector (RIAS)
- C. German Language Radio Berlin (GLRB)
- D. American Sector Airwaves (WASA)

22. Maintaining the Berlin Airlift through the winter of 1948-49 proved to be the most difficult time as weather conditions often forced the cancellation of many flights. One sure sign that the Berlin Airlift would be sustainable for an indefinite amount of time would be to make it through that winter. When spring arrived and West Berlin was surviving it became apparent that the Airlift would be a success. To celebrate, West Berlin staged a special event to demonstrate to the world that they would not give in to Soviet domination. What was this celebration called?

- A. Mardi Gras
- B. The Easter Parade
- C. St. Patricks Festival
- D. May Day Parade

23. On May 12, 1949, the official state-run Soviet news agency announced that the four allied powers in control of Berlin had reached an agreement and that the Berlin blockade was over. The Soviet news put a pro-Russian twist to the announcement to make them appear to be the winners in the standoff, but in reality it was an embarrassing defeat of Soviet plans for control of Berlin. The Soviet news agency in question would remain the official word of the Soviet government until its demise in 1991. What was the name of this Soviet news organization?

- A. KGB
- B. TASS

- C. USSR
- D. Pravda

24. The Berlin blockade and the subsequent airlift to confront it marked the real beginning of the Cold War. One of the major implications of the Cold War was the formation of defensive alliances to defend western democracies from potential Soviet aggression. What was the name of the defensive organization that included among its members Britain, France and the United States?

- A. Warsaw Pact
- B. The European Union

- C. SEATO
- D. NATO

The Berlin Airlift and the Beginning of the Cold War Multimedia Presentation
Test Answer Sheet

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D
11. A B C D
12. A B C D
13. A B C D
14. A B C D
15. A B C D
16. A B C D
17. A B C D
18. A B C D
19. A B C D
20. A B C D
21. A B C D
22. A B C D
23. A B C D
24. A B C D

Appendix B: Consent Forms

**School Superintendent, Principal and Department Head Consent Form
for permission to use students as part of an educational research study**

Dear Superintendent of Schools,

I want to take the time to thank you once again for your cooperation in helping me conduct research regarding efficient multimedia instruction with your 11th Grade students. The time is fast approaching when I will be executing the research portion of the project and your students will be watching the multimedia presentations that are part of the study. It is necessary at this point in time to remind you of what will be occurring in regards to the study and how it will impact the education of your students. The following is an outline of the project. If all of the information is still acceptable to you, please sign the bottom of this sheet to verify your approval to move ahead with the project. If you have any objections or questions please feel free to contact me for clarification.

Project Outline

1. The teachers who have agreed to participate will divide their classes into three random groups based upon the alphabetical class roster to each view a separate multimedia presentations.
2. The students will view their assigned 30-minute presentation in the computer laboratory or on laptops in the classroom during their regularly scheduled class time. Each presentation covers exactly the same content, just presented in a little different manner and employing different instructional strategies. The content of the presentations is relevant to United States history and can be justified under the Maine Learning Standards.
3. The students will take a 24-question multiple choice test to measure the retention of content material from the multimedia presentations.
4. The only demographic data that will be collected is the names of the students to make sure that their results are computed with the proper group. Once their data is collected, their names will be deleted.
5. Once the project is complete and all of the data has been tabulated, the results will be presented to you.

Potential Risks

1. Student names are being used to ensure that their data is tabulated with the appropriate

experimental group. Once a student's test results are verified to be in the correct group, their names will be physically removed from the data by tearing along a perforated line. There will be no way to reattach or associate the name with the test results once they are separated.

2. The regular classroom routine will be disrupted during two meetings; one for the presentation and one for the post-test. Every attempt has been made to mitigate this problem by ensuring that the subject matter in the presentation will be closely associated to the regular curriculum as outlined by the school and by the Maine Learning Standards.

Potential Benefits

1. The students will at the very least become familiar with a topic from American history that is unique and commonly taught in depth.
2. The students will be exposed to new strategies of multimedia instructional design that could potentially improve learning.
3. Results from the study could provide a valuable basis for future professional development.

Statement of Consent: I have read and understand the above information and have received answers to any questions I asked from the researcher listed below. I consent to take part in this study.

Your Signature _____ Date _____

Your Name (printed) _____

Project Researcher:

Adam Leach

848-2077

48 Stoneybrook Way

aleach@liberty.edu

Hermon, ME 04401

Dissertation Committee Chair:

Dr. David Holder

434-582-2418

Liberty School of Education

deholder@liberty.edu

1971 University Boulevard

Lynchburg, VA 24502

Student and Parent Consent Form

Dear parent and student,

As a doctoral student at Liberty University I am currently conducting a study that measures the learning efficiency of certain multimedia instructional strategies and your school has been kind enough to allow me access to some students to act as participants. Your son/daughter has been selected as a potential participant in this study because of his/her status as an 11th Grade student and as being enrolled in a social studies or history class. Your son/daughter will not be allowed to participate in the study unless this statement of consent is returned to the teacher who is allowing his/her class to participate.

The study is not concerned with any private information and all individual data collected will remain confidential. Each participant is only required to watch a 30-minute multimedia presentation that covers social studies content (i.e. The U.S. Constitution or the attack on Pearl Harbor) and to take a 24-question multiple choice test. The tests results are anonymous and once the data from the test is recorded, the names of the participants will be deleted. An outline of the project and a list of potential risks and benefits can be found on the back of this letter.

Participation in the study is on a voluntary basis and will not impact the student's evaluation in the cooperating class.

For more information regarding this study you may contact the researcher at 217-7413

Sincerely,

Adam Leach

Liberty University School of Education Doctoral Candidate

Statement of Consent: I have read the above information, and have received answers to any questions I asked from the researcher listed on the back of this statement. Therefore, I consent to take part in the study.

Your child's name _____

Your Signature _____ Date _____

Your Name (printed) _____

Potential Risks

2. Student names are being used to ensure that their data is tabulated with the appropriate experimental group. Once a student's test results are verified to be in the correct group, their names will be physically removed from the data by tearing along a perforated line. There will be no way to reattach or associate the name with the test results once they are separated.
2. The regular classroom routine will be disrupted during two meetings; one for the presentation and one for the post-test. Every attempt has been made to mitigate this problem by ensuring that the subject matter in the presentation will be closely associated to the regular curriculum as outlined by the school and by the Maine Learning Standards.

Potential Benefits

1. The students will at the very least become familiar with a topic from American history that is unique and commonly taught in depth.
2. The students will be exposed to new strategies of multimedia instructional design that could potentially improve learning.
3. Results from the study could provide a valuable basis for future professional development.

Contact Information

Project Researcher:

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Appendix C: Examples of Control Group Slides

Illustration 1

Control Group slide with no animation on a map and bulleted points read by the narration.

Post-War German Zones of Occupation

West Berlin is 100 miles inside the Soviet Sector

Four Zones (Sectors) of Occupation

- British
- Soviet
- French
- American

Similar to German occupation

Located completely inside Soviet controlled Germany

West Berlin "surrounded" by the Soviet sector

Illustration 2

Control Group slide in which the images do not support the learning and text is read by the narration.

German **Reichsmark** was intentionally debased by the Soviets
Caused continued economic hardship (part of Soviet plan)

Deutschmark was introduced by the U.S.
Intended to improve the German economy
Soviets refused to accept it as legal tender

Ostmark introduced by the Soviet Union
Intended to prevent Deutschmark from becoming established German currency

Illustration 3

Control Group slide with a map and no animations.

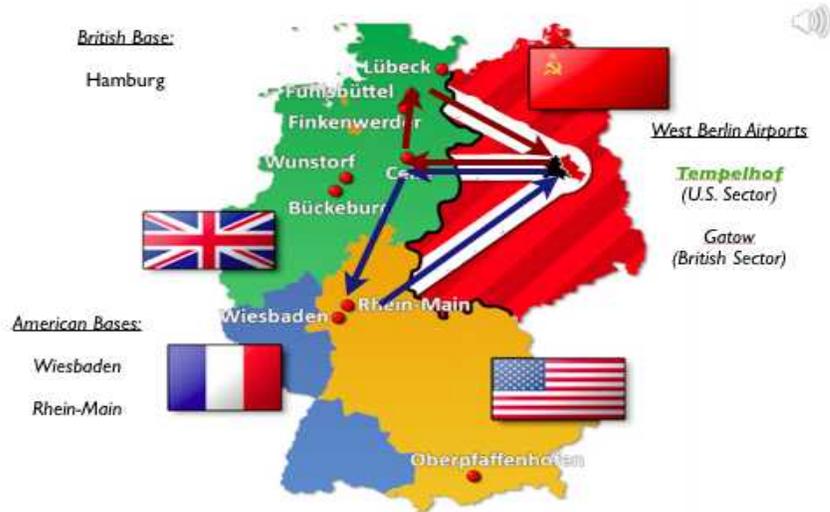


Illustration 4

Control Group slide with redundant text and narration with irrelevant images.

The Decision for an Airlift

Difficulties

- Needs to be indefinite
- If it fails? It could embolden the Soviets for more provocations elsewhere
- Could prolong starvation of Berliners

Air corridors to Berlin

As agreed upon by Roosevelt and Stalin at the Yalta Conference in 1945

Only way to stop airlift was to shoot down cargo planes



General Curtis LeMay

"We (the USAF) can haul anything!"

The slide features a map of Germany with air corridors to Berlin, a speaker icon, and a portrait of General Curtis LeMay. The text is repetitive and includes a quote from LeMay.

Illustration 5

Control Group slide redundant text and narration and irrelevant images.

The Berlin Blockade Begins



The currency crisis provoked the Soviet Union
Wanted the west completely out of Berlin
"We (the Soviets) are warning (the Allies) and the population of Berlin..."



250 million **Deutschmarks**
Secretly introduced into West Berlin



Quickly became the standard currency, even in the Soviet zone

Soviet propaganda: The U.S. will abandon West Berlin
Soviets postured by conducting military drills outside the city
Rumors spread quickly about a Soviet invasion of West Berlin

Appendix D: Examples of Multimedia Principle Group Slides

Illustration 6

Multimedia Principle slide with animated slides and synchronized narration (Step 1)



Illustration 7

Multimedia Principle slide with animated slides and synchronized narration (Step 2)



Illustration 8

Multimedia Principle slide with animated slides and synchronized narration (Step 3)

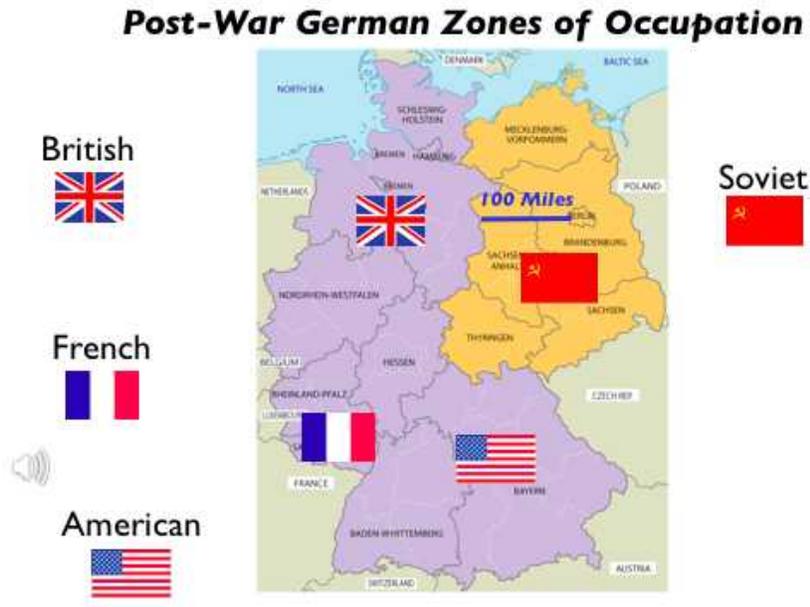


Illustration 9

Multimedia Principle slide containing images of items explained in narration



German **Reichsmark** was intentionally debased by the Soviets
Caused continued economic hardship (part of Soviet plan)

Deutschmark was introduced by the U.S.
Intended to improve the German economy



Illustration 10

Multimedia Principle Slide with map animations synchronized with narration (Step 1)



Illustration 11

Multimedia Principle Slide with map animations synchronized with narration (Step 2)



Illustration 12

Multimedia Principle Slide with map animations synchronized with narration (Step 3)



Illustration 13

Multimedia Principle Slide introducing action with item images, maps and synchronized narration (Step 1)

The Berlin Blockade Begins



Illustration 14

Multimedia Principle Slide introducing action with item images, maps and synchronized narration
(Step 2)

The Berlin Blockade Begins



250 million **Deutsche Marks**

Secretly introduced into West Berlin



Ostmark introduced by the Soviet Union

Intended to prevent Deutsche Mark from becoming established German currency

Provoked the Soviet Union

Wanted the west completely out of Berlin

Appendix E: Examples of Redundancy Principle Group Slides

Illustration 15

Control Group Slide showing the on-screen text that was eliminated in the Multimedia Principle Group Slide

The Chocolate Pilot

Captain **Gail "Hal" Halvorsen** gave some Wriggly's Gum to some kids in Berlin

He promised to bring more on his next trip into the city

Halvorsen told the kids he would wiggle his wings so that they would know it was him

Halvorsen got the nickname "**Uncle Wiggly Wings**"

He began receiving fan mail from children in Berlin

The U.S. Air Force used Halvorsen's popularity to show we were the "good guys"

Code name for the candy bombings was called "**Operation Little Vittles**"

Halvorsen received several marriage proposals when the story was promoted in newsreels





Illustration 16

Redundancy Group Slide showing the visual aspects without redundant on-screen text (Example 1)

The Decision for an Airlift



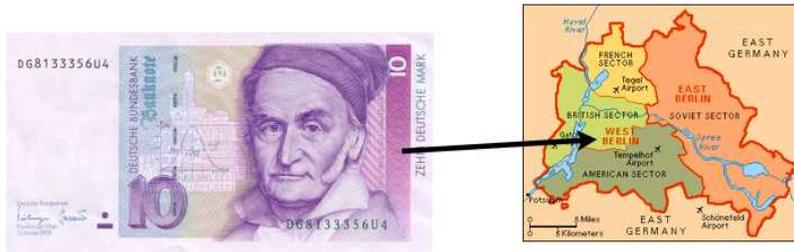


C-54 **General Curtis Lemay**

Illustration 17

Redundancy Group Slide showing the visual aspects without redundant on-screen text (Example 2)

The Berlin Blockade Begins



250 Million Deutschmarks introduced to West Berlin

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