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The Effects of Training, Modality, and Redundancy on the Development of a Historical Inquiry Strategy in a Multimedia Learning Environment

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Abstract

The purpose of this study was to assess the effects of training, modality, and redundancy on the participants' ability to apply and recall a historical inquiry strategy. An experimental research design was utilized with presentation mode as the independent variable and strategy application and strategy recall as the dependent variables. The participants were engaged in the multimedia intervention for a total of five days, for approximately 30 minutes a day. The results of the study revealed significant differences in the training main effects analysis indicating that strategy instruction can be effectively provided in a multimedia learning environment. However, no significant differences were found for the modality and redundancy main effects.

Introduction

The research surrounding the use of multimedia to deliver instruction has experienced significant change over the last several decades. Multimedia research that was once centered on the technologies used to deliver the presentation has shifted to a learner-centered approach that is grounded in theories of human learning (Lowe & Schnotz, 2008; Lusk et al., 2009). As a result of this shift, researchers now attempt to understand how the use of multimedia instructional materials can aid cognition. Research has supported the claim that learning is increased when information is presented via multimedia presentations (Mayer & Sims, 1994; Penney, 1989). Much of the success of multimedia can be explained through dual-coding theory, which suggests that individuals have two separate, but interconnected, systems for representing verbal and nonverbal information (Hodes, 1994; Paivio, 1990). Essentially, multimedia environments allow for the distribution of information across both the visual and verbal processing channels. Subsequent research in this area, however, has shown that multimedia can also impose undue burden on the information processing system of the learner if not designed appropriately (Chandler & Sweller, 1991; Kalyuga, Chandler, & Sweller, 1999).

Researchers have spent the past two decades applying theories of human learning, such as dual-coding theory and cognitive load theory, to the design of multimedia instruction (Mayer &

Anderson, 1991, 1992; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mayer & Gallini, 1990; Mayer, Heiser, & Lonn, 2001; Mayer & Moreno, 1998; Mayer & Sims, 1994). This research has examined the effects of various multimedia attributes on students' understanding of scientific cause-and-effect explanations, which has yielded numerous design principles (e.g., modality principle, redundancy principle). However, the results of this research are limited in that the instruction provided in the studies focused primarily on scientific cause-and-effect explanations.

This study attempted to extend previous findings on the modality and redundancy principles to a different learning outcome, namely, strategy development. Additionally, a different dependent measure (i.e., strategy application) was used to assess the effects of a multimedia tutorial dedicated to the instruction of a strategy for historical inquiry. Finally, this study was designed to address the effects of two multimedia attributes, modality and redundancy, on students' recall and application of a historical inquiry strategy.

Modality Principle

The modality principle stems from the limited capacity assumption of the cognitive theory of multimedia learning (Mayer, 2001). Accordingly, it indicates that words should be presented as auditory narration rather than on-screen text when presenting an explanation using multimedia. Cognitive load theorists pointed to this principle as an alternative way of dealing with split attention. Split-attention effects adversely affect learning because the process of mentally integrating disparate sources of information overloads working memory. However, if the textual information is presented in auditory rather than visual (written) form, the integration of the sources of information may not overload working memory.

Early research on short-term verbal memory provides evidence for a modality effect, referring to the finding that auditory presentation almost always resulted in higher recall than did visual presentation in short-term memory tasks (Penny, 1989). Mousavi, Low, and Sweller, (1995) found evidence for a modality effect in a series of experiments using worked-out geometry examples. The researchers found that a visually presented geometry diagram, coupled with narrated statements, enhanced learning compared to a conventional visual-only format. Tindall-Ford, Chandler, and Sweller (1997) also investigated the modality effect using basic electrical engineering instructions. The results showed that a narrated text and visual diagram format was superior to a visual-only format.

Mayer and Moreno (1998) produced the first demonstration of a modality effect within the context of multimedia learning with animations. Students were presented with an animation depicting the process of lightning formation or the operation of a car's brake system. One group of students was presented a simultaneous narration while the other group received concurrent on-screen text. Students receiving the simultaneous animation and narration performed better on tests of retention, matching, and transfer than students who received animation and on-screen text.

Research on the modality effect yields consistent evidence to suggest that in many situations mixed modality presentations are superior to most integrated text and visual presentations (Kalyuga, Chandler, & Sweller, 1999; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Mousavi et al., 1995; Tindall-Ford et al., 1997). Evidence for the benefits of a modality effect has been documented in research on verbal learning, cognitive load, and multimedia learning (Kalyuga et al., 1999; Moreno & Mayer, 1999; Mousavi et al., 1995; Penney, 1989; Tindall-Ford et al., 1997).

Redundancy Principle

Results from research on the modality principle indicate that words and pictures that are both presented visually increase cognitive load due to the competition for resources in visual working memory (Moreno & Mayer, 1999; Mousavi et al., 1995; Tindall-Ford et al., 1997). Consequently, the *redundancy principle* suggests that removing redundant on-screen text results in better performance than when redundant material is included (Mayer, 2001).

Kalyuga, Chandler, and Sweller (1998, 1999) used the term "redundancy effect" to refer to any multimedia situation in which eliminating redundant material results in better performance than when the redundant material is included. Kalyuga et al. (1999) generated evidence of this effect in an experiment aimed at testing the modality effect to ameliorate split-attention effects. Students were presented three computer-based instructional formats based on soldering materials: diagram and visual text, diagram and audio text, and diagram and visual-plus-audio text. The diagram and visual text format contained the animation with on-screen text while the diagram and audio text format contained the animation with narration only. The diagram and visual-plus-audio text format contained sequentially introduced animated components of the diagram with written explanations of the elements. The same explanations were simultaneously narrated to correspond with the animation. The results of this experiment confirmed the advantages of dual-modality presentation but they also demonstrated a disadvantage of the duplicate information. Ultimately, eliminating the redundant information proved to be beneficial (Kalyuga et al., 1999).

Mayer, Heiser, and Lonn (2001) used the term redundancy effect in a more restricted sense to refer to "multimedia learning situations in which presenting words as text and speech is worse than presenting words solely as speech" (p. 187). The researchers examined whether the redundancy effect would occur in a multimedia environment involving animation, on-screen text, and narration. College students viewed an animation and listened to concurrent narration explaining the formation of lightning. The redundancy effect was demonstrated when students who were presented on-screen text that summarized or duplicated the narration performed worse on tests of retention and transfer than students who received only the concurrent narration.

Overall, the redundancy effect occurs under conditions in which different sources of information are intelligible in isolation and when both sources provide similar information but in a different form (Kalyuga, Chandler, & Sweller, 2000). Consequently, attending to redundant information requires cognitive resources. Thus, attending to redundant material imposes an increased cognitive load, which can be ameliorated by removing the redundant information.

Strategy Instruction

Beyond traditional multimedia instruction focused on cause-and-effect explanations (e.g., lightning formation), strategies represent a learning outcome with little history of focus in the multimedia environment (Dehn, 1997; Hartley, 2001). Strategies are guides that focus on the internal cognitive processes of the learner and provide a means for learners to tackle less-structured tasks. While learners can acquire strategies through day-to-day experiences, strategies can also be taught explicitly, which has resulted in greater strategy deployment and maintenance in a variety of domains (Brown, Campione, & Day, 1981; Dehn, 1997; Mayo, 1993; McCombs, 1988; Palincsar, 1986; Pressley, Snyder, Levin, Murray, & Ghatala, 1987) . The findings from

such research indicate that when teaching strategies the instruction should take place within a specific context and should address essential metacognitive knowledge regarding the significance and utility of the strategy. Additionally, the instruction should be scaffolded and provide the learners opportunities to practice the trained strategy and receive feedback regarding their strategy use. (Brown et al., 1981; Dehn, 1997; Palincsar, 1986; Pressley et al., 1990).

Does strategy instruction deemed effective in traditional learning environments transfer to the multimedia learning environment? Do the multimedia effects discovered in the instruction of scientific explanations have the same effects when the focus of the instruction is strategy development? The purpose of this study was to assess the effects of training, modality, and redundancy on the participants' ability to apply and recall a historical inquiry strategy. Specifically, this study sought to answer the following questions:

1. Can strategy instruction be provided effectively in a multimedia environment?
2. What are the effects of multimedia presentation *modality* on students' performance on tests of strategy application and recall?
3. What are the effects of multimedia presentation *redundancy* on students' performance on tests of strategy application and recall?

Method

The purpose of this study was to assess the effects of training, modality, and redundancy on participants' ability to apply and recall a historical inquiry strategy. A multimedia tutorial was used to deliver instruction on the SCIM strategy for historical inquiry. Participants completed recall and application tests prior to four sessions of the strategy training, recall and application tests following the training, and then an application test one week beyond the completion of the training.

Participants and Design

A total of 56 participants completed the study. The participants included 38 females and 18 males, with an average age of 21.4 years. The ethnic breakdown of the sample included 41 White/Caucasian students, five Black/African American students, one American Indian/Alaskan Native student, three Asian students, two Hispanic/Latino students, three Multiracial students, and one "Other" student. The sample was drawn from a population of students enrolled in undergraduate courses in teacher education and student received course credit for participation.

In addition, participants were randomly assigned to one of three treatment groups resulting in 19 participants in the animation-narration (AN) group, 19 participants in the animation-text (AT) group, and 18 participants in the animation-narration-text (ANT) group. The study employed a 3 (AN, AT, ANT) x 3 (pre-test, post-test, maintenance test) repeated measures research design.

Materials and Apparatus

SCIM Historical Inquiry Tutorial. The SCIM multimedia tutorial was approximately 2.5 hours in length, experienced over four days, involved narrated animation, and was created using Adobe's Flash™ (see Hicks & Doolittle, 2008). Three versions of the tutorial were constructed containing the same animation involving short, 30-60 second instructional segments followed by

a "Continue" button that when pressed would initiate the next segment (participants could not "go back" to view a previously viewed segment). The three versions differed in their presentation of the verbal content. The AN version provide the verbal content in the form of simultaneous audio narration. The AT version provided the content in the form of simultaneous on-screen text at the bottom of the screen, and the ANT version provided both audio narration and on-screen text. The verbal content itself, however, was exactly the same for each of the three groups – the narrated words were the same as the on-screen text words.

The SCIM tutorial was designed around three sections: strategy explanation, strategy demonstration, and strategy participation. The *strategy explanation* section was designed as a direct, step-by-step explanation of the SCIM strategy; the *strategy demonstration* section provided modeling of the SCIM strategy by an expert historian; and the *strategy participation* section provided the user with extensive practice in analyzing a primary source, with explicit feedback.

The first phase of the tutorial consisted of the explanation of the SCIM strategy and the relevant metacognitive knowledge associated with the strategy. The purpose of this phase of the tutorial was to inform the participants of the purpose of using the SCIM strategy and why using the SCIM strategy is helpful in the process of historical inquiry. Additionally, this phase served to explain each level of the SCIM strategy and how it was used when analyzing a given primary source (see Figure 1).

The demonstration phase of the tutorial consisted of expert modeling of the SCIM strategy. To demonstrate how the SCIM strategy can be used to analyze primary sources, an expert historian modeled the process of using the SCIM strategy from the time the guiding historical question was presented to the final interpretation. The model demonstrated how he progressed through each of the levels of the SCIM strategy, asking specific questions within each level (See Figure 2). The model followed this demonstration with a historical interpretation of the guiding question based on the analysis of the source provided.

The practice phase of the tutorial provided participants the opportunity to practice the application of the SCIM strategy in analyzing a primary source. This phase overlapped with the strategy demonstration phase. Participants were presented with interpretive statements that they had to assess in terms of the passage's adequacy in representing the given primary source (see Figure 3). Informative feedback was provided immediately and consisted of knowledge of results and suggestions for successful strategy application.

Strategy recall test and scoring

A strategy recall test was developed to assess the participants' knowledge of the SCIM strategy. The design of this assessment consisted of two short-answer questions, (a) What is the purpose of the SCIM strategy?; and (b) Identify and explain the four levels of the SCIM strategy. The strategy recall test took approximately 15 minutes to complete and participants took completed recall test on the last day of training.

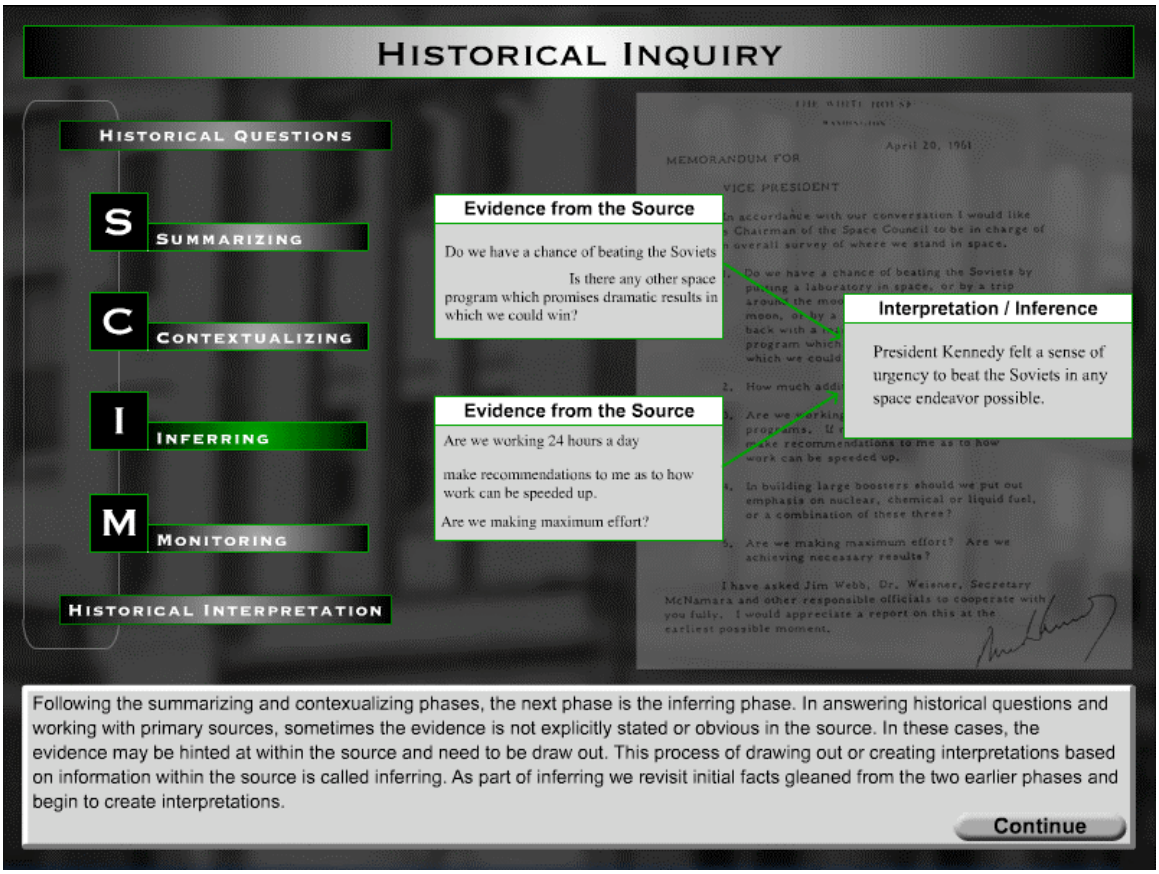

Figure 1. Explanation of the inferring phase of the SCIM strategy.

The strategy recall test responses were evaluated using a scoring rubric. The first section of the rubric contained five criteria addressing the *purpose* of the SCIM strategy (i.e., Develop a better understanding of history, Engage in historical inquiry, Investigate and respond to guiding historical questions, Evaluate historical sources, and Develop historical interpretation) and was worth 10 points, two points for addressing each criterion. The second section of the rubric also contained five criteria addressing the *explanation* of the SCIM strategy (i.e., levels of the SCIM strategy, detailed explanation of Summarizing, detailed explanation of Contextualizing, detailed explanation of Inferring, detailed explanation of Monitoring) and was worth 20 points, four points for addressing each criterion. Overall, the strategy recall test was worth 30 points. Two independent raters were trained on how to score the participants' responses using the assessment rubric. Subsequently, each response was scored by both raters with no knowledge of which group the response originated. All disagreements between raters were settled through direct discussion (inter-rater reliability, r = .87).

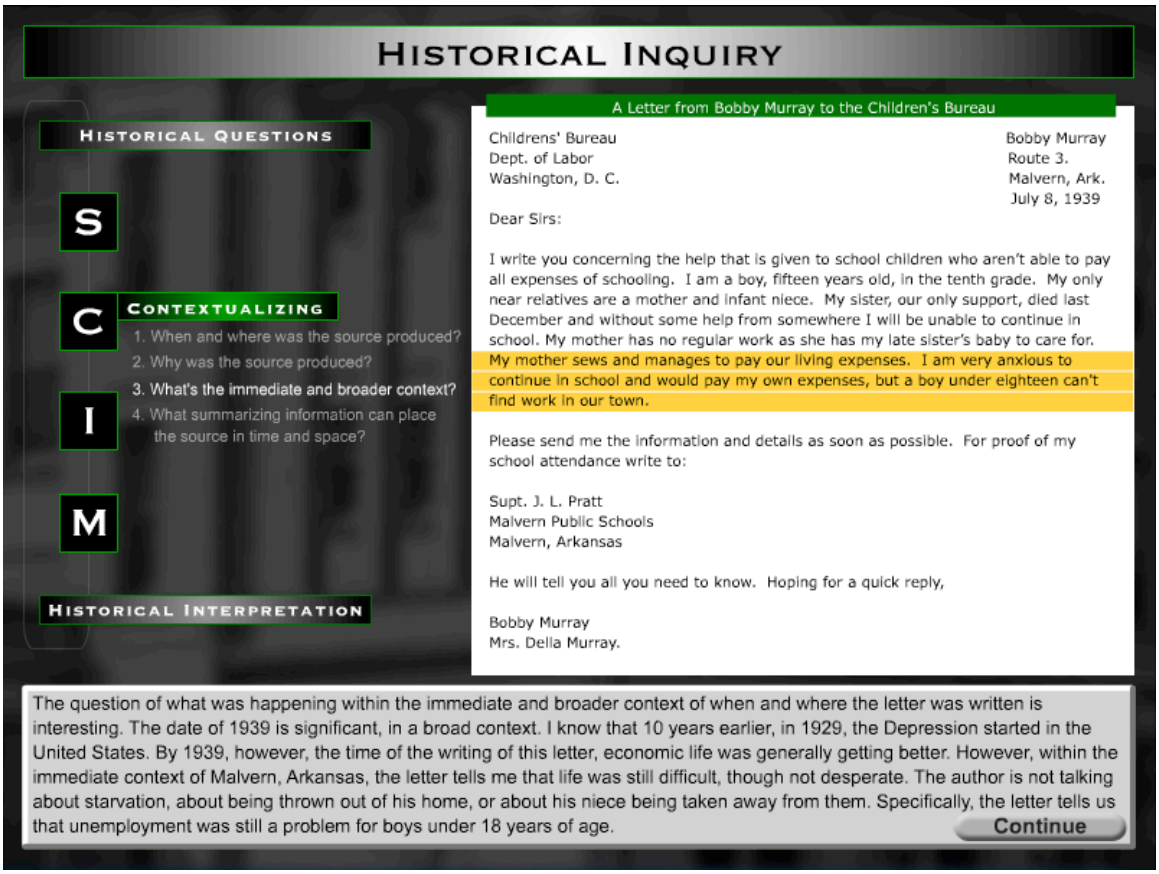

Figure 2. Demonstration of the contextualizing phase of the SCIM strategy.

Strategy application test and scoring

A strategy application test was used to measure the effects of the treatments on the participants' ability to apply the SCIM strategy to analyze a primary source, in order to answer a guiding historical question. Participants engaged in three strategy application tests, a pre-test, prior to engaging in the SCIM tutorial treatment, a post-test, immediately following final day of the SCIM tutorial treatment, and a maintenance test, one week following the end of the SCIM tutorial treatment. The design of the strategy application test consisted of a guiding historical question in which participants analyzed a primary source to develop a historical interpretation or "answer" to the question. Therefore, over the course of the study, participants read, analyzed, and created a historical interpretation for three historical letters. Specifically, letter A addressed farming in early 20th century in the mid-west United

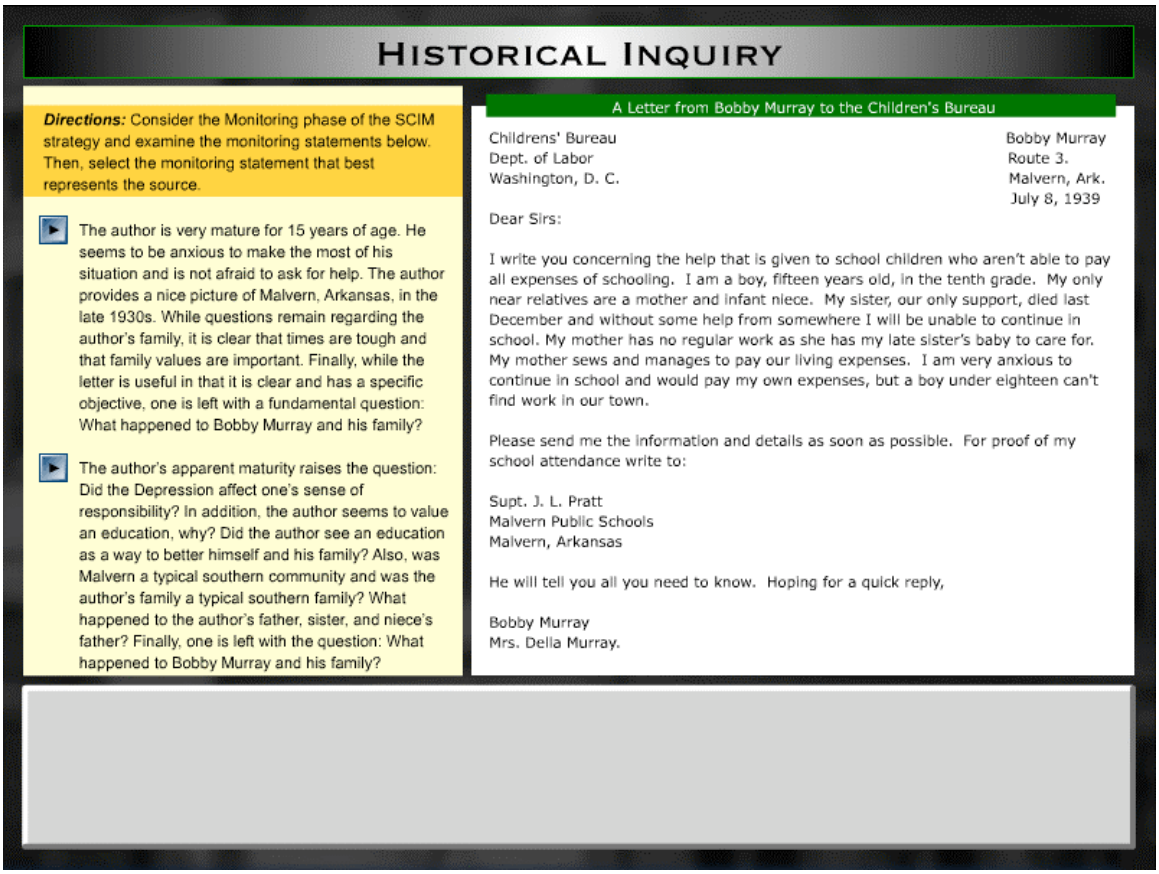

Figure 3. Practice phase of the SCIM strategy.

States and participants were instructed: "Use the letter below to help you in answering the following question: What does this source reveal about the conditions of life in farming communities on the great plains during the early 20th century?" Letter B addressed views on women's rights in the 1850s and participants were instructed: "Use the letter below to help you in answering the following question: What does this source reveal about nineteenth century views on women's rights?" Letter C addressed the interactions between missionaries and Native Americans in the late 1800s and participants were instructed: "Use the letter below to help you in answering the following question: What role did missionaries play in Native American/American Indian communities in the late 19th century?" The order in which the participants received the three forms of the strategy application tests was randomly assigned. The strategy application test was paper-pencil based and took approximately 15 minutes to complete.

An assessment rubric for the strategy application test was created to score the participants' responses. The rubric consisted of four sections, which corresponded to the four levels of the SCIM strategy (i.e., summarizing, contextualizing, inferring and monitoring) and the questions within each level. Participants acquired points by providing evidence of the questions inherent in each level of the SCIM strategy. Participants had the possibility of gaining 10 points for Summarizing, 10 points for Contextualizing, 12 points for Inferring, and 12 points for Monitoring for a total of 44 points. Two independent raters were trained on how to score the participants' responses using the assessment rubric. Subsequently, each response was scored by both raters with no knowledge of which session the response originated. All disagreements

between raters were settled through direct discussion. Inter-rater reliability, Cohen's kappa = .80, was determined by comparing the raters' responses (yes or no) to the scoring rubric questions across all participants.

Procedure

Participants were tested individually in groups of one to six students per session, across four days during a single week. The first day, participants completed a demographics questionnaire and the strategy application pre-test. Following the completion of these tasks, the experimenter provided participants with oral instructions explaining that they would be engaging in a tutorial explaining and demonstrating the process of historical inquiry. Participants then engaged in the first 30-minute segment of the multimedia tutorial. The second and third days of the study, participants were again given brief instructions and then completed a SCIM tutorial session. On the fourth day of the study, participants completed the final SCIM tutorial session. Immediately following the completion of final session, participants then completed a strategy recall test and a strategy application post-test. Participants were given 10 minutes to complete the strategy recall test and 15 minutes to complete the strategy application test. One week after completing the final SCIM tutorial session, participants completed a strategy application test. Participants were given 15 minutes to complete the strategy application test.

Results

The purpose of this study was to assess the effects of training, modality, and redundancy on the participants' ability to apply and recall a historical inquiry strategy. A 3 (AN, AT, ANT) x 3 (pre-test, post-test, maintenance test) repeated measures ANOVA, with the Greenhouse-Geisser adjustment, was used to address the strategy application data. This single analysis was used to address both the effects of training on strategy application and the effects of modality and redundancy on strategy application. In addition, a one-way (AN, AT, ANT) ANOVA was used to address strategy recall. All inferential analyses were conducted at an alpha of .05. Finally, effect size was computed using Cohen's *d* (small effect = .2, medium effect = .5, large effect = .8).

The Effects of Training on Strategy Application

The 3 x 3 ANOVA revealed a significant main effect for *training* on strategy application, $F(2, 53) = 51.29$, $p = .00$ (see Table 1). A Tukey post-hoc analysis revealed that application post-test scores were significantly higher than application pre-test scores ($p = .00$, $d = 1.18$) and that application maintenance test scores were also significantly higher than application pre-test scores ($p = .00$, $d = 1.44$). However, there was no statistically significant difference between application post-test and maintenance test scores ($p = .20$). These results indicate that participants scored significantly higher on tests of strategy application following the multimedia strategy instruction and that this improvement in application was sustained over a week's time.

The Effects of Modality and Redundancy on Strategy Application

The modality effect is determined by comparing the AN and AT groups, while the redundancy effect is determined by comparing the AN and ANT groups. The omnibus 3 x 3 ANOVA did not find a significant main effect for presentation group, $F(2, 53) = 2.83$, $p = .06$ (see Table 1), however, pairwise comparisons were examined for the post-test AN-AT and AN-ANT combinations, as well as the maintenance-test AN-AT and AN-ANT combinations as the omnibus test contained the pre-test data that were not germane to the evaluation of the modality and redundancy effects. The examination of these pairwise comparisons did not yield any statistically significant differences ($p > .05$).

Table 1.

General Descriptive Statistics for AN, AT, and ANT Groups for Strategy Application

	Strategy Application[a]		
Groups	Pre	Post	Maint
Animation-Narration (AN)	5.47 (2.67)	12.00 (8.12)	14.53 (6.78)
Animation-Text (AT)	6.11 (2.83)	12.95 (7.67)	14.47 (7.66)
Animation-Narration-Text (ANT)	8.17 (4.69)	17.39 (7.25)	17.67 (8.60)

Note. Values are based on strategy application test scores ranging from 1-44.

[a] Pre = Pre-test, Post = Post-test, Maint = Maintenance Test

The Effects of Modality and Redundancy on Strategy Recall

A one-way ANOVA was performed to examine the effects of modality and redundancy on recall, revealing no main effect for presentation group, $F(2, 53) = .506$, $p = .60$. Again, the modality effect is determined by comparing the AN ($M = 15.95$, $SD = 3.27$) and AT ($M = 15.21$, $SD = 4.25$) groups, while the redundancy effect is determined by comparing the AN and ANT ($M = 16.56$, $SD = 4.62$) groups; thus, pairwise comparisons were examined for the AN-AT and AN-ANT combinations. The examination of these pairwise comparisons did not yield any statistically significant differences ($p > .05$).

Discussion

The purpose of this study was to assess the effects of training, modality, and redundancy on participants' ability to apply and recall a historical inquiry strategy. The main effects for

strategy application revealed that both the participants' strategy application post-test and maintenance test scores were significantly higher than their strategy application pre-test scores. Specifically, participants were better at applying the SCIM strategy for historical inquiry to analyze a primary source in response to a guiding historical question following the instruction. In addition, the participants were able to maintain their improved level of strategy application over time. Based on this finding, it can be concluded that strategy instruction can be effectively provided in a multimedia environment.

The main effects for strategy application, as well as post-hoc pairwise comparisons, also revealed no significant differences in modality or redundancy. The findings indicate that none of the treatment conditions (i.e., AN, AT, or ANT) had any differential effect on participants' levels of strategy application from pre-test to post-test to maintenance test. Therefore, it can be concluded that neither the combination of presentation modes used to deliver the instruction (i.e., AN, AT) nor the presence of redundant on-screen text (i.e., ANT) had an effect on participants' ability to apply the trained strategy.

Finally, the main effects for strategy recall, as well as post-hoc pairwise comparisons, revealed no significant differences in modality or redundancy. This finding indicates that none of the treatment conditions (i.e., AN, AT, or ANT) had any differential effect on participants' levels of strategy recall. Therefore, it can be concluded that neither multimedia presentation modality (i.e., AN, AT) nor redundancy (i.e., ANT) had an effect on participants' ability to recall the trained strategy.

Multimedia Instruction

The multimedia instruction in Mayer's research (for overview see Mayer, 2001, 2005) focused on the understanding of scientific cause-and-effect explanations. One goal of the present study was to determine if instruction focused on a different learning outcome, namely the development of a cognitive strategy, could also be provided effectively in a multimedia environment. It was hypothesized that if the intervention was designed according to guidelines gleaned from literature on strategy instruction (Hicks & Doolittle, 2008; Pressley et al., 1990), as well as principles of multimedia design (Mayer, 2001, 2005), that participants would be better at applying a trained strategy following instruction than they were prior to the instruction. The results of the study supported this hypothesis.

Based on the significant improvement in strategy application test scores following the instruction, it can be concluded that the multimedia environment is a viable medium for the provision of strategy instruction. It has been suggested that the true effectiveness of strategy instruction is determined by the learners' continued use of a strategy following explicit instruction (Brown et al., 1983; Pressley et al., 1990). Consequently, a strategy application maintenance test was used to determine the participants' level of strategy application a week following the instruction. The results indicated that the participants maintained their improved level of performance on the strategy application maintenance test, which adds further strength to the conclusion that strategy instruction can be effectively provided in a multimedia environment.

The second goal of this study was to extend the findings from previous studies on the modality and redundancy principles. Traditionally, multimedia research addressing the modality and redundancy principles has focused on short (i.e., less than 3 minutes), system-paced multimedia presentations designed to teach scientific explanations (i.e., intellectual skill) utilizing animations to depict a cause-and-effect relationship (see Mayer et al., 2001; cf. Jamet &

Bohec, 2007). The present study differed from these studies in three respects. Specifically, the present study explored the effects of modality and redundancy on a different learning outcome (i.e., cognitive strategy), a longer instructional episode (i.e., 2.5 hours versus 3+ minutes), and a learner controlled instructional pace. The results of this study did not support the findings of the previous research, revealing neither a modality nor a redundancy effect.

Strategies and Animation

According to Rieber (1990), animation brings visualization, motion, and trajectory to an instructional setting and the efficacy of the animation depends on the learner's need for one or more of these attributes for successful completion of the instructional task. In the present study, making connections between the verbal information and animation was not crucial to the understanding of the material (i.e., strategy instruction). Instead, the animation was used as a supplement to guide the participants' learning and to highlight important aspects of the information being presented (i.e., signaling). It is possible that the use of animation in this manner does not impose heavy demands on the visual processing system. Consequently, when presented with additional visual stimuli (i.e. on-screen text), the cognitive load on the visual system would not have been exceeded, thus allowing the learner to attend to and process all of the information.

It seems that this finding and subsequent conclusion could also be true when the animation presented is not explanatory in nature and does not require high demands on the visual processing system. In the present study, there were no significant differences found in levels of strategy application or recall between the presentation groups who received redundant verbal information (i.e., ANT) and those who were presented with only narration or on-screen text (i.e., AN and AT) in conjunction with the animation. Therefore, the results of this study indicate that participants in the ANT group appeared to be able to attend to multiple modes of visual information (i.e., animation and on-screen text) and redundant verbal information presented auditorly without experiencing cognitive overload in the visual processing system, which would explain why no redundancy effect was revealed.

Length and Pace of Instruction

Another possible explanation for the lack of significant differences between the groups stems from the length and pace of the instruction used in the present study. According to Mayer (1999) two limitations to the conclusions yielded from his research were that the instructional presentations were short (i.e., less than three minutes) and system-paced. He emphasized the need for additional research that examined multimedia learning in settings where the instruction was longer in duration and where the pacing was under the learner's control.

The present study addressed the limitations cited by Mayer (1999) by utilizing a segmented instructional presentation that was two hours long and was presented over the course of four days for 30+ minutes each day. Each segment of the daily presentation was approximately one minute in duration. The participants had partial control over the pace of the instruction in that they had control over when they moved onto the next segment but were not permitted to move backward in the tutorial or repeat a segment. Thus, the participants could spend as much time as they wanted with the material presented in each segment.

Tabbers, Martens, and van Merrienboer (2004) found similar results in a study aimed at testing the generalizability of the modality effect in a classroom setting. The researchers focused on subject matter other than scientific explanations by utilizing a presentation on an instructional design model (i.e., 4C/ID model). The instructional presentation was learner-paced and consisted of a singe one-hour training session. The results of this study indicated a reverse modality effect where the participants in the visual conditions (i.e., diagram plus on-screen text, AT) scored significantly higher on tests of retention and transfer than those in the audio conditions (i.e., diagram plus spoken text, AN). Tabbers et al. (2004) cited the differences in the subject matter and pacing of the instruction as possible explanations for their finding of a reverse modality effect. They argued that instructional design models are more procedural and less descriptive than scientific explanations and that visual text may be the more suitable format for presenting procedural skills as the learner has more time to reflect on the information. Similarly, they suggested that in learner-paced presentations, visual-only conditions are superior to bi-modal conditions because participants have more time to relate the text to the corresponding visual diagrams. Ultimately, the authors concluded that, "a bi-modal presentation is only advantageous when the system sets the pace of the instructions, whereas visual-only instructions are the preferred format if the learner is in control" (Tabbers et al., 2004, p. 80)

From the results of the present study, and those of Tabbers et al. (2004), it appears that the effects of modality and redundancy are not a factor in lengthy, learner-paced instruction. It is possible that the extended period of instruction coupled with opportunities for review and practice allow the learner to adjust to the demands imposed by uni-modal (i.e., visual-only) and redundant visual material. Additionally, differences in cognitive load that have an influence on short learning tasks may lose their influence as more time-related factors become dominant in the learning process (e.g., practice, concentration and attention-span).

In conclusion, the results of this study support the notion that strategy instruction can be delivered effectively in multimedia learning environments. However, it appears that the presentation mode combination (i.e., AN, AT, and ANT) used to present strategy instruction does not have an effect on levels of strategy application or strategy recall. Specifically, neither a modality effect nor a redundancy effect was produced indicating that there was no difference among participants who received the instruction as animation and narration, animation and text, or animation, narration and text.

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