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Effects of Objectives, Practice, and Review in Multimedia Instruction

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This study examined the effects of instructional elements (objectives, information, practice with feedback, and review) on achievement, attitude, and time in a computer-based, multimedia program. Undergraduate college students used the multimedia lesson to learn about artists and their painting styles. Results indicated that practice had a significant effect on achievement while objectives and review did not. Participants who used the program with practice performed significantly better than those who did not receive practice. Student responses to the attitude survey showed that they were sensitive to the presence or absence of the instructional elements investigated in this study. Participants who used the lean program (information only) had the lowest overall attitudes. Results of paired comparison questions on the attitude survey revealed that participants perceived information, practice, and review to be more helpful than objectives. Turning to time, participants who received the full program spent the most amount of time working though the multimedia lesson and those who received the lean program spent the least amount of time. Implications for designing multimedia instruction are discussed.

Research on learning from multimedia indicates that the methods used in an instructional program, not the delivery media by itself, impacts learn-

ing (Mayer, 2001). According to Clark and Mayer (2007) instructional methods are "the elements included in instruction for the purpose of supporting the achievement of the learning objective…instructional methods are intended to encourage learners to use appropriate cognitive processing during instruction" (p. 314). These authors indicate that multimedia will promote learning to the extent that it supports human cognitive processes.

In 1965, Robert M. Gagné published the first edition of his book *The Conditions of Learning* in which he proposed nine events of instruction that provide a sequence for organizing a lesson. The nine events facilitate and support specific cognitive processes during learning such as attention, encoding, and retrieval (Driscoll, 2007). They serve as a vehicle for incorporating the conditions of learning into an instructional program and have been used as a framework for the design of many lessons over the last several decades (Gagné, Wager, Golas, & Keller, 2005). They also remain the foundation of current instructional design practice (Reiser, 2007; Richey, 2000).

The instructional events that Gagné incorporated into his model have been the subject of a substantial body of research. However, some of these events may produce a much different effect when they are studied individually than when they are combined into a more complete set that incorporates most or all of the events. As Hannafin (1987) noted, some design strategies may have a positive effect when used in isolation but this impact is diminished or negated when these strategies are used in combination with more powerful techniques.

This article reports on a research study conducted to examine the impact of combining several events from Gagné's model on learning from multimedia. The events from that were directly incorporated into a multimedia lesson in the current study are objectives, information, practice with feedback, and review. The literature on each of these events is briefly discussed.

Objectives

An instructional objective is a statement that describes an intended outcome of instruction (Dick, Carey, & Carey, 2005; Mager, 1997). Objectives facilitate cognitive processing by focusing student attention, directing selective perception of specific lesson content, communicating expectations, and organizing new information into an existing structure (Foshay, Silber, & Stelnicki, 2003; Gagné , 1985; Gagné et al., 2005, Smith & Ragan, 2005).

According to Reiser and Dick (1996), "At a fairly early stage, learners should be informed of what it is that they are going to be able to do when they finish the instructional process. By knowing what will be expected of them, learners may be better able to guide themselves through that process"

(p.48). Morrison, Ross, and Kemp (2006), indicated that although the general trend continues to be the use of objectives as a preinstructional strategy, research results suggest providing learners with objectives is not as effective as once thought.

Some researchers have found that the presence of objectives may not make a difference when computer-based instruction is systematically designed; however, learning will increase when objectives are provided in lessons that are not well designed (Hannafin, 1987). Furthermore, the benefits of objectives are likely reduced when more powerful instructional events such as practice is included in computer-based lessons (Hannafin, Philips, Rieber, & Garhart, 1987; Martin, Klein, & Sullivan, 2007; Philips, Hannafin & Tripp, 1988).

Information

According to Forcier and Descy (2002), "every learning environment has an implied method of information presentation" (p. 104). During this event of instruction, students encounter the content they will be learning either in a didactic form or through a discovery approach (Smith & Ragan, 2005). All models of direct instruction include strategies for presenting didactic information to students. A significant part of direct instruction involves presenting students with the necessary information for learning (Reiser & Dick, 1996). A designer or teacher determines the information, concepts, rules and principles that will be presented to students (Dick et al., 2005). Information that is necessary to perform the task stated in an objective is presented in a straightforward manner (Sullivan & Higgins, 1983).

Gagné et al. (2005) stressed the importance of emphasizing information presented to the learners. They indicated that distinctive features of what is to be learned should be emphasized or highlighted when the information is presented. Content presented should be chunked and organized meaningfully (Foshay, et al., 2003; Kruse & Kevin, 1999). In multimedia instruction, information can be displayed using text and graphics and attention focusing devices such as animation, sound, and pointers can be used (Clark & Mayer, 2007).

Practice with Feedback

Practice involves eliciting performance from learners (Gagné, 1985; Gagné et al., 2005). It is often provided after learners have been given information required to master an objective. Practice provides an opportunity for

learners to strengthen new knowledge by internalizing it so they can recall and use it (Foshay et al., 2003). It helps to confirm correct understanding and repeated practice increases the likelihood of retention (Klein, Spector, Grabowski, & de la Teja, 2004; Kruse & Kevin, 1999). Practice is effective when it is aligned with assessment and with the skills, knowledge and attitudes reflected in the objectives (Merrill, 2002; Reiser & Dick, 1996).

Researchers have found that practice has a significant effect on learning from computer-based instruction. Martin et al. (2007) found that practice had the most impact on learner achievement and attitude when compared with four other instructional events in a web-delivered lesson. Hannafin (1987) reported a significant difference between practiced and nonpracticed items on the learning of information presented through computer-based instruction. Phillips et al. (1988) found a significant difference favoring practice over no practice in an interactive video in which practice items were embedded questions. Hannafin et al. (1987) noted that practice effects were more pronounced for facts than for application items in computer-based instruction.

Practice provides an opportunity for feedback that confirms the student's answer as being correct or indicates that it is incorrect. Feedback is "knowledge of one's performance provided" (Delgado & Prieto, 2003, p. 73). It strengthens the probability of correct responses and reduces the probability of subsequent incorrect responses. Practice should be followed by corrective feedback and an indication of progress (Merrill, 2002). Simple forms of feedback are effective when learners are able to answer items correctly. More elaborate forms such as providing and explaining the correct answer and explaining why a wrong answer is incorrect are helpful when learners answer incorrectly (Kulhavy & Stock, 1989).

Review

The review process typically provides an outline of the key information that was presented to learners. It is intended to reinforce learning, at the end of the instruction, often just before students are tested. Reiser and Dick (1996) cited the value of reviews to bring closure to instruction and to help reinforce the skills and knowledge students should have acquired. Mattiske (2001) suggested that a review activity immediately after participants have learned something new reassures them that they are learning. Klein et al. (2004) suggested that learners should be given time to reflect and review after new information has been presented to them. Gagné et al., (2005) indicated that spaced reviews should be given to learners to help them retrieve and use newly acquired information.

Purpose of Current Study

Many studies have been conducted to examine the effect of a single instructional event. In general, these studies found that the presence of the event under investigation resulted in a positive effect on student learning. As was previously noted, the impact of some of these events may be reduced considerably when they are combined with other events into a more complete and generally more appropriate program of instruction. Furthermore, while some studies of the events of instruction have been conducted using computer-based instruction, very little work has been done to examine the impact of instructional events in multimedia instruction.

The purpose of this study was to investigate effects of instructional elements in a multimedia lesson. These instructional elements were combined in a systematic manner with other events from the Gagné set. Information was a constant across all of the program versions in the study because information is a crucial element of instruction that cannot sensibly be deleted from it. The other elements of instruction investigated in the study—objectives, practice with feedback, and review were combined into four different versions of a multimedia program in a manner that permitted investigation of the effectiveness of the program when all the events were present, when practice was present and absent and when only information was present. The primary research questions for this study were:

1. What is the effect of practice with feedback on achievement, attitude, and time when students use a computer-based multimedia program?

2. What is the effect of objectives and review on achievement, attitude, and time when students use a computer-based multimedia program?

3. Does practice and objectives/review interact to influence achievement, attitude and time?

METHOD

Design and Participants

This study employed a posttest-only experimental design. A 2X2 factorial design was used with practice (present/absent) and objectives/review (present/absent) as the independent variables. The dependent variables were posttest achievement, time in program, and student attitudes. Participants

were randomly assigned to one of four multimedia programs. These consisted of (a) a full version that included information, objectives, practice with feedback, and review, (b) a version that included information and practice with feedback, (c) a version with information, objectives, and review, and (d) a lean version containing information only.

Participants were 108 undergraduate students enrolled in a computer literacy course at a large southwestern university. The participants had varied background knowledge on computers and were nonart majors. There were 72 female students and 36 male students and their ages ranged from 18 to 47 with the average age being 21.6 years. Participants earned five extra credit points for completing the multimedia program used in the study; the posttest score at the end of the program was not part of their grade in the computer literacy course.

Materials

A computer-based, multimedia program entitled "The Painting World" was the source of instruction for this study. This multimedia program included text, graphics, and interactive activities. It was developed using Macromedia Director and consisted of four units: (a) Strokes in History, (b) Paintings and Styles, (c) Know the Masters, and (d) The Masters' Styles. The screens included for each instructional event are briefly described below.

Introduction screens. The program had three introductory screens (a welcome screen, a login screen and a help menu screen) placed at the beginning of the program.

Objective screens. There were five objective screens in the module. There was a screen that listed all four objectives together at the beginning of the module. Then, there were four objective screens, one screen per unit, at the beginning of each unit, which introduced the unit and listed the objective for each unit. There was one objective per unit.

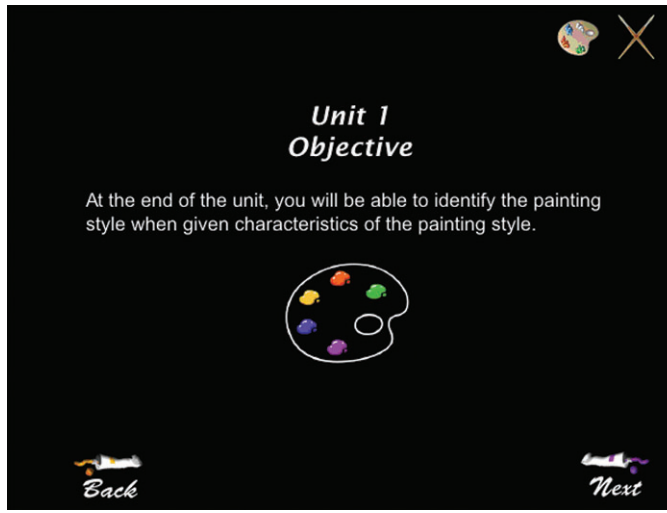

Figure 1. Screenshot of objective screen

Information screens. Information screens contained the content for understanding the different objectives on Strokes in History, Painting and Styles, Know the Masters, and Masters' Styles. There were a total of 50 information screens in the multimedia program.

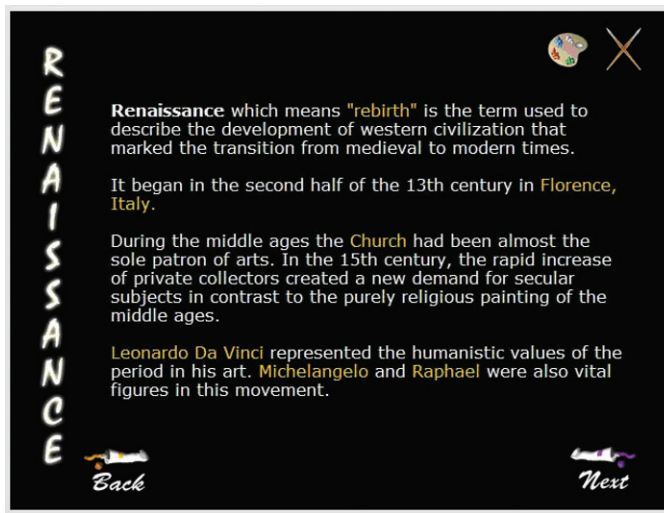

Figure 2. Screenshot of information screen

Practice screens. The practice screens provided students with an opportunity to practice the content they learned. There were a total of 24 practice screens, six practice screens per unit, with one multiple-choice question per screen. The student received immediate feedback after each response to a practice item. Practice screens were presented after information screens in each unit. Verification feedback was given to the learners, if the item was answered correctly. If an item was answered incorrectly, the learners were told that their choice was wrong, and the correct answer was given.

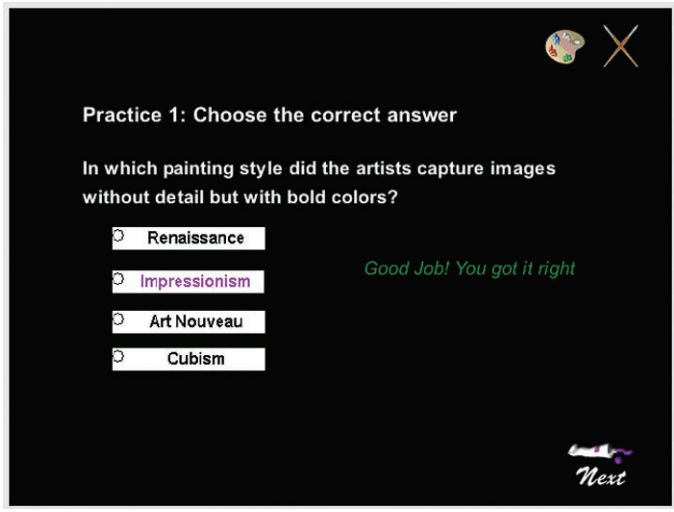

Figure 3. Screenshot of practice with feedback screen

Review screens. The review screens contained a review of the salient facts and concepts from the information screens. A total of 16 review screens were presented. The review screens for the first and second unit were placed after the second unit and the remaining review screens were placed after the fourth unit, just before the posttest.

The sequence of instruction in the program was linear. Participants navigated through the program by selecting a "next" or "ok" or "continue" button found at the bottom of the screen. The introduction screens had the "continue" button, the information, objectives and review screens had the "next" button and the practice, posttest, and attitude screens had the "ok" button. Participants were not able to skip any screen but had an option to go backward on the information screens.

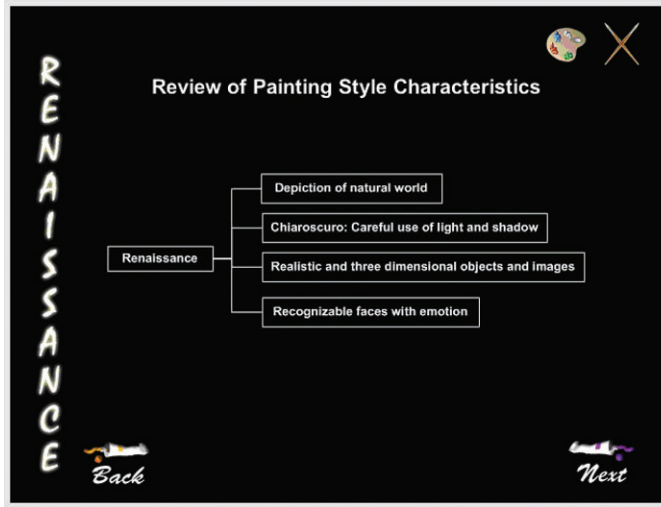

Figure 4. Screenshot of review screen

The four units of instruction were structured in the same manner. The full program included the objectives for each unit, information, practice items with feedback, and review. At the end of the fourth unit, the students were directed to an online posttest and an attitude survey.

Procedures

Information about the research study was given to the students enrolled in the course both verbally and also as an announcement on the course Blackboard site. Students who signed up to participate in this research study received five extra credit points. This recruitment procedure was approved by the Office of Human Subjects at the university where the study took place.

Each student was randomly assigned to one of the four treatment groups: (a) a full program, (b) full program minus practice, (c) lean program plus practice, and (d) lean program. The study was implemented in a reserved computer lab. Participants were directed by the researcher to the multimedia lesson. The length of the program (including instruction, posttest, and attitude survey) averaged approximately one hour. Participants navigated the program at their own pace. At the end of the lesson, the post-

test and the attitude survey were taken online. All four treatment groups followed the same procedure. Thus, the experimental differences in treatments occurred exclusively in the materials themselves and not in the procedure.

Criterion and Enroute Measures

There were three measures used in this study. An online posttest and an online attitude survey were the criterion measures while time data recorded by the computer was an enroute measure.

Posttest. The posttest consisted of 24 multiple-choice questions. The reliability of the posttest was .81. An example of a posttest question is given here.

> What is the painting style in which the artists captured the images without detail but with bold colors?
> a. Renaissance
> b. Impressionism
> c. Art Nouveau
> d. Cubism

Attitude survey. The survey assessed student attitudes towards the multimedia program and the presence or absence of the instructional events. The survey consisted of 12 Likert-type questions that were rated from strongly agree (scored as 5) to strongly disagree (scored as 1), two open-ended questions on what students liked and disliked about the program and six paired comparison items on the instructional elements. The reliability of the attitude survey was 83. The survey was administered after the lesson and the posttest were completed.

Time in program. The amount of time spent viewing the different screens (objectives, information, practice with feedback, review) was captured by the computer for each participant. The total time spent going through the complete program was also calculated.

Data Analysis

A 2X2 analysis of variance (ANOVA) test was conducted on data obtained from the achievement posttest and on the total time spent on the

program. The attitude survey results for the Likert type items (Items 1-12) was analyzed using univariate analysis with each survey item constituting a separate dependent measure. Chi-square tests were conducted to test for paired comparisons (Items 13-18) to determine participant perceptions of how helpful the instructional elements were in their learning. The open ended questions (Items 19-20) on what participants liked best and least about the program were analyzed using frequency data. Alpha was set at .05 for all statistical tests.

RESULTS

Achievement

Table 1 shows the mean scores and standard deviations for achievement on the posttest. The average posttest score for all participants was 20.46 out of a possible 24 items (SD = 3.54). Participants who received all the instructional elements (objectives, information, practice with feedback, and review) scored the highest on the posttest (M = 22.04, SD = 2.12). Participants who received information, objectives and review but did not get practice scored the lowest on the posttest (M = 19.07, SD = 3.47).

A 2X2 ANOVA conducted on data obtained from the achievement posttest revealed a significant main effect for practice [F (1, 104) = 10.41, p < .01, η^2 = .09, MSE = 11.56]. The analysis did not reveal a significant main effect for objectives/review or an interaction between practice and objectives/review.

Table 1

Means and Standard Deviations for Posttest Scores by Treatment

	Practice		
	Yes	No	Total
Objectives/ Review Yes	22.04 (2.12)	19.07 (3.47)	20.56 (3.22)
No	21.00 (3.03)	19.74 (4.53)	20.37 (3.87)
Total	21.52 (2.64)	19.41 (4.01)	20.46 (3.54)

Note: Maximum possible posttest score was 24.

Time in Program

Table 2 shows the total time spent in the multimedia program by participants in the different treatments. These data revealed that participants who received all the instructional elements (objectives, information, practice with feedback, and review) spent the most amount of time in the instructional program (M = 23:23 minutes). Participants who received only information spent the least amount of time in the program (M = 16:08 minutes). Participants who did not receive objectives/review but received the other elements spent 19:33 minutes and those who did not receive practice but received the other elements spent 18:38 minutes in the instruction.

A 2X2 ANOVA conducted on total time indicated a significant difference between participants who received practice and those who did not receive practice, F (1,104) = 7.55 $p < .01$, η^2 =.07, MSE = 59.16. ANOVA also revealed a significant difference between participants who received objectives/review and those who did not receive objectives/review, F (1,104) = 4.56, $p < .05$, η^2 =.04, MSE = 59.16.

Table 2
Overall Time Spent in the Multimedia Program

	Practice		
	Yes	No	Total
Objectives/ Review Yes	23:23	18:38	21:00
No	19:33	16:08	17:51
Total	21:28	17:23	19:26

Note: Time is reported in minutes and seconds.

Student Attitudes

Table 3 shows means for responses to the 12 Likert-type items on the attitude survey. Participants who received objectives and review but did not get practice had the highest overall attitudes toward the multimedia program (M = 4.39). The participants who did not receive practice and objectives/review (information only) had the lowest overall attitudes (M = 4.21). In gen-

eral, participants had positive attitudes toward the program and the elements included in it (M = 4.28). The item, "The visuals in the program helped my learning" was rated the highest (M = 4.59) and the item, "I would enjoy using other computer programs like this one in future lessons" was rated the lowest (M = 3.96).

Univariate analysis conducted on each attitude survey item indicated that presence of practice had a significant main effect on the item—The program gave me enough opportunity to practice what I was learning, F (1,104) = 5.39 p <0.05, η^2 = .05, MSE = 0.62. Furthermore, the presence of objectives/review had a significant main effect on the item – I knew what I was supposed to learn at the start of each section of the program F (1,104) = 5.96 p < .05, η^2 = 0.05, MSE = 3.00. No other significant results were found for the 12 Likert-type attitude items.

Items 13 to 18 on the attitude survey were paired comparisons to determine participant perceptions of how helpful the instructional elements were in learning from the multimedia program. Chi-square tests were conducted to test for significance among these paired comparisons. Table 4 gives the frequencies and chi-square test results for the six comparisons on the attitude survey. Three out of the six comparisons were significantly different. Practice was perceived to have helped learning more than objectives, review was perceived to be more helpful than objectives, and information was perceived to be more helpful than objectives.

Items 19 and 20 on the attitude survey were two open ended questions that asked participants what they liked best and least about the multimedia program. Overall, the most frequent responses for what they liked best were the visuals (n=41), the information (n=33), and the ease of use (n=10). The most frequent response for what they liked least was the length of the program (n=15) and repetition of content (n=14).

DISCUSSION

This study examined the effects of instructional events (objectives, information, practice with feedback, and review) on achievement, attitude, and time in program. Undergraduate college students used a computer-based, multimedia lesson to learn about artists and their painting styles. All participants received the same information and examples from the multimedia lesson; the programs varied based on the presence or absence of practice and objectives/review.

Table 3
Attitude Scores by Treatment

Survey Item	Full Program (Information, Practice, Objectives & Review)	Full Program minus Practice	Lean Program plus Practice	Lean Program (Information Only)	Total
The objectives of the program were clear to me.	4.44	4.52	4.26	4.37	4.40
The program gave me enough opportunity to practice what I was learning.*	4.41	4.04	4.26	3.93	4.16
The program had enough opportunity to review the content.	4.30	4.41	4.37	4.44	4.38
I knew what I was supposed to learn at the start of each section of the program.*	4.37	4.67	4.15	4.22	4.35
The practice in the program helped me learn the content.	4.19	4.26	4.41	4.07	4.23
The review at the end of each section helped my learning.	4.30	4.44	4.30	4.04	4.27
The information in the program helped my learning.	4.19	4.48	4.37	4.30	4.34
The visuals in the program helped my learning.	4.48	4.67	4.63	4.56	4.59
I learned a lot from this program.	3.93	4.40	4.11	3.93	4.09
The overall quality of the program was good.	4.48	4.44	4.22	4.37	4.38
I would recommend this program to other students.	4.19	4.19	4.04	4.26	4.17
I would enjoy using other computer programs like this one in future lessons.	3.81	4.07	3.96	4.00	3.96
Total	4.26	4.39	4.26	4.21	4.28

Note: 5=Strongly Agree 4=Agree 3=Neither Agree nor Disagree 2=Disagree 1=Strongly Disagree
* *Significant at* $p < .05$

Results indicated that practice had a significant effect on achievement while objectives and review did not. Participants who used the program with practice performed significantly better than those who did not receive practice. It is likely that practice had a significant effect on achievement because it gave learners an opportunity to perform an identical task to that assessed on the posttest. Practice is most effective when it is aligned with assessment and with the skills, knowledge and attitudes reflected in the objectives of a lesson (Merrill, 2002; Reiser & Dick, 1996). Furthermore,

practice has the advantage of eliciting overt responses from learners, a form of active participation not directly provided by other elements of instruction.

Table 4
Paired Comparison of Attitude Data

Which of these two things helped you to learn from the program?	Frequency (N)		Chi-Square X^2	*df*	Asymp.Sig
Objectives or Practice	36	72	12.00	1	.001
Objectives or Review	28	80	25.04	1	.000
Objectives or Information	30	78	21.33	1	.000
Practice or Review	55	53	.037	1	.847
Information or Practice	44	64	3.70	1	.054
Information or Review	44	64	3.70	1	.054

When combined with feedback, practice also enables learners to confirm their correct understandings and identify their incorrect ones. This increases the probability of retention of correct responses and decreases the probability of incorrect responses. In the multimedia lessons used in this study, participants were given verification feedback after they answered each practice item. If students responded to a practice item correctly, feedback was given saying that they did a good job, but if they responded incorrectly, feedback was given saying that they missed it and could try again. Other researchers have reported that verification feedback is effective in promoting learning (Mason & Bruning, 2001; Merrill, 1987; Mory, 1992).

While practice with feedback had an impact on achievement in this study, objectives and review did not. These results are consistent with findings by other researchers who reported that the benefits of objectives are reduced when a more powerful instructional element such as practice is included in a computer-based lesson (Hannafin, 1987; Hannafin et al., 1987; Martin et al., 2007; Philips et al., 1988). These researchers also noted that the presence of objectives did not influence performance when computer-based instruction was systematically designed, but did make a difference in lessons that were not well designed. The multimedia programs used in the current study were designed following a systematic, competency-based approach. Furthermore, objectives may not have influenced learning because certain instructional materials carry implicit objectives that experienced students recognize, which makes statements of objectives superfluous (Morrison, et al., 2006). However, the presence of objectives is essential for an instructional designer to systematically design the instruction.

Review in the instructional program used in this study provided an outline of the key information that was presented to learners. Reiser and Dick (1996) cited the value of reviews to bring closure to instruction and to help reinforce the skills and knowledge students should have acquired. Practice elicits overt responding from learners whereas objectives and reviews investigated in the study either provide information that is additional to that contained in the information screens (i.e., objectives) or primarily redundant (i.e., review) to the information (Martin et al., 2007). Unlike practice, this additional or redundant nature of objectives and reviews could have resulted in the lack of significant effect for these two instructional elements.

Turning to attitudes, results revealed that most participants had a favorable impression about the multimedia lesson used in this study. In general, the statements such as, "the visuals in the program helped my learning" and "the overall quality of the program was good" were rated very high.

Student responses to the attitude survey showed that they were sensitive to the presence or absence of the instructional elements investigated in this study. Participants who used the lean program (information only) had the lowest overall attitudes. When the individual items on the attitude survey were analyzed, participants who received practice had significantly higher agreement with the attitude item—"the program gave me enough opportunity to practice what I was learning." In addition, participants who received objectives and review had significantly higher agreement with the attitude item—"I knew what I was supposed to learn at the start of each section of the program." These findings suggest that students are aware when practice and objectives are left out of multimedia instruction and that excluding these elements may have a detrimental effect on their attitudes.

However, this pattern was not found for the attitude items related to review. Participants in the treatments without review rated the survey items on review as high as participants in the treatments that had review. Students may not have realized review was missing due to the systematic design of the program and the amount of content included in the lesson. When asked what they liked least about the program, many students mentioned the repetition of content. Two of the units in the lesson built on the other two units in the program. This may have made students feel that the content was being reviewed throughout.

Results of the paired comparison questions on the attitude survey revealed that participants perceived information, practice, and review to be more helpful than objectives. This could have been due to the fact that there were 50 information screens, 16 practice screens, and 16 review screens in the full program but only 5 objective screens. Furthermore, practice was

perceived to be more helpful than information and review, though these differences only approached statistical significance ($p = .054$).

The open-ended questions on the attitude survey revealed that the visuals in the multimedia program were what participants liked best followed by the information and the ease of use. The visuals were colorful paintings, which likely held participant attention and interest during the lesson. Furthermore, the content was written to be interesting and the navigation was simple and clear.

Results for time revealed that participants who received the full program spent the most amount of time working though the multimedia lesson and those who received the lean program spent the least amount of time. This can be explained by the number of instructional screens included in the lesson. The full program had a total of 87 instructional screens while the lean program had only 50 screens.

Findings for time also revealed that participants who received practice spent significantly more time working on the multimedia program than those who did not receive practice. Furthermore, participants who received objectives and review spent significantly more time on the program than those who did not receive these two elements of instruction. It is not surprising that adding practice or objectives and review to a multimedia lesson increases the amount of time participants spend on it. However, these results should be interpreted in light of finding that practice was the only instructional element to impact achievement in this study and others.

This study has implications for the design and development of computer-based, multimedia instruction. Practice was the one consistently effective instructional element for enhancing student achievement and attitude in the study. These findings remained consistent with a previous study conducted by Martin et al. (2007) and thus imply that practice with feedback should be included in multimedia instruction especially when students are tested using items aligned with the objectives and practice items. Even though objectives and review did not have a significant effect on achievement, results of this study do not necessarily imply that these two elements should be eliminated from multimedia instruction. They are not costly to write in terms of time spent in development. They were included and removed systematically in the present study in order to investigate their effects in a controlled instructional environment. Their effects may vary in other settings depending on such factors as the age and motivation of learners and the complexity of the subject matter.

Future studies should be conducted on different types of learning outcomes. The current study examined student acquisition of facts and concepts. Additional studies should examine the use of objectives, practice,

and review in a multimedia lesson that teaches problem solving. Research should also investigate the effects of different types of practice items and the way in which they are presented to learners. Studies on different types of placement of instructional elements in multimedia lessons could be conducted. These studies should be implemented in both face-to-face and online environments.

Finally, research on instructional events should be conducted among different age groups. This study was conducted using college students; the effects of objectives, practice, and review may differ among younger learners. Future research should continue to explore the use of well designed multimedia instruction. As was done in the current study, research should continue to investigate the effectiveness of instructional elements to determine their impact on attitude, learning, and achievement.

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