

The Effect of Varied Cognitive Strategies Used to Complement Animated Instruction in Facilitating Achievement of Higher Order Learning Objectives

Huifen Lin
Kun Shan University

Francis Dwyer and Jeff Swain
The Pennsylvania State University

The purpose of this study was to investigate the effects of advance organizers and audio narrations used to complement animated instruction on tests measuring different educational objectives. One hundred forty-one participants were randomly assigned to five treatment groups, received their respective instructional presentation and completed four criterion measures. No statistically significant differences in achievement were found among the five treatment groups on each of the criterion measures indicating that the type of cognitive strategies employed to complement animation did not instigate deeper levels of information processing and were not effective in facilitating higher order learning outcomes. These results raised concerns about the usefulness of prior research related to advance organizers and audio narrations when the objective is to complement animated instruction to facilitate higher order learning objectives.

Recent advances in instructional technology have stimulated research interest toward looking at the effect of various techniques on computer-based instructional (CBI) development. Among all advances, animation has drawn much research attention due to its appealing nature and dynamic representation, of which few other means of instructional delivery can accommodate. Park and Gittelman (1992) defined animation as “artificially generated movements of pictures or graphics in computer displays, resulting in apparent motion” (p. 27). A major function of animation is to focus learners’ attention by employing special effects either to highlight the importance of a topic or to demonstrate the beginning or ending of a section. Animation also has the potential to provide feedback in various forms that may be both entertaining and motivating to learners striving for a correct response. The most powerful and direct application of animation is to use it to present instructional materials that are dynamic in nature, too abstract to understand or physically invisible, such as the flow of blood in a human heart or concepts in physics (Dwyer, 1994; Kaiser, Proffitt, & Anderson, 1985).

Previous research on animated instruction has not been encouraging. Wilson and Dwyer (2001) in their study investigating the effect of dynamic visuals on students’ achievement of specific types of educational objectives determined that animation failed to optimize achievement of the more complex types of learning outcomes. Lin, Chen, and Dwyer (2006) compared the effects of static visuals versus computer-generated animation on learners’ comprehension and retention of a content-based lesson in a computer-based learning environment for learning English as a Foreign Language (EFL). The results indicated that the animation group outperformed the static visuals group in only one of the four tests. Overall, some studies showed significant positive effects of animation on

learning (Alesandrini & Rigney, 1981; Kaiser, Proffitt, & Anderson, 1985; Rieber, 1989; Rieber & Boyce, 1990), while other studies showed no significant effects (Caraballo, 1985; King, 1975; Moore, Nawrocki, & Simutis, 1979; Reed, 1985; Rieber & Hannafin, 1988).

Although prevailing findings regarding animation studies have been inconclusive, instructional designers as well as researchers continue to investigate the causes that might contribute to the lack of effect of animation. Owens and Dwyer (2005) indicated that learners may have failed to focus on critical aspects of the animation and therefore were not able to effectively interact with the animation and fully benefit from it. It seems plausible, then, that some types of cognitive strategies are necessary to accompany animated instruction and to scaffold students when they are learning from animated instruction. In a study conducted by Munyofu et al. (2006) looking at the effect of chunking as a cognitive strategy to complement animation, students receiving the complex chunking treatment significantly outperformed their counterparts receiving animation alone indicating chunking was an effective instructional strategy to complement animated instruction designed to facilitate higher level learning outcomes. Lin, Ching, Ke, and Dwyer (2006) conducted a meta-analysis to examine the relative effectiveness of varied enhancement strategies used to complement animated instruction on different educational objectives. The results of this meta-analysis indicate that when enhancements are used to complement animated instruction they can have either a positive or negative effect depending on the type of enhancement and the type of learning objective to be facilitated. The enhancements themselves may have distracted participants’ attention from the critical information designed to be imparted by the animation, thereby reducing their effectiveness. These results would indicate that further research should concentrate on the

design of enhancements that ensure that more intense interaction occurs between the content and the learner and that this interaction be assessed in terms of its effectiveness in facilitating achievement of different types of educational objectives. The purpose of the study was to investigate the effectiveness of two types of advance organizers and narrations used as enhancement strategies to reinforce students' learning from animated instruction.

Theoretical Framework/Literature Review

Three theories that are particularly important and relevant to instructional visual design as commonly cited in the literature are: (a) cognitive theory of multimedia learning, (b) cognitive load theory (CLT), and (c) dual coding theory. These theories all draw on research findings from cognitive science and are based on how human beings process information and, in particular, how the components of human memory process information.

Foundations of Animated Instruction

Mayer (1994) developed the cognitive theory of multimedia learning, a generative theory, to provide design principles for multimedia instructional materials. This theory draws upon several additional theories and extension of these theories, including Wittrock's generative theory (1990) and by extension Mayer (1984, 1993) and Sternberg (1985); and Paivio's dual coding theory (1986) as well as its extensions by Baddeley (1992), Mayer (1992, 1993) and Schnotz (1993). The basic tenet of the cognitive theory of multimedia learning is that learners are active knowledge constructors who are involved in a meaningful learning process. A meaningful process occurs when learners consciously select information from presented stimuli, organize information into coherent representations, and then make efforts to integrate new information with other or existing information (Mayer, 2001).

Reducing working memory load in learners is necessary to facilitate the encoding and storing of information in a learning process (Baddeley, 1992; Sweller, 1988). Dual coding theory supports this cognitive information-processing and assumes the existence of two separate information processing systems: (a) the verbal system that is comprised of words, and whose strength lies in its sequentially ordered hierarchy; and (b) a non-verbal system whose strength lies in its synchronous hierarchy (Clark & Paivio, 1991; Sadowski & Paivio, 2001). All information is assumed to be processed in a cognitive system composed of a visual system that processes visual information and a verbal system that processes verbal information.

Mayer and his colleagues found that the effect of dual coding was enhanced when the verbal and visual information was presented concurrently with the animation rather than before or after it (Mayer & Anderson, 1992; Mayer & Sims, 1994). Placing supporting text near the animation it is meant to support is known as the contiguity principle (Clark & Mayer, 2003). Moreover, placing printed words next to the animation they are supporting can reduce the split-attention effect (Clark & Mayer, 2003).

While animation helped to reduce cognitive load it was not reduced as much as it could be because both text and animation have to pass through the same (the visual) sensory channel (Mousavi, 1995; Chandler & Sweller, 1992). This meant that students were forced to shift their attention between the text and the animation while going through the pattern recognition and selective perception processes. Miller (1956) referred to the limitation of the sensory register as our "channel capacity" (pp. 85). Channel capacity is the maximum amount of information we can hold in our sensory memory at any given point in time.

When animation is supported by a spoken explanation, as opposed to a textual explanation, cognitive load is further reduced. This time the reduction comes through the way that information passes from the environment through sensory memory and into working memory (Chandler & Sweller, 1992; Paivio, 1986; Penney, 1989).

Mann (1995), in a study testing student's ability to construct a solution to an educational problem, used spoken information that highlighted or detailed static or moving visuals, in a computer-based lesson to more effectively use students' channel capacity in sensory memory. Mann found that students were able to recall a greater amount of critical detail when concurrent spoken information was used.

Using written text or spoken text that closely matches the animation it supports without extraneous details is also an important factor for success. In a study on reducing the cognitive load in lesson summaries, Mayer (1996), using a lesson on the process of lightning formation, found that students receiving concise lesson summaries that included both visual and verbal information, performed best on verbal recall and problem solving tests. Similarly, Moreno and Mayer (2002) found that extraneous details hurt student performance when using the lesson on the process of lightning formation.

Advance Organizers

Advance organizers are appropriately relevant and inclusive in nature and are used to accomplish progressive differentiation in the subject matter by "using a hierarchical series of organizers, each

organizer preceding its corresponding unit of detailed, differentiated material” (Ausubel, 1968, p. 82). At least two advantages accompany the construction and use of advance organizers for new material. First, the advance organizer creates a subsumer that would give the learners a general overview of the new material, and second, the advance organizer creates cognitive connections between established knowledge and new material in terms of relevant concepts and therefore enhances the “familiarity and learnability of new material” (Ausubel, 1968, p.82).

Research has suggested that student achievement can be facilitated by the use of advance organizers (Hirumi & Bowers, 1991) because advance organizers are “designed to have [a] specific effect on how readers deal with upcoming text” and that they “set up a context for encoding” (Corkill, Glover, Bruning & Krug, 1988, p. 304). A tremendous amount of studies have been undertaken to investigate the use of advance organizers in the classroom. Stone (1983) in her meta-analysis of 29 advance organizer studies conducted between 1970 and 1980. The results of this analysis suggested that generalized advance organizers facilitated factual learning. Specifically, the results indicated that lower effect sizes were associated with written and abstract advance organizers, while higher effect sizes were associated with non-subsuming advance organizers. Finally, Stone (1983) determined that low-ability and low-knowledge learners did not benefit from the use of advance organizers.

Statement of the Problem

The purpose of this study was to examine the instructional effectiveness of cognitive strategies; that is, two types of advance organizers (descriptive and questions) and two types of narrations (descriptive and questions) used to complement animated instruction in facilitating student achievement of different educational objectives. The purpose of the cognitive strategies employed in this study was to focus participants’ attention, increase their depth of information processing, and enhance interactivity between instructional material and learners so as to facilitate achievement. The researchers were especially interested in investigating whether advance organizers and audio narrations of different types are effective in facilitating achievement of higher order learning outcomes. Higher order learning outcomes here refer to learners’ ability to apply concepts and rules and engage in problem solving after receiving the instruction embedded with advance organizer and narration cognitive strategies.

Methodology

Two Pilot Studies

Two pilot studies were conducted to identify where participants were experiencing difficulty in learning within the instructional unit so that enhancement strategies could be embedded. Item analysis was conducted on scores of the criterion measures to determine exactly where in the instructional material participants experienced difficulty. The item analysis was conducted by awarding one (1) point to an item for each student when it was answered correctly and zero (0) to an item for each student when it was answered incorrectly. Item difficulty was then determined by dividing the total point for each question by the number of pilot study participants. Thus, an item that had a difficulty level of .40 would indicate that 40% of the participants answered the item correctly. For the purpose of this research, any item with a difficulty level below .60 was targeted for instructional support. Both pilot studies used the same criterion measures as was used in the formal study.

The first pilot study. The purpose of the first pilot study was to identify the areas within the instructional unit that learners had experienced difficulty in order to determine the positioning of the animation to improve achievement. The instructional material used in this study contained a 2,000-word physiology unit focusing on the human heart, its parts, locations, and functions during the diastolic and systolic phases (Dwyer & Lamberski, 1977). The instructional script was accompanied by 20 static visuals of the human heart.

Participants for the first pilot study were 12 undergraduate information system technology majors participating for course credit. Data were gathered in a one-shot study conducted in a multimedia computer lab. The results of the first pilot study suggested that a total of 25 out of 80 items have difficult indexes lower than .60. These items were identified as areas that students experienced learning difficulties and were ideal positions for animated instruction that may be embedded to improve learning. To be specific, the distribution of difficult items was five (5) in the drawing test, one (1) in the identification test, ten (10) in the terminology test and nine (9) in the comprehension test.

The second pilot study. The purpose of the second pilot study was to identify the area of instructional module that produced difficulties to learners even after animation was embedded into the instructional unit. The results of the study, via item analysis, would be used as indications where further enhancement strategies, two types of advance organizers and narration, could be embedded to optimize learning. For the purpose of the second pilot study, material used in

the first pilot study was enhanced with 8 animated sequences that addressed the 25 difficult items identified in the first pilot study. The original 20 instructional frames were thus expanded to 27 instructional frames containing 13 animated sequences. It has to be noted that the amount of content contained in the original 20 frames used in the first pilot study had to be adjusted so that a single animation sequence did not deliver too much information in a single frame.

Participants of the second pilot study were 44 undergraduate business management majors participating for course credit. The results of the second pilot study suggested that a total of 24 out of the 25 items identified in the first pilot study still remained difficult even after animated sequences were developed to enhance comprehension. These items were again identified as areas that students have experienced learning difficulties and provided ideal positions that enhancement strategies, advance organizers and narrations, could be inserted to

improve learning. To be specific, the distribution of difficult items was five in the drawing test; none in the identification test, nine in the terminology test and ten in the comprehension test. Table 1 summarizes the items identified as difficult with corresponding difficulty level obtained from two pilot studies.

Development of Computer-Based Instruction Module

The instructional content used in the formal study was based on the result of the second pilot study. The computer-based instruction contained 27 instructional frames in which 13 frames contained animated sequences. To further describe the instructional material used for the present study, the instructional content contained a 2,000-word reading passage related to the function of the human heart – its parts, blood cycle and pressure during both the diastolic and systolic phases. Specifically, the material was divided into six units: (a) the four layers of the heart, (b) the

TABLE 1
Items Identified as Difficult with Difficulty Index from Two Pilot Studies

Item No.	First pilot	Second pilot
Drawing Test		
No.6	.58	.50
No.8	.54	.46
No.11	.48	.34
No.12	.30	.45
No.18	.53	.57
Identification test		
No.8	.34	.78
Terminology Test		
No.1	.33	.49
No.5	.56	.56
No.8	.45	.50
No.9	.56	.58
No.10	.57	.58
No.11	.34	.45
No.13	.45	.50
No.14	.35	.45
No.18	.54	.50
Comprehension Test		
No.2	.54	.57
No.4	.42	.48
No.5	.30	.47
No.6	.35	.48
No.14	.45	.58
No.15	.57	.41
No.16	.48	.48
No.17	.41	.50
No.18	.20	.52
No.20	.29	.57

heart's structure, (c) the veins and arteries of the heart, (d) the valves of the heart, (e) the blood flow through the heart, and (f) the phases of the heart cycle. The material was developed based on the principles of instructional consistency and congruency paradigm (Dwyer, 1994). In other words, the material is presented in an increasingly complex and difficult sequence. Therefore, participants must acquire basic facts and simple concepts presented in earlier sections of the instructional material to be able to comprehend later portions of the material that delivered more complex and difficult information. Additionally, a portion of the animated instructional unit was designed in a programmed unit format. That is, four quizzes containing 5 practice questions each were embedded after the first four frames that primarily delivered factual knowledge and simple content. Participants were asked to answer the questions based on the material just presented. If students' scores were satisfactory, 90% correct, they were able to move on to the next part of the lesson, which is more complex and concerns higher level of learning outcomes. If the score was unsatisfactory they were brought back to the beginning of that series of content.

The insertion of a programmed unit in the instructional unit was to address the concern that Mayer and Sim (1994) raised. In their study that investigated the effect of animation and narration on transfer learning for both high and low spatial ability students, they found that learners with more domain/subject knowledge were better able to retrieve familiar knowledge from their long-term memory and to be able to "build connections between retrieved system and the system described in words" (p. 391). The employment of programmed instruction in our study ensured that both inexperienced and experienced learners were equipped with requisite knowledge and thus able to benefit from animated instruction.

Treatment Descriptions

The following section describes the individual treatment materials used in the present study. The computer-based instructional material described above was used as the base material and was the treatment received by the control group.

Descriptive advance organizers. Descriptive advance organizers were inserted prior to twelve selective frames that covered the 24 difficult items identified from the second pilot study. In total, 18 advance organizers were designed and distributed prior to the 12 frames. Occasionally, several advance organizers had to be developed and embedded prior to some of the 12 frames that contained more difficult items. Each descriptive advance organizer was accompanied by a static visual that depicted important

information to be encountered in the next frame. The most important concept/key word was highlighted in red and was presented as a descriptive statement. Figure 1 presents a screenshot of a descriptive advance organizer followed by an animated frame (see Figure 2) that was designed to enhance understanding. Figure 3 presents the screenshot of an on-going animated sequence while it was playing.

Question advance organizer. Questions advance organizers were inserted prior to the same 12 instructional frames as were the descriptive advance organizers. Each question advance organizer was accompanied by a static visual which was exactly the same as the one used in the descriptive advance organizers. The question organizer was presented as a question with four or five possible answer choices. The correct choice was shown after 15 seconds. This timeframe was determined based on a pilot study with 5 undergraduate students. Figure 4 provides a screenshot of a question advance organizer.

Descriptive oral narration. Two types of oral narrations, descriptive and question oral narrations, were embedded in the 12 instructional frames that contained material that were difficult based on the results of the second pilot study. The descriptive oral narration provided audio support for animation and was presented in the form of simple declarative sentences. It should be noted that the two types of advance organizers were embedded prior to the difficult frames, whereas the oral narrations were concurrent with the instructional frames. For example, for a frame that an animation sequence was designed to show that the ventricles are the thickest walled chambers of the heart, the student, when he/she selected the "play" button would see the animation and simultaneously heard a statement that said, "The ventricles are the thickest walled chambers of the heart."

Question oral narration. Question oral narrations accompanied the same animated sequences as the descriptive oral narration group. However, the audio support was delivered in a question and answer format. Continuing the example above regarding the ventricles, a student receiving this treatment would hear, "What are the thickest walled chambers of the heart?", while the animation was playing. After a short pause, students hear the answer, "The ventricles are the thickest walled chambers of the heart." The same voice was used in both treatment groups and the speed at which the animation was played was adjusted to fit the length of the audio support. Table 2 presents a summary of each frame embedded with a specific treatment

Criterion Measures

Achievement was measured via four criterion tests developed to accompany the instructional unit: drawing

FIGURE 1
Screenshot of a Descriptive Advance Organizer

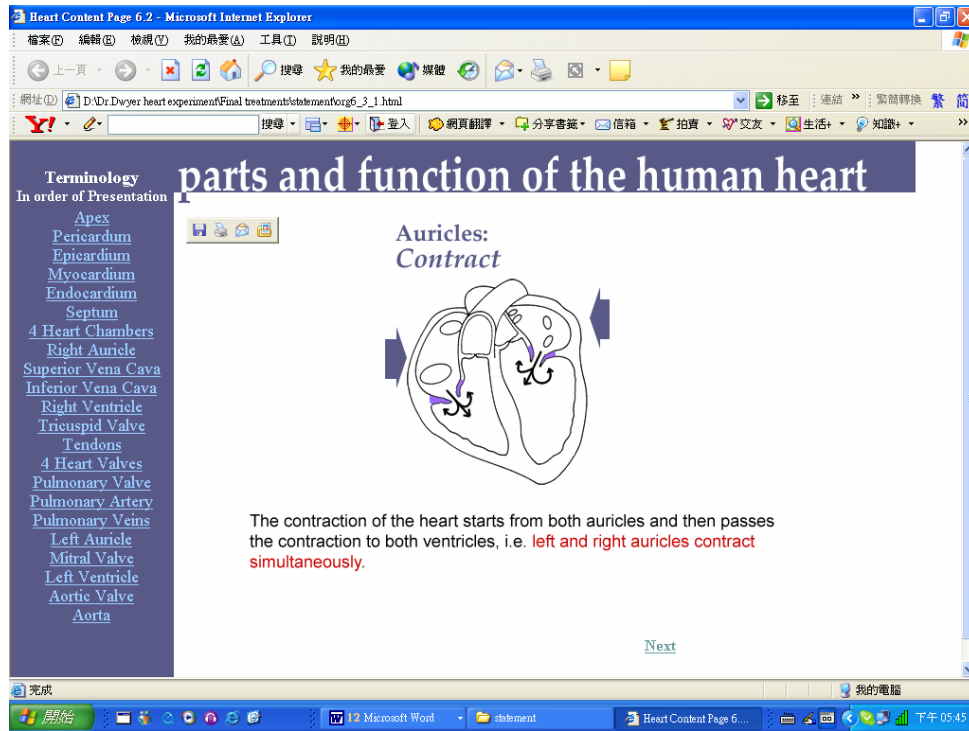


FIGURE 2
Screenshot of an Animation Sequence

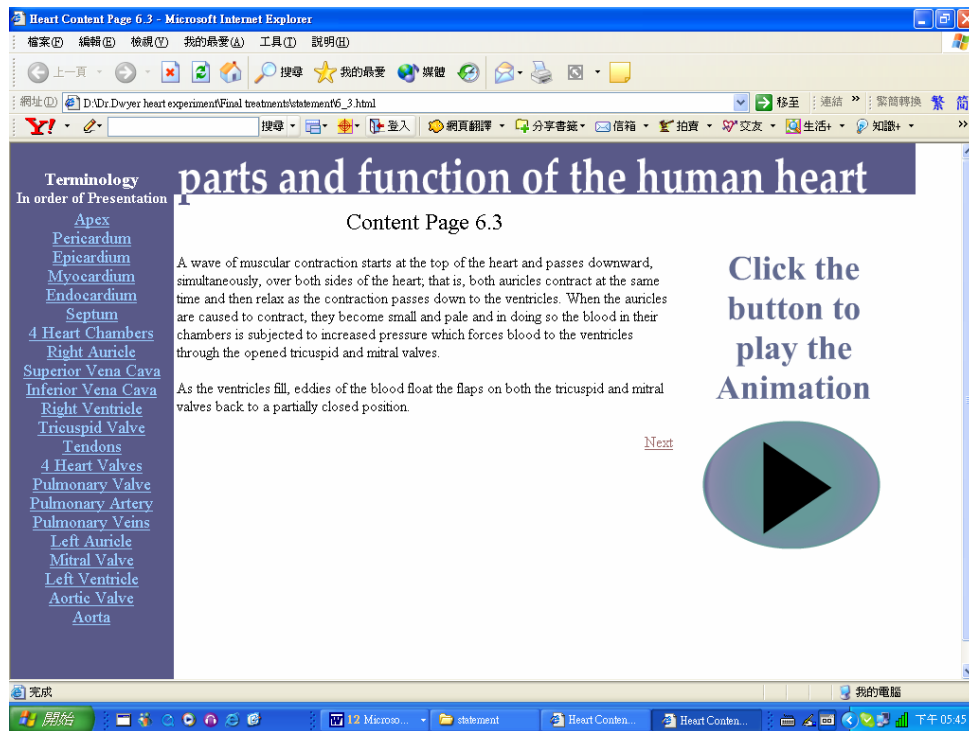


FIGURE 3
Screenshot of Animation on Display

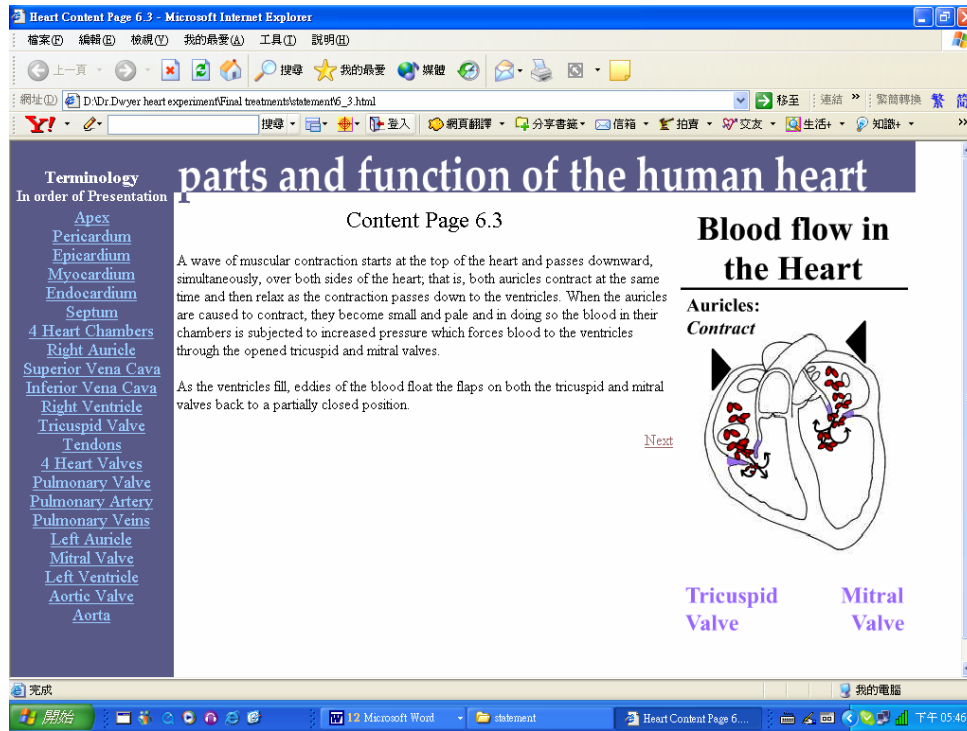


FIGURE 4
Screenshot of a Question Advance Organizer

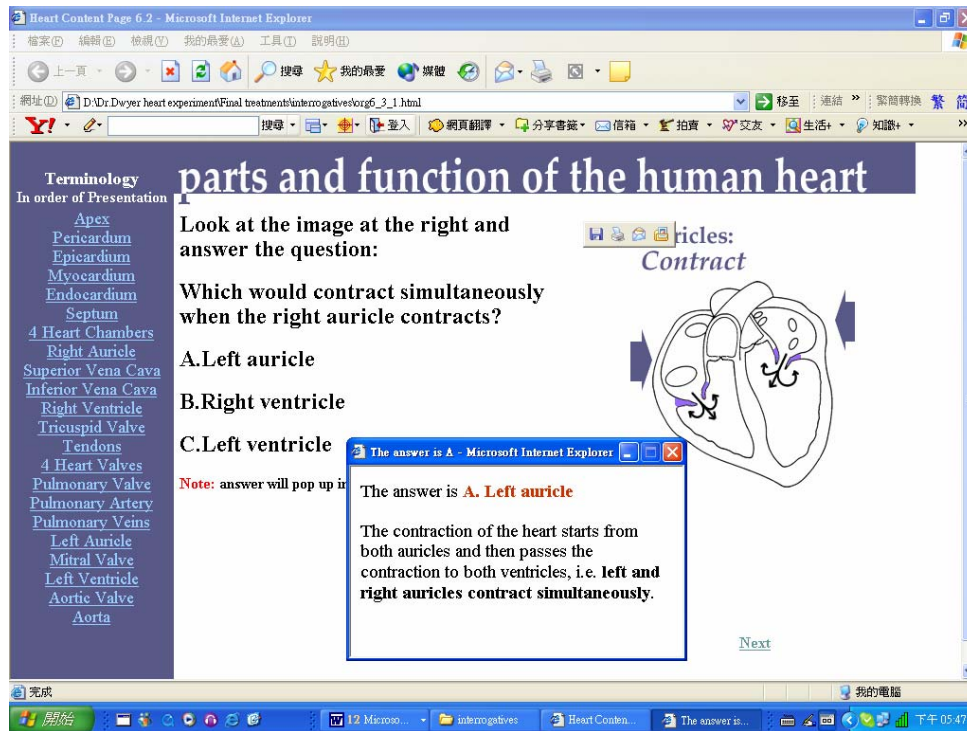


TABLE 2
Summary of Instructional Frames with Treatments

Frame	Content ¹	Treatment ²	Frame	Content	Treatment	Frame	Content	Treatment
1	1.1		10	4.1		19	6.3	A/N/O
2	1.2	A/N/O	11	4.2		20	6.4	A/N/O
3	2.1		12	4.3		21	6.5	A/N/O
4	2.2	A/N/O	13	4.4		22	6.6	A/N/O
5	2.3		14	5.1	A/N/O	23	6.7	
6	3.1	A/N/O	15	5.2		24	6.8	A/N/O
7	3.2		16	5.3	A/N/O	25	6.9	A/N/O
8	3.3		17	6.1		26	6.10	A/N/O
9	3.4		18	6.2		27	6.11	

¹ Title for each unit: Unit 1. Four layers of the heart; Unit 2. The heart’s structure; Unit 3. Veins and arteries; Unit 4. Valves of the heart; Unit 5 Blood flow through the heart; Unit 6. The phases of the heart cycle.

² A = animation displayed in this frame; N = narrations embedded in this frame; O = advance organizers embedded prior to this frame

test, identification test, terminology test, and comprehension test. Each test, except for the drawing test that asked students to draw a human heart, consisted of 20 multiple-choice questions. The maximum score for each test was 20. All of the tests, except for the drawing test, were provided online and were completed by participants after they finished the instructional module.

Drawing test (KR-20 = 0.70). The drawing test measured participants’ conceptual understanding of the instructional unit as well as their ability to reproduce the parts of the heart in their appropriate context. Participants were asked to draw a simple line diagram of the human heart on a blank piece of paper in which 20 parts of the heart needed to be included and identified in the diagram that they drew. The quality of the drawing did not affect the test score since correct positioning of the 20 parts of the heart was the only criterion of assessment. Since the test scoring required human judgment, multiple raters were asked to assess the tests. The raters were two doctoral students with a major in instructional systems. Raters were given instruction on scoring procedure and were trained to score 100 drawing tests used in previous studies. The raters were not asked to score the drawing tests for this study until they reached a designated inter-rater reliability of .90 by scoring tests from previous studies. The inter-rater reliability of the drawing test for this study was .92. Achievement on this test represented participants’ understanding of factual/verbal knowledge of the instructional material and mastery of this learning objective corresponds to a lower-level learning outcome.

Identification test (KR-20 = 0.67). Participants were provided with a diagram of the human heart, that had 20 numbered arrows pointing to specific parts of a human heart. Participants were asked to select from the alternatives the correct alternative that corresponds to the numbered part of the human heart. The test

evaluated participants’ ability to identify facts or positions of the parts of the human heart. Achievement on the identification test indicated participants’ ability to recognize instructional stimuli and to make discriminations among them. This test measured lower-level learning outcome.

Terminology test (KR-20 = 0.84). The terminology test consisted of 20 multiple-choice items measuring knowledge of specific facts about the human heart. The knowledge measured in this test can be categorized as verbal information considered as prerequisite to participants’ acquisition of higher-order knowledge, such as concepts, rule/procedures, and comprehension.

Comprehension test (KR-20 = 0.76). The comprehension test consisted of 20 multiple-choice questions designed to measure participants’ knowledge of the functions of the human heart during both diastolic and systolic phases. Participants needed to demonstrate their understanding of how a specific part of the heart functions simultaneously while relative parts are functioning. For example, one of the questions in the comprehension test asked, “When the tricuspid and mitral valves are forced shut, in what position is the pulmonary valve?” To be able to answer this question correctly, participants need to first demonstrate their correct understanding of the position of the tricuspid and mitral valves (facts), and secondly, comprehend the diastolic process of the human heart during which tricuspid and mitral valves are shut (process/procedures), to be able to understand the relative position of pulmonary valve in the process. The test required participants to fully comprehend the facts, concepts, and procedures related to the parts of the human heart and its function and therefore, it measured a higher-level learning outcome.

Composite score (KR-20 =0.92). Scores of the four criterion tests were combined to form a composite score. This score measured participants’ total comprehension

of the material contained in the instructional module. The maximum composite score is 80.

Participants

Participants included 141 undergraduate students enrolled in a university on the east coast. The participants were recruited from a subject pool that involved majors of business, education, visual arts and instructional technology. Participants with a major in physiology were excluded from the study to eliminate a possible confounding factor that these participants may already have a higher level of prior knowledge related to the instructional material.

Participants were freshmen and sophomores at the time of study and were recruited from a Survey of Management class. They voluntarily participated in the study and were given extra credit by their instructor for their participation. Data on participants' gender and age were not collected since these are not variables of interest in the study. In addition, participants were not required to have pre-requisite knowledge to be able to benefit from the intervention as the instructional module is comprehensive, covering different levels of knowledge from simple to complex. Any existing prior knowledge differences were controlled through the random assignment of participants to groups.

Procedure

Employing a posttest-only control group design, the study was conducted in a multimedia lab. The computers in the lab were equipped with two speakers, headphones and the necessary software was installed beforehand in order to run the animation and specific treatment conditions. Participants were randomly assigned to one of the five treatment groups. The researcher first introduced the study, its process and approximate duration before participants were asked to log on a website in which each specific treatment was located. Each treatment was preceded with an instructional page that described the content of the instructional unit, the use of navigation buttons and treatment condition. For the Animated Instruction only (AI) treatment group, the control group, participants were asked to read the text located on the left side of each screen and then click a button to play the accompanying animation sequence. Participants could view the animation as many times as needed before proceeding to next frame. For the Descriptive Advance Organizer + Animated Instruction treatment group (DAO), participants were encouraged to look at the static visual on the right of the screen and relate it to a descriptive statement that depicted the visual. Participants selected the "Next" button to proceed to the next frame. For the Question Advance Organizer +

Animated Instruction (QAO) treatment group, participants were advised to view a static visual on the right side of the screen and read the corresponding question. Participants then chose an appropriate answer in their mind and waited for the correct answer to show up in a pop-up window after 15 seconds. Participants then closed the window and selected "Next" to go to the next frame.

The Descriptive Narration + Animated Instruction (DN) and Question Narration + Animated Instruction (QN) groups were asked to test the headphones and adjust the volume before they started the study. Participants in the (DN) group were encouraged to listen carefully to the narration while watching the animation. Participants in the (QN) group, in addition to listening carefully to the questions, were advised to think about the answers before the narrator provided answers.

Subsequently, three criterion tests (i.e., the identification test, the terminology test, and the comprehension test) were embedded in the online instructional module. The exception, the drawing test, was given on a piece of paper. Participants were instructed to raise their hands and asked for the drawing test when they finished the first 2 units of the lesson. Completed drawing tests were collected before participants proceeded to unit 3. Participants took the remaining three tests after they completed the entire instructional module.

Results

Four analyses of variance (ANOVA) were conducted across the five treatment groups, one for each of the four criterion measures. Since advance organizers (i.e., DAO and QAO) and narrations (i.e., DN and QN) were only positioned on specific frames in the instruction to facilitate student achievement, only those specific 24 test items that aligned with those specific frames were included in the ANOVA analyses. These 24 test items were distributed across three of the criterion measures such that 5 items aligned with questions on the Drawing test, 9 items aligned with questions on the Terminology test, and 10 items aligned with questions on the Comprehension test. None of these test items align with the Identification test, thus the Identification test is not included in any further analyses. Table 3 presents the means and standard deviations obtained by participants in each treatment on each criterion measure.

The results of the ANOVAs indicated that no statistically significant differences existed in achievement for any of the criterion measures: Drawing test, $F(4,136) = 1.92, p > .05$; Terminology test, $F(4,136) = .80, p > .05$; Comprehension test $F(4,136) = 1.71, p > .05$; Composite score $F(4,136) = 1.50, p > .05$.

TABLE 3
Means and (Standard Deviations) for Each Treatment^b on Each Criterion Test

Criterion Test ^a	AI (n = 29)	DAO (n = 27)	QAO (n = 29)	DN (n = 30)	QN (n = 26)
Drawing	3.28 (1.60)	3.22 (1.05)	3.62 (1.21)	2.97 (1.45)	3.85 (1.19)
Terminology	4.14 (2.49)	4.56 (2.41)	5.17 (2.11)	4.93 (2.24)	4.73 (2.54)
Comprehension	4.38 (1.64)	4.85 (1.99)	5.62 (2.04)	4.60 (2.01)	4.69 (2.07)
Composite score	11.79 (4.38)	12.63 (4.72)	14.41 (4.22)	12.50 (4.39)	13.27 (3.85)

^a Maximum scores: Drawing test = 5; Terminology test = 9; Comprehension test = 10; Composite test = 24.

^b AI: Animation only (control group); DAO: descriptive advance organizer plus animation; QAO: question advance organizer plus animation; DN: descriptive narration plus animation; QN: question advance organizer plus animation.

Discussion and Conclusion

This study was designed to investigate the instructional effectiveness of different kinds of advance organizers and narrations as complements to animated instruction. A number of pilot studies were conducted to design and position the advanced organizer and narration strategies precisely where student were experiencing difficulty in comprehending the information presented in the animation. No significant differences in achievement were expected on the Drawing test since the programmed instruction was designed to provide competency of the factual and simple conceptual content. Competency in these two areas was considered prerequisite if participants were to be able to profit from the subsequent strategies and achieve at the higher order learning levels. No significant difference in achievement on the Terminology and Comprehension tests was unexpected since the advance organizer and narration strategies used in this study have been effectively used in print material and in face-to-face instructional environments (Alvermann, 1981; Barron & Schwartz, 1984; Corkill, Glover, Bruning & Krug, 1988; Herron, York, Cole & Linden, 1998; Kang, 1997, Kirkman & Shaw, 1997). Both strategies used were intended to organize instructional content such that the participants' cognitive structures could more easily subsume the most important concepts. The anchoring function of both descriptive statements and questions were to direct participants' attention towards the more specific, attention-demanding segments in the animated instruction.

One plausible explanation for the results may be that the advance organizer and narration strategies, originally designed to reduce cognitive load, were actually increasing cognitive load. In this study, instructional content was presented as text as well as visuals. Dual coding theory (Paivio, 1986) suggests that simultaneous processing of verbal and visual information results in deeper information processing since the same information is processed twice, and the possibility of it being retained is increased. However, in

our study, the addition of advance organizers and narration may have required extra working memory capacity, which may have competed with the space and processing originally used to engage the instructional content. The use of narration to accompany animation has drawn much research attention recently. The results from a series of studies (Mayer & Anderson, 1992; Mayer & Sims, 1994; Moreno & Mayer, 1999; Moreno & Mayer, 2000; Mayer & Heiser, 2001) suggest the positive use of narration with animated instruction.

The types of narration used in our study were selective in nature, in that we did not use narration to explain the full animation but only used narration to explain those aspects of animation where participants experienced difficulties in comprehending the information being presented. The ineffectiveness of the advance organizers may be explained in that the nature of the advance organizers used in this study were quite different from previous studies which summarize or preview entire upcoming material using printed text or graphics alone (Alvermann, 1981; Barron & Schwartz, 1984; Corkill, Glover, Bruning & Krug, 1988; Herron, York, Cole & Linden, 1998; Kirkman & Shaw, 1997).

The advance organizers used in our study were selective in nature as were the narrations. Each organizer summarized only part of instructional material and was positioned immediately prior to that part of the material using either a question or a statement with a visual. This type of design may have interfered with the processing flow of learners since their comprehension may have been interrupted by the intermediate advance organizer. In addition, a great deal of research has suggested that advance organizers can only facilitate or enhance learners' retention or recall of text material when the organizers are actively processed (Corkill et al., 1988; Dinnel & Glover, 1985). The results of our study may indicate that advance organizers in our study failed to elicit the necessary processing.

The lack of significant difference in achievement between the control group and the experimental groups receiving either descriptive narration or question narration indicated that the use of animation

or animation with narration may be problematic for teaching concepts and rules/principles. These results contrast to prior studies whose results indicated that animation supported with narration was effective at teaching facts and problem-solving skills (Mayer & Anderson, 1991; Mayer & Anderson, 1992; Mayer, Fennell, Farmer, & Campbell, 2004). With factual knowledge being a prerequisite for learning concepts and rules/principles, and rules/principle knowledge being a prerequisite for problem solving learning, it was anticipated that animation supported by narration would have been effective at teaching concepts and rules/principles. However, the results did not support this hypothesis. Specifically, in the question narration treatment condition, although a question was asked, no expectation of a response was expected from participants since the answer was given by the system automatically. In addition, there was a very short pause between the question asked and the corresponding answer provided. This short pause may have deprived participants the opportunity of interacting with the animation to determine the answer. With responses automatically given to a prompted question, participants may have been rendered passive learners. In addition, the quality of narration may also have impacted student achievement (Mayer et al., 2004). Mayer's study found that participants learn better when narration was in conversational style rather than in formal style. The narration used in this study may be regarded as more formal in nature.

In summary, the results of this study suggest that the effects of advance organizers and narrations designed to facilitate higher order learning objectives from animated instruction were not significant in terms of student achievement. These findings raised significant concerns when generalizing the results obtained from prior research related to the effectiveness of advance organizers and narrations when the intent is to complement animated instruction designed to facilitate higher order learning outcomes.

References

- Alesandrini, K. L., & Rigney, J. (1981). Pictorial presentation and review strategies in science learning. *Journal of Research in Science Teaching*, 18, 465-474.
- Alvermann, D. (1981). The compensatory effect of graphic organizers in the learning and retention of meaningful verbal material. *Journal of Educational Research*, 75, 44-48.
- Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart & Winston.
- Baddeley, J. R. (1992). Working memory. *Science*, 255, 556-559.
- Barron, A. E. (1993). The effectiveness of digital audio in computer-based training. *Journal of Research on Computing in Education*, 25(3), 277-290.
- Barron, R. F., & Schwartz, R. M. (1984). Traditional postorganizers: A spatial learning strategy. In C. D. Holley & D. F. Dansereau (Eds.), *Spatial learning strategies: Techniques, applications, and related issues* (pp. 275-289). Orlando, FL: Academic Press
- Caraballo, A. (1985). *An experimental study to investigate the effects of computer animation on the understanding and retention of selected levels of learning outcomes*. Unpublished doctoral dissertation, The Pennsylvania State University.
- Chandler, P., & Sweller, J. (1992). The split-attention effect as a factor in the design of instruction. *British Journal of Educational Psychology*, 62, 233-246.
- Clark, J. M., & Paivio, A. (1991). Dual coding theory in education. *Educational Psychology Review*, 3, 149-210.
- Clark, R., C., & Mayer, R. E. (2003). *E-learning and the science of instruction*. San Francisco, CA: John Wiley & Sons.
- Corkill, A. J., Glover, J. A., Bruning, R. H., & Krug, D. (1988). Advance organizers: Retrieval context hypotheses. *Journal of Educational Psychology*, 80(3), 304-311
- Dinnel, D., & Glover, J. A. (1985). Advance organizers: Encoding manipulations. *Journal of Educational Psychology*, 77, 514-521.
- Dwyer, F. M., & Lamberski, R. (1977). *The human heart: Parts of the heart, circulation of blood and cycle of blood pressure*. US: Published Privately.
- Dwyer, F. M. (1994). One dimension of visual research: A paradigm and its implication. In D. Moore & F. M. Dwyer (Eds.), *Visual learning: A spectrum of visual learning* (pp. 383-401). NJ: Educational Technology Publications.
- Herron, C., York, H., Cole, S. P., & Linden, P. (1998). A comparison study of student retention of foreign language video: Declarative versus interrogative advance organizer. *The Modern Language Journal*, 82(2), 237-247.
- Hirumi, A., & Bowers, D. R. (1991). Enhancing motivation and acquisitions of coordinate concepts by using concept trees. *Journal of Educational Research*, 84(5), 273-279.
- Kaiser, M., Proffitt, D., & Anderson, K. (1985). Judgments of natural and anomalous trajectories in the presence and absence of motion. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 11, 795-803.
- Kang, S. H. (1997). The effects of using an advance organizer on students' learning in a computer

- simulation environment. *Journal of Educational Technology Systems*, 25 (1), 57-65.
- King, W. A. (1975). *A comparison of three combinations of text and graphics for concept learning*. San Diego, CA: Navy Personnel Research and Development Center.
- Kirkman, G., & Shaw, E. L. (1997). *Effects of an oral advanced organizer on immediate and delayed retention*. Paper presented at the 26th Annual Meeting of Mid-South Education Research Association (MSERA), Memphis, TN.
- Lin, H., Chen, T., & Dwyer, F. M. (2006). Effects of static visuals and computer-generated animations in facilitating immediate and delayed achievement in the EFL classroom. *Foreign Language Annals*, 39(2), 203-219.
- Lin, H., Ching, Y-H., Ke, F., & Dwyer, F. (in press). Effectiveness of various enhancement strategies to complement animated instruction: A meta-analytic assessment, *Journal of Educational Technology Systems*.
- Mann, B. L. (1995). Focusing attention with temporal sound. *Journal of Research on Computing in Education*, 27(4), 402-425.
- Mayer, R. (1984). Aids to prose comprehension. *Educational Psychologist*, 19, 30-42.
- Mayer, R. E. (1992). Cognition and instruction: Their historic meeting within educational psychology. *Journal of Educational Psychology*, 84 (4), 405-412.
- Mayer, R. E. (1993). Comprehension of graphics in text: An overview. *Learning and Instruction*, 3, 239-246.
- Mayer, R. E. (1994). Visual aids to knowledge construction: Building mental representations from pictures and words. In W. Schnotz & W. Khlhavy (Eds.), *Comprehension of graphic* (pp. 125-138). Amsterdam: Elsevier science.
- Mayer, R. E. (1996). When less is more: Meaningful learning from visual and verbal summaries of science textbook lessons. *Journal of Educational Psychology*, 88(1), 64-73.
- Mayer, R. E., & Anderson, R. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, 83(4), 484-490.
- Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology*, 84(4), 444-452.
- Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, 86(3), 389-401.
- Mayer, R. E., & Heiser, J. (2001). Cognitive Constraints On Multimedia Learning: When Presenting More Material Results In Less Understanding. *Journal of Educational Psychology*, 93(1), 187-198.
- Mayer, R. E., Fennell, S., Farmer, L., & Campbell, J. (2004). A personalization effect in multimedia learning: Students learn better when words are in conversational style rather than formal style. *Journal of Educational Psychology*, 96(2), 389-395.
- Miller, G. A. (1956). The magical number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81-97.
- Moore, M., Naworcki, L., & Simutis, Z. (1979). *The instructional effectiveness of three levels of graphics displays for computer-assisted instruction*. Arlington, VA: Army Research Institute for the Behavior and Social Sciences.
- Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology*, 91, 358-368.
- Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology*, 97, 117-125.
- Moreno, J., & Mayer, R. E. (2002). Verbal redundancy in multimedia learning. *Journal of Educational Psychology*, 94(1), 156-163.
- Mousavi, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology*, 87(2), 319-334.
- Munyofu, M., Swain, W., Ausman, B., Lin, H., Kidwai, K. & Dwyer, F. (in press). Effect of different chunking strategies in complementing animated instruction. *Learning, Media & Technology*.
- Owens, R., & Dwyer, F. M. (2005). The effect of varied cueing strategies in complementing animated visual imagery in facilitating achievement of different educational objectives. *International Journal of Instructional Media*, 32(4), 373-384.
- Paivio, A. (1986). *Mental representation: A dual coding approach*. Oxford, England: Oxford University Press.
- Park, O. C., & Gittelman, S. S. (1992). Selective use of animation and feedback in computer-based instruction. *Educational Technology Research and Development*, 40(4), 27-38.
- Penney, C. G. (1989). Modality effects and the structure of short-term verbal memory. *Memory and Cognition*, 17, 398-422.
- Reed, S. K. (1985). Effects of computer graphics on improving estimates to algebra word problems. *Journal of Educational Psychology*, 77(3), 285-298.
- Rieber, L. (1989). The effects of computer-animated elaboration strategies on factual and application

- learning in an elementary science lesson. *Journal of Educational Computing Research*, 5(4), 431-444.
- Rieber, L., & Boyce, M. (1990). The effects of computer animation on adult learning and retrieval tasks. *Journal of Computer-based Instruction*, 17, 46-52.
- Rieber, L., & Hannafin, M. J. (1988). The effects of textual and animated orienting activities and practice on learning from computer-based instruction. *Computers in the Schools*, 5, 77-89.
- Schnotz, W. (1993). On the relation between dual coding and mental models in graphics comprehension. *Learning and Instruction*, 3, 247-249.
- Sadowski, M., & Paivio, A. (2001). *Imagery and text: A dual coding theory of reading and writing*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Sternberg, R. J. (1985). *Beyond IQ: A triarchic theory of human intelligence*. Cambridge: Cambridge University Press.
- Stone, C. L. (1983). A meta-analysis of advance organizer studies. *Journal of Experimental Education*, 51(4), 194-199.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257-285.
- Wilson, F., & Dwyer, F. M. (2001). Effect of time and level of visual enhancements in facilitating student achievement of different educational objectives. *International Journal of Instructional Media*, 28, 159-167.
- Wittrock, M. C. (1990). Generating processes of comprehension. *Educational Psychologist*, 24(4), 345-376.
-
- HUIFEN LIN completed a doctorate in instructional systems at the Pennsylvania State University in 2006. Her research is focused on foreign language learning/teaching, computer-assisted instruction and instructional visualization. She is now an associate professor in the department of applied English at Kun Shan University, Taiwan. Address for correspondence: Applied English Department, 949 Da-Wan Rd., Yung-Kang City, Tainan Hsien, 71003 Taiwan, ROC.
- FRANCIS DWYER is currently a Professor of Education at The Pennsylvania State University at State College. He has influenced literally hundreds of graduate students directly and many thousand other students indirectly by his guidance and research focus. Address for correspondence: 310B Keller Building, the Pennsylvania State University, University Park, PA 16802, USA.
- WILLIAM J. SWAIN is currently a Ph.D. candidate in Instructional Systems in the Pennsylvania State University. He is also an instructional designer in Information Technology Services in the Pennsylvania State University. Address for correspondence: 0210 Rider Building II, University Park, PA 16802, U.S.A.