Facilitating Learning from Animated Instruction: Effectiveness of Questions and Feedback as Attention-directing Strategies

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ABSTRACT
The purpose of this study was to investigate the relative effectiveness of different types of visuals (static and animated) and instructional strategies (no strategy, questions, and questions plus feedback) used to complement visualized materials on students’ learning of different educational objectives in a computer-based instructional (CBI) environment. Five hundred eighty-two ($N = 582$) undergraduate students enrolled in an eastern university in the United States participated in the study. Students were randomly assigned to treatments and after interacting with their respective treatments, they received four individual criterion posttests to measure achievement of different educational objectives. Data analysis consisted of two phases. The first analyzed data that included all items in the four criterion posttests (80 items) plus a composite score. The second phase analyzed only the 34 enhanced items complemented by different instructional strategies and animation. Results indicated that students who received the animated visual treatment scored significantly higher on all criterion posttests than those who received the static visual treatment consistently for both phases of analysis. For the instructional strategy, students who received questions plus feedback or questions in their treatment scored significantly higher than those who received no strategy on selective criterion measures.

Keywords
Visualization, Animation, Questions, Feedback

Introduction

Recent technological advances have made possible individualized learning opportunities that integrate multiple ways of combining such media devices as audio, varied types of visuals, graphics, and sounds. There has been a long history of using visualization to complement textual material (Feaver, 1977; Slythe, 1970; Anglin, Vaez, & Cunningham, 2004). Research findings have generally supported the proposition that human beings remember pictures better than words (Anglin et al., 2004). Human memory is composed of two interdependent types of memory mode to process and store information — the verbal and nonverbal modes. Paivio (1990) has indicated that the dual coding of pictures both in its verbal and nonverbal forms is more likely to occur than words, which are more likely to be encoded verbally only. This hypothesis is presented to explain the superior effect of pictures to words when used in instruction.

Animation has been used in various disciplines to deliver instructional material that is hard to present alone using static visuals or that contains content that is highly abstract or invisible to human eyes. Animation, presented as pictures in motion, is analogous to a subset of visual graphics (Weiss, Knowlton, & Morrison, 2002). In a computer-based instructional (CBI) environment, animation is typically used due to its inherent characteristics that facilitate the instructional and learning processes. Animation also has the potential to provide feedback in various forms that may be both entertaining and motivating to learners striving for the correct response.

Different types of questions or questioning strategies can be used to engage learners in deeper cognitive information processing and therefore enhance their learning. King (1992) indicated that having students ask and answer high-level questions facilitates their comprehension of the text material by engaging them in tasks such as “... focusing attention, organizing the new material, and integrating the new information with existing knowledge” (p. 304).

The importance of feedback in the learning process has long been recognized, and feedback has been a variable of interest in educational research. During a learning process, feedback generally plays a role as a motivator or incentive to encourage accurate performance or as an information confirmer that learners can use to judge the correctness of a previous response. In terms of its purpose, feedback has both reinforcing and informational attributes. It is believed that letting learners know how well they are performing a task and that giving them the opportunity to monitor or assess their learning progress can result in a better learning effect (Kulhavy & Wager, 1993).
Dynamic visualized materials created in an interactive learning environment always depend on “learners’ actions” and “…active learner engaged processing of learning materials…” (Kalyga, 2007, p. 387). Cognitive load theory (CLT) originated in the 1980s, heavily relies upon theories drawn from cognitive architecture and the memory system of human beings. It provides instructional designers with theory-based guidelines for designing instructional materials. Researchers conducting studies on effectiveness of animation or simulation-based instruction recognized and discussed their findings mostly from a cognitive load perspective, especially when the cognitive load was associated with the level of interactivity of learners engaged in the learning process (Paas, Van Gerven, & Wouters, 2007; de Koning, Tabbers, Rikers, & Paas., 2007; Moreno, 2007; Lusk & Atkinson, 2007). These studies have used this framework to establish the conditions and methods for enhancing the effectiveness and efficiency of animated instruction (Kalyga, 2007). Major findings of animated instruction design employing a cognitive load approach included examinations of the learner differences and design principles to optimize the effect of animated instruction. For example, Cohen and Hegarty’s study revealed that accuracy of mental representation of animated visuals greatly depends on learners’ spatial abilities. Students with high-level spatial ability are more likely than their low-level counterparts to interpret animated visuals more correctly and efficiently (Cohen and Hegarty, 2007).

Design principles of animated instruction have also focused on techniques to reduce cognitive load. Techniques that have been discussed in previous studies include the employment of learner control of the pace of instruction rather than a system-paced instruction (Hasler, Kersten, & Sweller, 2007). Research has also suggested that attention cueing in the animation and embedded animated pedagogical agents, designed to direct students’ attention to relevant visual information, also reduced extraneous cognitive load (Ayres & Paas, 2007; de Koning et al., 2007). Guided-discovery principle is another design principle that has been utilized to develop animated instruction (De Jong, 2005; Plass et al., 2009). Questions and feedback embedded in a computer-based animated instruction is one example that follows guided-discovery principle. Moreno (2004) and Moreno and Mayer (2005) indicated that corrective feedback is less effective than explanatory feedback in supporting retention and far transfer. The former simply informed users whether they were right or wrong, and the latter provided relevant explanations (Plass, Homer, & Hayward, 2009).

In this paper, the author draws on cognitive load theories and guided-discovery principle to design both static and animated visualized materials. By inserting questions and feedback into segments of the visualized materials, the study further compared the relative effectiveness of such strategies in enhancing learning from both types of visualized materials.

**Statement of the problem**

Although there is increasing interest in conducting animated visual research, there has been little work done to precisely specify what educational objectives animated visuals are most effective in facilitating. There is a need to specify the levels of learning outcomes that animated visuals are most effective in improving due to the high cost associated with the development of animated instruction. Furthermore, a series of previous studies has shed light on factors that may have undermined the effectiveness of animation (Owens & Dwyer, 2005; Wilson & Dwyer, 2001; Rieber & Boyce, 1990; Lin, Kidwai, Munyofu, Swain, Ausman, & Dwyer, 2005). Researchers indicated that learners, when presented with animated instruction, were not able to “. . . effectively attend to the animation” or were “. . . distracted by the combination of visual and verbal information presented to them” (Rieber, 1990, p. 81). Owens & Dwyer (2005) also found that learners failed to focus on critical aspects of the animation that depicted important concepts.

Furthermore, unlike studies that employed animated visuals alone to examine their effects with different designs, this study incorporated a comparison group using static visuals. As Ayres and Paas (2007) have argued, the effectiveness of static visuals could be enhanced and therefore might be more effective than animation when additional techniques are used. Based on previous research findings and suggestions, this study employed varied instructional strategies to accompany animated and static visuals instruction to scaffold students. The primary purpose of this study was to investigate the effect of varied types of visuals (static and animated) on students’ learning of different educational objectives in a CBI environment. The study also investigated the relative effectiveness of using varied instructional strategies (questions and feedback) used to complement static and animated visualization on students’ learning.
Methods

Participants

The participants of the study consisted of 582 undergraduate students enrolled in an eastern university in the United States. They were recruited from a number of classes and majored in different disciplines, such as education, engineering, physics, statistics, etc. Among them, 324 participants were female and 258 male. The components of the participants were as follows: 13% freshmen \((n = 77)\); 29% sophomores \((n = 169)\); 35% juniors \((n = 202)\); and 23% seniors \((n = 134)\). Participation was voluntary, and students received course credits for their participation.

Research design

This study employed a posttest only, a 2 x 3 factorial experimental design. The two independent variables were visual type and instructional strategy. The dependent variables were four criterion posttests measuring differences in subjects’ understanding of the materials after being exposed to the learning materials. The first independent variable, that is, visual type, consisted of two levels: static visuals or animated visuals. The second independent variable, that is, instructional strategy, was comprised of three levels: no strategy, questions, and questions plus feedback. Figure 1 describes the research design employed in the study.

![Figure 1. 2 x 3 factorial-posttest-only research design](image)

Computer-based instructional module

The instructional material used in this study, originally presented in print material, was modified into a computer-based format. The instructional module consisted of five units dealing with physiological knowledge of the human heart. Content for each unit was presented in texts supported by either static or animated visuals. Enhancement strategies, that is, questions or questions plus feedback, were integrated within each frame to facilitate learning. The total number of instructional frames for the module was 20.

Pilot study

A pilot study employing the identical criterion measures and material was conducted using participants with similar background as the main study. The purpose of the pilot study was to effectively develop animated visuals that would facilitate the students’ learning and comprehension of the treatment instructional material. Based on the result of the
pilot study, difficult and complex concepts presented in the material were identified by item analyses and were later on complemented by questions and feedback.

Respective treatment groups

**Group One: Animation alone.** Participants assigned to this treatment group received instructional material that contained text and animated visuals in selective frames. In total, 14 animation sequences, developed to address 34 difficult items, were embedded in these frames. Students in this treatment group were instructed to first read the text carefully and then interact with the animation. Each animated sequence was developed to complement a portion of the text and to facilitate understanding of complex concepts that were found in the pilot studies to be difficult to comprehend with static visuals only. Figure 2 provides a screenshot of the instructional frame containing an animated visual.

![Figure 2. Instructional frame containing an animation sequence](image)

**Group Two: Animation + questions.** Participants assigned to this treatment group received instructional material that contained text, animated visuals, and questions in selective frames. Students in this treatment group received exactly the same instructional material as did the “animation alone” group; however, 32 questions addressing 34 difficult items were embedded after the 14 frames to reinforce students’ comprehension and acquisition of the difficult knowledge contained in previous frames.

**Group Three: Animation + questions + feedback.** The instructional material used for the treatment group contained the text, animated visuals in 14 frames, questions following these 14 frames, and corresponding feedback. After viewing the animation, students proceeded to a frame that contained a question. Participants needed to make an overt response to each question. In addition, after a response was submitted, feedback on the correctness of the response was displayed as either “incorrect” or “correct.” A short sentence elaborating upon the correct answer was provided as well.

**Group Four: Static visuals alone.** The instructional module received by participants in this treatment group consisted of text and static visuals used to complement the text. In total, there were 20 static visuals in this module, with one static visual accompanying each instructional frame. The 20 visuals matched those in the previously described treatments, with all being static in this treatment. Figure 3 provides a screenshot of the instructional frame that contained an animated visual.

**Group Five: Static visuals + questions.** Participants in this treatment group received exactly the same instructional material as that received by the “static visuals alone” treatment group; however, an additional instructional strategy was embedded in the instructional module. Questions following the same 14 instructional frames as those in the animated visual treatments were provided to students in this group. Students were required to read the question
carefully, recall what they had learned from previous frames, and choose a correct answer. There was no feedback in regard to the correctness of the submitted response.

Group Six: Static visuals + questions + feedback. The instructional module received by this treatment group was exactly the same as that received by the “static visuals + questions” group; however, the students received feedback on their responses immediately after submission. The feedback, presented in the same format and with the same amount of information as the “animated visuals + questions + feedback” treatment group, first assessed the students’ submitted responses as either correct or incorrect, then provided a simple elaboration of the correct response.

Figure 3. Instructional frame containing a static visual

Criterion measures

Four criterion measures developed by Dwyer (1972) were used to assess students’ understanding and achievement of the instructional material. These four criterion tests measured different learning outcomes in educational technology area, such as facts, concepts, rules/procedures, comprehension, and problem solving. Each criterion test consisted of 20 items. All but the drawing test, terminology, identification, and comprehension tests consisted of 20 multiple-choice questions. Cronbach’s alpha coefficients (α) were calculated to establish the reliability and internal consistency of the dependent variables in this study. A detailed description of the criterion measures is summarized below.

Drawing Test (α = .98). The purpose of the drawing test was to measure students’ overall understanding of the instructional material as well as their ability to “. . . reproduce the parts of the heart in their appropriate context . . .” (Dwyer, 1994, p. 391). This criterion test was developed to assess specifically the level of intellectual skills/concept learning regarding the instructional module according to the types of learning outcomes developed by Gagne (1985). Each student was provided with a blank piece of paper on which they were required to draw a simple diagram of the human heart.

Identification Test (α = .87). The purpose of the identification test was to assess the students’ ability to identify parts of the human heart. The level of knowledge measured in this test was verbal information based on Gagne’s types of learning outcomes (1985). In this test, a diagram of the human heart with 20 numbered arrows was provided to students, who had to then choose the corresponding letter to the numbered arrow from four possible answer choices.

Terminology Test (α = .84). The terminology test measured several levels of learning including verbal information, concepts, and rules/procedures. The students’ knowledge of specific terms of the human heart and their association with various functions of the human heart were assessed.
Comprehension Test \((\alpha = .84)\). The test measured a higher-level learning outcome; the mastery of this learning outcome would require the students’ competent acquisition of knowledge concerning facts, rule/procedures, concepts, and problem solving pertaining to the instruction.

Total Composite Score \((\alpha = .96)\). Two composite scores were calculated. One composite score was calculated by adding the separate scores of all items on the drawing, identification, terminology, and comprehension tests. Another total composite score was calculated by adding the separate score of enhanced items only on the drawing, terminology, and comprehension tests.

Data analysis

Two phases of analyses were conducted in the study to answer the research questions. The data analysis in the first phase investigated the effectiveness of respective treatments by comparing the participants’ achievement scores on all 80 items contained in the four criterion posttests and a composite score based on these 80 items. The second phase of analysis focused on the 34 enhanced items, nine (9) items in the drawing test, none (0) in the identification test, twelve (12) in the terminology test, thirteen (13) in the comprehension test was identified in the pilot study as difficult. The latter analysis aimed to assess students’ achievement in those portions of the instructional module in which animated visuals, questions, and feedback were included.

Analysis based on 80 enhanced items

The drawing test \(\text{(number of items = 20)}\). ANOVA source data indicated that the interaction between the visual type and instructional strategy was not statistically significant: \(F = .352, df = 2/576, p = .704\). The main effect of the visual type was significant, \(F = 25.452, df = 1/576, p = .000\). Participants receiving the animated visual treatment \((M = 12.66; SD = 5.80)\) scored significantly higher in the drawing test than did participants receiving the static visual treatment \((M = 10.22; SD = 5.89)\). However, the main effect of the instructional strategy was not significant, \(F = .991, df = 2/576, p = .372\).

The identification test \(\text{(number of items = 20)}\). ANOVA conducted on the identification test indicated that the interaction between the visual type and instructional strategy was not statistically significant: \(F = .655, df = 2/576, p = .520\). The main effect of the visual type was significant, \(F = 20.716, df = 1/576, p = .000\). However, the main effect of instructional strategy was not significant, \(F = .154, df = 2/576, p = .857\). Participants receiving the animated visual treatment \((M = 14.51; SD = 4.71)\) scored significantly higher in the identification test than did participants receiving the static visual treatment \((M = 12.70; SD = 4.85)\).

The Terminology Test \(\text{(number of items = 20)}\). The interaction between the visual type and instructional strategy was not statistically significant: \(F = 2.026, df = 2/576, p = .133\). However, the main effects for both the visual type and the instructional strategy were significant, for the visual type, \(F = 4.706, df = 1/576, p = .030\), and for the instructional strategy, \(F = 5.969, df = 2/576, p = .003\). An inspection of the means for the static visual and the animated visual treatment groups indicated that animated visual \((M = 12.09; SD = 4.80)\) significantly outperformed static visuals \((M = 11.25; SD = 4.66)\). For the main effect of the instructional strategy, post hoc tests indicated that the “questions + feedback” treatment \((M = 12.30, SD = 4.88)\) significantly outperformed the “no strategy” treatment \((M = 10.74, SD = 4.49)\), and the difference is significant at the .003 level. In addition, the “questions” treatment \((M = 11.97; SD = 4.74)\) also significantly outperformed the “no strategy” treatment \((M = 10.74; SD = 4.49)\), and the difference was significant at the .026 level. The observed differences between the “questions + feedback” and the “questions” treatments were not significant at the .05 level.

The Comprehension Test \(\text{(number of items = 20)}\). The interaction between the visual type and the instructional strategy was not statistically significant: \(F = 1.685, df = 2/576, p = .186\). However, the main effects for both the visual type and the instructional strategy were significant, for visual type, \(F(1,576) = 8.789; p = .003\), and for the instructional strategy, \(F = 4.154, df = 2/576, p = .016\). An inspection of the means for the static visual and the animated visual treatment groups indicated that animated visual \((M = 11.63; SD = 4.64)\) significantly outperformed static visuals \((M = 10.47; SD = 4.81)\). For the main effect of the instructional strategy, post hoc tests indicated that the “questions + feedback” treatment \((M = 11.66; SD = 4.64)\) significantly outperformed the “no strategy” treatment.
(\(M = 10.30, \text{SD} = 4.72\)), and the difference was significant at the .005 level. The observed differences between the “questions + feedback” and the “questions” treatments and the “questions” and the “no strategy” treatments were not significant at the .05 level.

The composite score (number of items = 80). The interaction between the visual type and the instructional strategy was not statistically significant: \(F = 1.063, df = 2/576, p = .346\). However, the main effect for the visual type was significant, \(F = 17.235, df = 1/576, p = .000\). The main effect for the instructional strategy was not significant, \(F = 1.388, df = 2/576, p = .250\). An inspection of the means for the static visual and the animated visual treatment groups indicated that animated visual (\(M = 50.89; \text{SD} = 18.33\)) significantly outperformed static visuals (\(M = 44.64; \text{SD} = 18.03\)).

Summary of results

Table 1 presents a summary of results for the data analysis of the learning achievement of all items based on visual type. As indicated, differences on all criterion tests between static and animated visuals were significantly in favor of animated visuals.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Static (S)</th>
<th>Animated (A)</th>
<th>Result</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>10.22(5.89)</td>
<td>12.66(5.80)</td>
<td>A &gt; S</td>
<td>.000***</td>
</tr>
<tr>
<td>Identification</td>
<td>12.70(4.85)</td>
<td>14.51(4.71)</td>
<td>A &gt; S</td>
<td>.000***</td>
</tr>
<tr>
<td>Terminology</td>
<td>11.25(4.66)</td>
<td>12.09(4.80)</td>
<td>A &gt; S</td>
<td>.030*</td>
</tr>
<tr>
<td>Comprehension</td>
<td>10.47(4.81)</td>
<td>11.63(4.64)</td>
<td>A &gt; S</td>
<td>.003**</td>
</tr>
<tr>
<td>Composite</td>
<td>44.64(18.03)</td>
<td>50.89(18.33)</td>
<td>A &gt; S</td>
<td>.000***</td>
</tr>
</tbody>
</table>

Table 2 summarizes the results of the first phase analysis based on instructional strategies. As indicated, both “questions” and “questions + feedback” were significantly more effective than “no strategy” in the terminology test, and “questions + feedback” was significantly more effective than “no strategy” in the comprehension test.

<table>
<thead>
<tr>
<th>Measures</th>
<th>NOa</th>
<th>QS</th>
<th>QF</th>
<th>Result</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>11.56(5.91)c</td>
<td>10.97(6.06)</td>
<td>11.78(5.93)</td>
<td>nsd</td>
<td>.372</td>
</tr>
<tr>
<td>Identification</td>
<td>13.72(4.78)</td>
<td>13.46(4.97)</td>
<td>13.64(4.85)</td>
<td>ns</td>
<td>.857</td>
</tr>
<tr>
<td>Terminology</td>
<td>10.74(4.49)</td>
<td>11.97(4.74)</td>
<td>12.30(4.88)</td>
<td>QF &gt; NO</td>
<td>.003**</td>
</tr>
<tr>
<td>Comprehension</td>
<td>10.30(4.72)</td>
<td>11.18(4.84)</td>
<td>11.66(4.64)</td>
<td>QF &gt; NO</td>
<td>.005**</td>
</tr>
<tr>
<td>Composite</td>
<td>46.33(17.97)</td>
<td>47.59(18.79)</td>
<td>49.39(18.48)</td>
<td>ns</td>
<td>.250</td>
</tr>
</tbody>
</table>

Table 2. Results of all items based on instructional strategy

Table 2. Results of all items based on instructional strategy

Analysis based on 34 enhanced items

The second phase of the data analysis was focused on the items for which the instructional strategy and animation were particularly designed to improve achievement. As with the first phase of data analysis, a two-way ANOVA was conducted to compare the mean scores of the enhanced items in each dependent variable among the treatment groups.

The drawing test (number of items = 9). ANOVA results indicated that the interaction between the visual type and the instructional strategy was not statistically significant: \(F(2/576) = .042, p = .959\). However, the main effect of the visual type was significant, \(F = 38.328, df = 1/576, p = .000\). The main effect of the instructional strategy was not
significant, $F = 1.147$, $df = 2/576$, $p = .318$. Participants receiving the animated visual treatment ($M = 5.10; SD = 3.04$) scored significantly higher on the enhanced items in the drawing test than did the participants receiving the static visual treatment ($M = 3.57; SD = 2.92$).

The terminology test (number of items = 12). The interaction between the visual type and the instructional strategy was not statistically significant: $F = 1.392$, $df = 2/576$, $p = .249$. However, the main effects for both the visual type and the instructional strategy were significant: for the visual type, $F = 4.140$, $df = 1/576$, $p = .042$, and for the instructional strategy, $F = 7.603$, $df = 2/576$, $p = .001$. An inspection of the means for the static visual and animated visual treatment groups indicated that the animated visual ($M = 6.67; SD = 3.13$) significantly outperformed the static visuals ($M = 6.16; SD = 3.05$). For the main effect of the instructional strategy, post hoc tests indicated that the “questions + feedback” treatment ($M = 6.87; SD = 3.26$) significantly outperformed the “no strategy” treatment ($M = 5.73; SD = 2.84$), and the difference was significant at the .001 level. In addition, the “questions” treatment ($M = 6.64; SD = 3.08$) also significantly outperformed the “no strategy” treatment ($M = 5.73; SD = 2.84$), and the difference was significant at the .01 level.

The comprehension test (number of items = 13). The interaction between the visual type and the instructional strategy was not statistically significant: $F = .863$, $df = 2/576$, $p = .423$. However, the main effect for both the visual type and the instructional strategy was significant: for the visual type, $F = 6.215$, $df = 1/576$, $p = .013$; and for the instructional strategy, $F = 3.397$, $df = 2/576$, $p = .034$. An inspection of the means for the static visual and the animated visual treatment groups indicated that the animated visual ($M = 6.87; SD = 2.81$) significantly outperformed the static visuals ($M = 6.29; SD = 2.87$). For the main effect of the instructional strategy, post hoc tests indicated that the “questions + feedback” treatment ($M = 6.91; SD = 2.80$) significantly outperformed the “no strategy” treatment ($M = 6.18; SD = 2.84$), and the difference was significant at the .02 level.

The composite score (number of items = 34). The interaction between the visual type and the instructional strategy was not statistically significant: $F = .863$, $df = 2/576$, $p = .423$. However, the main effects for both the visual type and the instructional strategy were significant: for the visual type, $F = 16.889$, $df = 1/576$, $p = .000$; and for the instructional strategy, $F = 3.569$, $df = 2/576$, $p = .029$. An inspection of the means for the static visual and the animated visual treatment groups indicated that the animated visual ($M = 18.64; SD = 7.88$) significantly outperformed the static visuals ($M = 16.01; SD = 7.64$). For the main effect of the instructional strategy, post hoc tests indicated that the “questions + feedback” treatment ($M = 18.34; SD = 7.91$) significantly outperformed the “no strategy” treatment ($M = 16.25; SD = 7.61$), and the difference was statistically significant at the .021 level.

Summary of results

Table 3 presents a summary of results for the data analysis of the learning achievement of enhanced items based on visual type. As indicated, the differences on all criterion tests between the static and animated visuals were significantly in favor of the animated visuals.

<table>
<thead>
<tr>
<th>Measures $^a$</th>
<th>Static (S)</th>
<th>Animated (A)</th>
<th>Result</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>3.57$^b$ (2.92)$^c$</td>
<td>5.10 (3.04)</td>
<td>A &gt; S</td>
<td>.000**</td>
</tr>
<tr>
<td>Terminology</td>
<td>6.16 (3.05)</td>
<td>6.67 (3.13)</td>
<td>A &gt; S</td>
<td>.042*</td>
</tr>
<tr>
<td>Comprehension</td>
<td>6.29 (2.87)</td>
<td>6.87 (2.81)</td>
<td>A &gt; S</td>
<td>.013*</td>
</tr>
<tr>
<td>Composite</td>
<td>16.01 (7.64)</td>
<td>18.64 (7.88)</td>
<td>A &gt; S</td>
<td>.000***</td>
</tr>
</tbody>
</table>

$^a$ Maximum score for the drawing test, 9; terminology test, 12; comprehension test, 13; composite score, 34.
$^b$ Mean score. $^c$ Value in parentheses is the standard deviation.
* $p < .05$. ** $p < .01$. *** $p < .001$.

With regard to learning achievement on the enhanced items, based on the instructional strategy, Table 4 indicates that “questions + feedback” was a significantly more effective instructional strategy than “no strategy” in facilitating achievement in the terminology, the comprehension test, and the composite test.
Table 4. Results of enhanced items based on instructional strategy

<table>
<thead>
<tr>
<th>Measures</th>
<th>NO$^a$</th>
<th>QS</th>
<th>QF</th>
<th>Result</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawing</td>
<td>4.35(3.15)$^b$</td>
<td>4.10 (3.05)</td>
<td>4.56 (3.03)</td>
<td>ns$^c$</td>
<td>.318</td>
</tr>
<tr>
<td>Terminology</td>
<td>5.73 (2.84)</td>
<td>6.64 (3.08)</td>
<td>6.87 (3.26)</td>
<td>QF &gt; NO</td>
<td>.001**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QS &gt; NO</td>
<td>.010*</td>
</tr>
<tr>
<td>Comprehension</td>
<td>6.18 (2.84)</td>
<td>6.66 (2.88)</td>
<td>6.91 (2.80)</td>
<td>QF &gt; NO</td>
<td>.028*</td>
</tr>
<tr>
<td>Composite</td>
<td>16.25 (7.61)</td>
<td>17.39 (7.97)</td>
<td>18.34 (7.91)</td>
<td>QF &gt; NO</td>
<td>.021*</td>
</tr>
</tbody>
</table>

$^a$ NO = No Strategy. QS = Questions. QF = Questions + Feedback.
$^b$ Mean score. $^c$ Value in the parentheses is the standard deviation.
$^d$ The maximum score for the drawing test, 9; terminology test, 12; comprehension test, 13; composite score, 34.
$^e$ $p$>=.05 * $p$<.05. **$p$<.01.

Discussions

General findings

The major interest of this study concerned whether the provision of question and feedback would optimize students’ learning in visualized instruction. The results of the study, however, indicate that questions with or without feedback were equally effective in students’ learning from visualized instruction. This finding may suggest that the use of feedback as simple as the one used in the study was not an effective instructional technique for increasing student achievement of different types of learning objectives when accompanying visualized instruction.

Related work

Previous research has shown that embedded questions designed to focus student attention effectively reinforced relevant learning cues. By responding to the embedded questions inserted before or after the text, students may activate their prior knowledge, engage in deeper information processing, and therefore enhance their recall and retention of the instructional material (Anderson & Pearson, 1984). The type of questions and feedback employed in this study to enhance learning from visualized instruction are easy to construct in a CBI environment and, consequently, the instructional effect that can be expected is minimal. Other types of questions and more elaborate feedback may be used to produce more desirable learning effects. As Anderson and Biddle (1975) have indicated, “. . . higher order questions consistently increased both recall and application of information . . .” (p. 122). In this study, the provision of feedback to responses that students made to inserted questions seems not to have produced a satisfactory instructional effect, which can be seen from both phases of the data analysis, which consistently showed that the “questions + feedback” group did not significantly outperform the “questions” group in any posttests. This finding was consistent with previous studies that found the no-feedback condition to be equally effective as providing feedback of some type (Clariana, Ross, & Morrison, 1991; Clark & Dwyer, 1998; Pridemore & Klein, 1995; Kulhavy & Stock, 1989).

However, the finding also contradicted previous research that supported that providing some kind of feedback is superior to no feedback at all (De Klerk & De Klerk, 1978). As suggested from research on feedback, many factors contributed to the effectiveness of feedback. The type of feedback investigated in this study was analogous to the combination of KCR and KOR. Learners were informed as to the correctness of their submitted responses as well as a statement of the correct response. This kind of feedback is simple in nature and easy to construct in a CBI environment. It is also associated with low cost in terms of instructional design and development. However, the study found out that this type of feedback did not help students in the acquisition of even the simplest factual knowledge, as reflected in their performance of the drawing and identification tests, which measured lower-level learning outcomes. Other types of feedback, which are more dedicated and complex in nature and developed to accompany visualization instruction to maximize students’ learning, may be more effective.

In regard to the effects of visual types, the findings of the study suggested the superior effectiveness of animated visuals compared to static visuals. Students receiving the animated instructional treatment outperformed significantly on all criterion posttests across both phases of the analysis than did students who received static visuals. The findings were encouraging and consistent with previous studies that found significantly superior effects with animation than...
with static visuals (Kaiser, Proffitt, & Anderson, 1985; Rieber, 1989; Rieber, Boyce, & Assad, 1990). Indeed, no other studies conducted positioned treatments via item analysis. Animation, at its core nature, has attention-gaining and entertaining features, which is believed to motivate student learning. Rieber (1990, 1991) indicated that the most powerful and effective application of animation is in presenting instructional materials rather than focusing learners’ attention or for its cosmetic function. The animation used in the study complemented textual material. The findings of this study also contradicted previous studies that suggested that animation was no more effective than static visuals (Caraballo, 1985; King, 1975; Moore, Nawrocki, & Simutis, 1979).

Conclusion

Mirzoeff (1998), as cited by Jeffers (2002), indicated that visual culture resides in everyday life and that to explore visual culture, we need to understand how visuals have shaped our society, including how we visualize things and how we learn visually. Anderson and McRorie (1997) further indicated that visual culture is determined by the context in which visuals were made and used (Jeffers, 2002). Visuals have been well recognized in terms of their function in facilitating knowledge construction and in shaping, reflecting, and representing our society. People in post-modern society learn visually and most of the time, need to learn to “visualize” things that are not visual-based, since visuals have occupied almost every aspect of our society and everyday life (Jeffers, 2002, p.157). Visuals have dominated most instructional materials that we use and, therefore, instructional designers need to understand general instructional principles that apply to all graphic materials. Rieber (2000) has suggested conditions that need to be taken into consideration when designing graphics or visuals based instructional materials. First, the purposes that graphics serve and the specific type of instructional objective each graphic is designed to achieve must be determined prior to the design process and evaluated throughout the process. Second, the selection of the types of graphics depends on the needs and the types of learner, the content to be delivered, and the characteristics of the learning task. Thirdly, graphics should be designed to present a meaning context through which students can achieve the predetermined learning objectives as well as feel highly motivated in the learning process. One important design principle that Rieber (2000) pointed out that is especially relevant to this study is “. . . the important relationship between attention-gaining and presentation principles associated with graphics . . .” (p. 222). As was revealed in previous studies, students might not attend to relevant parts of a graphic presentation due to selective attention. Therefore, “. . . direct and overt directions to actively search for or use specific information in the visual . . .” should be provided to increase the chance that students would pay attention to a graphic. Such strategies also reduce extraneous cognitive load resulting from irrelevant search and free working memory space for more intrinsic learning.

Computers can be a powerful medium to design graphics for “. . . attention-gaining and presentation purposes . . .” (Rieber, 2000, p. 224). However, much of the strengths of the computer in achieving above purposes have not been explored. This study explored the effect of computer-based questions and feedback in complementing visuals (both static and animated) to examine the relative effects. The significance of the study is two-fold. First, the results provide instructional designers with empirical evidence that supports the use of varied types of visuals in a computer-based learning environment specifically to achieve designated instructional objectives. Second, although this study did not intend to explore the effects of different types of feedback in learning, it examined a basic issue — the provision (or not) of feedback, specifically in a computer-based learning environment that used varied visuals. That is, this study examined the notion that providing feedback to the responses would enhance learning from the visualized instruction, especially with regard to animated visualized instruction.

The results of this study were affected by a particular system in which the author tested the hypothesis that questions or questions plus feedback can be used to optimize learning from visualized instruction, in particular, animated instruction. The learning outcomes of visualized materials integrated with questions or feedback are not superior to those of visualized materials not integrated with questions or feedback. One plausible explanation might be that simple textual feedback on the correctness of a submitted response was not effective in conveying information for visualized materials. Another possible explanation might be that well-designed visualized materials, such as those in this study, are self-contained and therefore no additional aids were necessary in conveying meanings.

Furthermore, this study found no effect of questions and feedback in facilitating student learning specifically from animated visualization. Future research may investigate other types of cueing strategies such as advance organizers, narrations, audios, or chunking. In addition, new and emerging technology has been becoming increasingly available
to offer more advanced types of instructional strategies that involve sounds, digital images, audio, and more. Feedback certainly can be constructed combining these new advanced technology features. Future research on the relative effectiveness of these multisensory instructional strategies is warranted.

References


