

COMMENTARY

▲ Using Multimedia Effectively in the Teaching-Learning Process

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This report presents current learning theories that relate to multimedia use. It is important to understand how these learning theories apply to the instructional environment that faculty find themselves teaching in today's classroom. Textual information is often presented concurrently with visual information, but the way they are presented can improve or hinder the learning process of novice students. *J Allied Health 2007; 36:176-179.*

WITH THE INCREASING DEMAND to teach via computers and the Internet, it is important for educators to become familiar with how students learn best when using multimedia. Over the past two decades, there have been numerous studies on how visual information incorporated into instruction can foster meaningful learning.¹⁻³ Initially researchers focused on illustrations that accompanied text, but with computer instruction different presentation modes are easily presented and are often needed for clarification when an instructor is not readily available. Multimedia can be defined in many ways, but this report refers to multimedia as a computer system using more than one format, such as text accompanied by an illustration or narration accompanied by an illustration.

While some researchers question the effectiveness of illustrations, others have offered evidence that they can be helpful.^{4,5} Mayer and Anderson discovered that illustrations along with narration helped increase students' recall and comprehension.⁶ Other studies have supported this same finding.^{7,8} This report will first discuss key theories that are being tested by the research and then will describe current findings of when visuals and narrations should be used in multimedia instruction, concluding with how the research findings can help educators effectively design instruction for multimedia environments.

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Received February 24, 2006; revision accepted November 21, 2006.

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Current Cognitive Theory

COGNITIVE LOAD THEORY AND SPLIT-ATTENTION EFFECT

Cognitive load theory, which is the notion that there is a limit to the information that can be processed in working memory at one time, has been used to explain the split-attention effect.⁹⁻¹² Evidence has been provided that a high load on working memory can be detrimental to learning.¹³⁻¹⁵ The split-attention effect occurs when instructional formats present both visual and verbal information together in a signal format. This may be particularly important when the individual formats are unintelligible until they are integrated together. This can create an overload on working memory, making it more difficult to learn the information.¹⁶ This is a common occurrence in novice students when they try to mentally integrate information from several sources. If students pay full attention to text, they may miss information presented on an illustration or on an animation. Likewise, if they pay full attention to the animation, they may miss some textual information. Study results suggest that reducing or eliminating the split-attention effect improves student comprehension.^{13,17-19}

DUAL CODING THEORY AND CONTIGUITY EFFECT

Dual-coding theory proposes that people have two separate pathways or systems in working memory to process information.^{20,21} One system processes verbal information, and the other processes visual information. If both of these systems are used to learn information, then the information may be more likely to be remembered and recalled. This theory has been modified to describe how visual and verbal information might be integrated in working memory.²² Here the learner builds a verbal representation in working memory from the verbal material; likewise, a visual representation is built in working memory derived from visually presented material. Then a connection, called a referential connection, between the two representations is created in the brain. Being able to connect the two types of information received is hypothesized to improve student problem solving.

This problem-solving transfer has been noted in research when text and visuals are presented concurrently rather than individually or isolated from one another. This is known as the contiguity effect.^{1,2,6}

REDUNDANCY EFFECT

This effect occurs when multiple sources, such as text and illustrations, present information that is repetitive or present information that is intelligible separately. For example, if textual material states the entire information seen in a diagram, then one source is redundant. The question becomes should both types of information be offered together or should one be eliminated. Conventional wisdom assumes that having two formats presenting the same information enhances learning, but there is research that contradicts this assumption.^{13,18,23,24}

Narration versus On-Screen Text in Multimedia Learning

When instructing via multimedia, there is an option to present verbal information through an auditory narrative or through on-screen text. Mayer and Gallini found that coordinating text with pictures improved problem-solving transfer for novice learners but not for experienced learners.² These results may indicate that some previous knowledge in a specific area compensates for uncoordinated instruction; however, novice learners who have little domain-specific knowledge benefit most from coordinated instruction, which is believed to help encode information better. Because novice learners are most likely to benefit from coordinated instruction, it is important to keep that in mind when designing instruction. Multimedia also gives the instructor the ability to show animations instead of still illustrations. Mayer and Moreno used novice learners to study learning outcomes in two groups; one group was given animations with concurrent narration, and one group was given animations with concurrent on-screen text.²⁵ They found that students who were presented with a narrative scored significantly higher on retention, matching, and transfer tests.

These studies imply that coordinating visual information with verbal information, like a narrative with an animation, encourages the development of referential connections between the two types of information as described in dual-processing theory and contiguity effect. This study also suggests that learners can generate more problem-solving solutions when verbal information is presented in a narrative form rather than text form when accompanied by animations.²⁵ This provides evidence for split-attention effects and demonstrates that learners recall more information when presented with a narrative. This is perhaps because the load on working memory is minimized to better process the information. Allied health educators can easily incorporate this design format when using multimedia.

Narration versus Animation Sequence in Multimedia Learning

Educators not only need to understand the effects of using narrations with graphics, but also how to sequence them to

be the most effective. Previous research has demonstrated that learners transfer information better when both text and illustrations are presented together on one page rather than when they were presented on separate pages, isolated from one another.¹ This research can be extended into the realm of multimedia, where there is the capability of using narrations and animations as opposed to text and illustrations. Mayer and Sims looked at the sequencing of narrations with animations,²² specifically, when narrations and animations were presented simultaneously compared with when narrations and animations were presented sequentially. The study looked at sequential formats, including both animations followed by narrations and narrations followed by animations. The research found that using narrations and animations simultaneously allowed students to perform better on assessment tests than neither sequenced version. Interestingly, the students that had sequenced narration and animations showed no difference in problem-solving scores than those who had no instruction at all.

These studies provide additional evidence to support the dual-coding theory and the contiguity effect. The students in the sequential groups scored lower on problem-solving test items. This suggests that they were unable to build connections because of the cognitive overload of working memory. The difficulty may have been so great that some learners scored the same as the control group who received no instruction. This is support for educators to provide material simultaneously when possible so that learning is as effective as possible.

Effective versus Noneffective Narration in Multimedia Learning

Narrations can be used to enhance student learning; however, there may be times when their use is harmful. Leahy et al. studied conditions under which narrations may not be effective or may be detrimental to learning.²⁶ They performed two studies. In the first, one group viewed a diagram with concurrent narration while another group viewed a diagram with text explanation identical to the narration. The diagram was not self-explanatory, so the additional verbal information was required for understanding. The second study used a similar diagram that was modified to be self-explanatory. Neither text nor narrative was required to understand what was occurring in the diagram. These students were split into a diagram-only group and a diagram with narration group.

There was no significant difference in comprehension between the learning outcomes of the diagram-only group and the diagram with narration group. However, when high-complexity vs. low-complexity test items were teased out, the group that received the diagram with concurrent narration scored higher on the complex test items. What is most interesting is the results of the second study comparing the self-contained diagram group and the self-contained diagram with a concurrent narration group. The diagram-

only group demonstrated significantly higher scores, even on the higher-complexity test items.

This study indicates that text information is fine when teaching basic material, but if a deeper comprehension is needed, then a narrative with a diagram may help decrease cognitive load, allowing students to form relationships easier. This is specifically when the visual diagrams are not self-explanatory. When diagrams are self-explanatory, they are more effectively used alone than in conjunction with a narrative. Using a self-explanatory diagram and narrative together may overload working memory unnecessarily and hinder the learning process. This provides evidence of the redundancy effect on working memory and indicates that redundant material should be omitted completely from instruction. Other studies have supported the existence of this effect.^{11,13,18,24,27}

General Discussion

Several important teaching techniques are suggested by the studies discussed in this report. First, students have performed better on outcome tests when visual information is presented concurrently with verbal information. More specifically, if an educator has a choice between a text presentation and a narrative presentation, a narration should be used. This minimizes the load on working memory, so students may process information better. Second, novice learners may benefit most from simultaneous narrations with visuals. This may be because experienced learners are able to generate their own visual representations as they read or listen to material. This internal generation is likely to overload the working memory of a novice learner and hinder the processing of information. It is important when educators begin designing instructional material that they consider who the learners are. Novice learners may need supplemental material, like diagrams, that more experienced learners do not require. Third, while there is evidence that shows the inclusion of narratives within multimedia to be effective, it is dependent on certain conditions.^{16,22,25} Redundancy between visual information and verbal information may impose an excessive load in working memory, causing it to process less effectively. If a diagram alone is able to teach the concept, educators should consider using a diagram only. Using narration or text with the diagram may put a high load on working memory, making the instruction less effective. Research is also needed to more fully examine the role that individual differences play in a multimedia environment. Some areas that could be focused on are novice versus experienced learners, learner attitudes toward multimedia environment, and long-term retention. Most of the studies included in this review only measure short-term retention of information.

Current research provides some answers as to how verbal and visual information should be used in multimedia instruction. This is important to educators because demands for designing instruction via the Internet or CD-

ROM steadily increase. Because the instructor is not physically present in these environments to provide impromptu explanations to student questions, the organization and presentation of material become extremely important. Improved learner outcomes may become more dependent on the students being able to maintain a low enough cognitive load in working memory so that connections between the visual and verbal pathways can be built, helping the student to better learn the information.

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