On the utility of pictorial feedback in computer-based learning environments

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ABSTRACT

Extensive research has added to what is known about the nature of feedback and how to best incorporate it into instruction. Yet, many questions related to learner feedback remain unanswered. One problem of practical importance is the utility of incorporating semantically related pictures into the feedback. Decades of research on feedback have largely focused on the use of verbal feedback in written instruction. This research included two experiments. The first experiment ($n = 63$) addressed the incorporation of pictorial feedback into instruction; the second experiment ($n = 69$) extended this study through the use of a more ecologically valid intervention. Results suggest that the use of pictures in feedback did not influence learning any more than text-only treatments. A discussion and recommendations for future research are provided.

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1. Introduction

In recent years, researchers in educational technology have been criticized for holding a one-directional view of the connection between theory and practice in which basic research questions (theory) precede and gives rise to investigations having an applied focus (practice). The concept of developmental research or "design experiments" offers an exciting and useful alternative, whereby practical instructional interventions are rigorously studied for their usefulness in solving authentic problems (Reeves, 2000). One area of research that has been characteristically a theory-driven research perspective is that of feedback in written instruction.

Feedback is a key component in both behaviorist and cognitive theories of learning that has been reflected in the research questions and methods posed by each (Bangert-Drowns, Kulik, & Kulik, 1991). By contrast, the current research is driven by practical concerns of exploring approaches to the design and implementation of feedback may yield learning improvement, particularly in computer-based learning environments. A practical matter of particular concern in our research was the exploration of alternatives to the verbal responses that have characterized the feedback used in most research studies. The current research examined the effectiveness of accompanying verbal feedback with a semantically

related image. Hypothetically, such a strategy should improve the efficacy of feedback due to the dual coding (linguistic and imaginal) of the feedback. In Paivio's (1986) conception of dual coding, the mental processing of words and images occurs through separate but mutually accessible encoding mechanisms. When, in this manner, linguistic material and semantically related imagery are conjointly retained in memory (such as when a text is accompanied by relevant images), the latter are available to serve as secondary cue for the associated verbal information during recall (Kulhavy, Lee, & Caterino, 1985; Kulhavy & Stock, 1996).

Historically, tests of the conjoint retention hypothesis have (CRH) only studied the impact of dual coding during the *acquisition phase* of learning. Alternatively, the potential benefits of adjunct images during feedback have not been fully explored. Conceivably, the addition of an adjunct picture during feedback should have the same beneficial effect on learning as when it is introduced during the initial study of prose. In both instances, CRH proposes that the adjunct picture serves as a secondary cue for prompting recall of related verbal storage. Moreover, as learners revise their thinking to accommodate the correction provided by verbal feedback, the accompanying image offers information redundancy that is processed through a modally different encoding channel. This theoretically affords a stronger memory trace for the correct material that lessens the chance for proactive interference by the incorrect response.

Numerous studies on the memorial benefits of including a relevant map with a prose passage (Abel & Kulhavy, 1989; Kulhavy, Stock, & Kealy, 1993; Schwartz & Kulhavy, 1981) reveal such

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adjuncts only support recall of text information that is semantically related to specific features on the map, especially when such features are represented mimetically as small pictures (Griffin & Robinson, 2000). For this reason, we expected that presenting a picture during feedback that was previously encountered during the reading of a text paragraph would only improve recall for facts relevant in meaning to the picture. By contrast, supplementing verbal feedback with a picture would not enhance subsequent recall for facts in the paragraph that were semantically unrelated to the image.

Supplementation of traditional verbal feedback with adjunct pictures may also offer a strategy for overcoming the interference of a learner's incorrect prior knowledge with the new correct information. Some research on feedback suggest that providing new information after a brief delay may allow incorrect prior knowledge to have less salience at the time of corrective feedback, a phenomenon referred to as the "delayed retention effect" (DRE). However, from an instructional design perspective, incorporating delayed feedback into instruction may be an inefficient practice. Conceivably, pictorially-supplemented immediate feedback may provide encoding of new material with sufficient strength to supplant incorrect prior knowledge.

The absence of research in the use of pictures in feedback is especially surprising given that the value of including pictures in a text to be learned is well-documented (Carney & Levin, 2002; Levin, Anglin, & Carney, 1987). More than merely duplicating the information in a text, adjunct pictures can provide an alternate route for accessing and understanding the text (Schallert, 1980). Hence, supplementing feedback with an image may assist learners in revising their understanding of what was read. Kulhavy and Stock (1989) presented feedback in written instruction as a three-cycle phenomenon involving (1) eliciting a response to a question on what was read, (2) providing corrective feedback to the learner, and (3) again presenting the question response in the first cycle. In our study we sought to examine the impact of pictures during the first two phases of the feedback cycle as well as during the initial reading of the text to be learned.

An additional area of research interest, reflected in the two studies described herein, is the effectiveness of feedback for constructed responses. Past research on feedback has, by and large, used criterion measures involving performance on multiple choice questions (Morey, 2004). By contrast, our current studies presented participants with prose passages followed by cued recall testing—a task that we believe represents more complex and educationally valid learning compared to recognition of a correct response from a given set of options (i.e., multiple choice).

Our first experiment was undertaken with several hypotheses in mind. First, feedback that was supplemented with pictures would yield more accurate and lengthier constructed responses to recall questions on a subsequent test than feedback that did not have accompanying images. Second, this relatively superior performance would be evident for questions about text information semantically related to the accompanying images but not for ones based on story material that was unrelated to the picture. Third, based on the results of extensive prior research showing the benefits of adjunct pictures on learning (Carney & Levin, 2002), we predicted superior recall performance by those who studied an illustrated story compared to those who viewed text without relevant pictures. Finally, we speculated that higher confidence reported by learners on the correctness of their responses would correspond with increased time examining feedback, particularly when the response was incorrect (Kulhavy, Stock, Hancock, Swindell, & Hammrich, 1990).

2. Experiment 1

2.1. Method

2.1.1. Design and participants

The study involved four experimental groups that varied in how learning material was presented—text with pictures (P) versus text alone (T)—as well as the nature of the feedback provided: text with pictures (P) versus text alone (T). Accordingly, the four groups were designated at PP, PT, TP, and TT. We also explored this effect of this between-subjects variable across test occasion (i.e., story recall immediately after being read compared to performance following feedback) as well as the relative success in recalling story details related to the pictures shown versus material unrelated to these images. Hence, the study was a 4 Group (PP vs. PT vs. TP vs. TT) × 2 Test Occasion (Test 1 vs. Test 2) × 2 Type Recall (text related vs. unrelated to the adjunct picture) factorial design with Group varied between-subjects while Type Recall and Test Occasion served as repeated measures.

Sixty-three undergraduate education majors at a major university in the southeastern U.S. volunteered for the study, receiving extra course credit for their participation. As participants arrived for a research session, they were randomly assigned to computers containing one of four experimental treatments: an illustrated story followed by post-assessment feedback consisting of the pictures and text studied earlier (PP); an illustrated story followed by feedback consisting of text alone (PT); a text-only story followed by feedback consisting of pictures and text (TP); and a text-only story followed just textual feedback (TT). This random assignment resulted in the following participation in each experimental group: PP = 17; PT = 15; TP = 14; and TT = 17.

2.2. Materials

Text. A 631-word fictitious story titled "The Roman Town of Albano" was used in the study, which had a Flesch Reading Ease of 62.3 and a Flesch–Kincaid Grade level of 8.5. The story consisted of two introductory sentences followed by 12 paragraphs, each containing three sentences. In every case, the first sentence provided a rich description of a prominent structure or landmark in the town (hereafter referred to as a *feature*) depicted by a picture that accompanied the text of some participants. The second sentence provided information semantically related to the feature discussed in the first sentence. Finally, a third sentence presented information unrelated to the feature and served as a transition between paragraphs as well as a source of information that was semantically unrelated to the feature. An example of a typical paragraph (feature shown in italics) follows:

> The *cemetery* had chipped, purple rocks sitting in short, square rows. The cemetery was where the trade unions held their initiations, and each new member received a small tattoo of the union symbol on the palm of the hand. Because there were no waterways, the townspeople traveled about the country in four-wheeled horse chariots.

Twenty-four constructed-response questions were created based on the second and third sentences of each paragraph. In this manner, half of the questions were semantically related to the adjunct pictures accompanying the text while the rest were unrelated to these features. For the aforementioned sample paragraph, for instance, we derived the following two questions:

> Feature: What did each new member of the trade union receive upon initiation? (related to the picture of the *cemetery* where the initiations took place)