Clip Art or No Clip Art: A Lesson from Cognitive Science for Social Work Educators

Monte D. Butler
Joanne Yaffe

ABSTRACT. The effect of electronic slides on student learning in the classroom and the impact of adding clip art to these slides were evaluated. One hundred forty-two college students were randomly assigned to one of three groups: a lecture without slide presentations (control), a lecture that used slides containing only text, or a lecture that used slides containing both text and clip-art pictures. Student learning was measured using questions on a scheduled 2-day postinstruction quiz and new questions on a final examination. Knowledge retention was not different for the three groups on the postinstruction quiz, but was lower for both experimental groups at the time of the final examination. Educators are cautioned to evaluate empirically the use of educational innovations.

KEYWORDS. Cognitive science, presentation slides, education and learning

---

Monte D. Butler is affiliated with the Pacific Union College. Joanne Yaffe is affiliated with the University of Utah.

Journal of Technology in Human Services, Vol. 24(2/3) 2006
Available online at http://www.haworthpress.com/web/JTHS

doi:10.1300/J017v24n02_07

Many college instructors believe that the use of electronic slide presentations (e.g., PowerPoint) in the college classroom have a positive effect on student learning (Ahmed, 1998), and that the addition of clip art to slides will serve to improve student learning. These beliefs have led to a growing pressure on social work educators to use slides in the classroom. Unfortunately, empirical studies in education journals do not address these beliefs. The present study evaluated the effect of electronic slide presentations on undergraduate student knowledge acquisition and retention.

A THEORETICAL ADVANTAGE OF CLIP ART ON ELECTRONIC SLIDES

The dual coding theory of cognition, developed by Paivio, Rogers, and Smythe (1968), provides a theoretical explanation of how clip-art-containing slides might improve student learning. This theory argues that there are two systems, nonverbal (imagery) and verbal, that constitute what most people think of as memory (Paivio & Csapo, 1973) rather than the dominant single code theory that maintains that there is only one (verbal) system involved in cognition (te Linde, 1983). In dual coding theory, the imagery system is specialized in the process of storing image codes (a somewhat all-in-one form of storage), while the verbal system is specialized in storing language codes in a linear fashion (somewhat like several letters in a string constructing a word and several words in a string building a sentence).

Central to dual coding theory are two assumptions about the way imagery and verbal codes function in human memory: the imagery and verbal systems can function apart from each other, and that there are also interconnections between memory codes in the two systems. These assumptions lead to several conclusions that help explain the strength of pictures in memory. As illustrated in Figure 1, pictures are more easily remembered because they are encoded both as images and as words. In much the same way, concrete words are more likely to be recalled than abstract words because they are more likely to be encoded both as words and as pictures. Abstract words are only encoded as verbal codes (Paivio & Csapo, 1973).

What dual coding means for students listening to and viewing a slide presentation-based lecture is that clip art is encoded in the visual and the verbal memory systems, whereas slide text and lecture narration are most likely coded only in the verbal memory system (see Figure 2). Clip art is more easily remembered than text or narration because it provides students twice the encoding. Theoretically, interconnections between

FIGURE 1. Dual Coding of a Picture or Graphic, Concrete Word, and Abstract Word

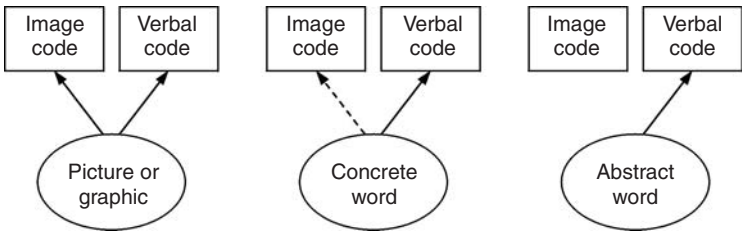
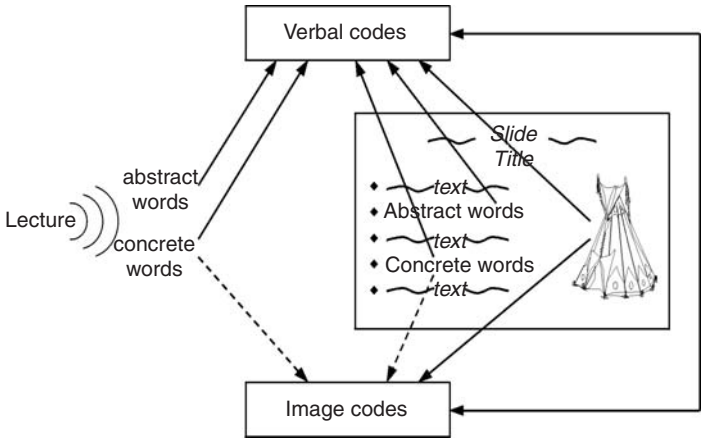


FIGURE 2. Dual Coding of a Lecture and a Text and Clip-Art Slide



the more easily remembered clip-art codes and the text and narration codes can provide alternative pathways to the less easily remembered text and narration codes. As a result, what would not have been remembered is remembered. Put differently, the student has learned what would not have otherwise been learned, and the clip art has served the role of making the text and narration more memorable, rather than playing a purely decorative function (Levin, 1981).

Pictures and Learning from Oral and Written Text

Peeck and Jans (1987) investigated the effect on university student learning of augmenting orally presented stories with pictures. Their

findings were mixed. Participants who listened to a story while viewing story illustrations remembered the portions of the story covered by both narration and pictures better than participants who heard only the narrative. Participants who listened only to the narration remembered portions of the story covered only by the narration equally as well as those who had viewed story illustrations.

Similar results have been found for silently read text. In studies of graduate students, Anglin (1986, 1987) found that prose-relevant pictures increased recall for students tested immediately following exposure as well as for those tested 14, 26, and 55 days following exposure, and that recall of nonpictured details of a story was not negatively impacted by the presence of pictures. Levie and Lentz (1982) reviewed 55 published studies and concluded that when learning illustrated text information is the goal, there is an "overwhelming advantage for the inclusion of pictures" (p. 203), and that as a general rule, the use of illustrations does not affect the learning of nonillustrated text.

In contrast, van Dam and colleagues (1986) found that picture and imagery-evoking words had such a strong effect on the recall of embellished text that they actually interfered with the recall of unembellished text. This finding was surprising, because previous researchers had concluded that pictures would have little or no distractive power for adult learners (Rosinski, Golinkoff, & Kukish, 1975; Samuels, 1967; Willows, 1978).

In the classic study on attention, Samuels (1967) found that kindergarteners with little formal reading instruction were inclined to use pictures instead of words as cues for reading, but that 1st-graders with about 7 months of reading instruction used words and were not distracted by pictures. Like Samuels, Willows (1978) found that younger readers were more susceptible to the distractive influence of pictures, but unlike Samuels, Willows found that pictures could play a distractive role even for readers with several years of formal reading instruction. In addition, Willows concluded that pictures not related to the content of the text were more distracting than pictures that were related. Rosinski and colleagues (1975) concluded that unrelated pictures did distract participants of all age groups from reading presented words, although the impact was not as dramatic for college-age participants as for 2nd- and 6th-grade participants.

These studies on the impact of pictures on learning from oral and written prose are applicable to the use of electronic slide presentations in the college classroom in several ways. Based on the studies just discussed, the addition of clip art to a slide likely will increase learning of

slide content directly related to the clip art but may serve as a distractor to unrelated slide content and decrease overall learning, but it remains unclear if the potential distractive effect of clip art will impact college students. van Dam and colleagues (1986) and Rosinski and colleagues (1975) predicted an ongoing distractive potential even as readers get older, whereas Samuels (1967) and Willows (1978) predicted the disappearance of distractibility as years of reading experience are accumulated.

Computer-Based Instruction and Learning from Computer-Generated Visuals

Empirical studies have not been conducted on the effect the classroom use of slides has on college student learning; however, researchers have studied the use of different types of slides within computer-based instruction for college students. ChanLin (1998) provided college students with text-only slides, slides containing text and custom-still graphics, and slides containing text and custom-animated graphics. He found that slides containing custom-made graphics, both still and animated, enhanced learning of descriptive facts to a greater degree than text-only slides. ChanLin's findings are helpful, but they do not address the use of off-the-disk decorative clip art on student learning in the college classroom. The findings also do not provide information on the possible modifying impact of the lecture (narration) that generally accompanies the use of slides in the classroom.

Mayer and Anderson (1991) found that college students presented with narration concurrent with animated graphics exhibited greater improvement in problem-solving ability than students presented with narration followed by animated graphics or vice versa. Later, Mayer and Anderson (1992) provided additional detail. Students presented with concurrent narration and animated graphics did not demonstrate greater overall retention when compared to students provided animated graphics or narration alone.

ChanLin (1998) found that static and animated graphics enhanced the learning of descriptive facts for computer-based instruction students. Unfortunately, ChanLin's graphics were custom designed to enhance students' learning experiences, which is seldom the case with clip art used in electronic slide presentations. The Mayer and Anderson (1991, 1992) studies, with their addition of computer-generated narration, came close to replicating slide presentations accompanied by professor-delivered lectures. Their findings that the combined effects of

narration and custom animations did not result in higher overall retention scores than narration or animation alone raise doubt about the ability of clip art to improve knowledge retention.

Teacher and Student Reactions to Projected Slides in the Classroom

To date, studies on the use of electronic slides in the college classroom have focused on student and instructor reactions to the technology rather than on measures of their impact on student learning. Beins (1984) found that global ratings of his course increased with the addition of slides but that more focused ratings of himself as the instructor and of the textbook did not reveal a difference between nonslide and slide sections of the course. In addition to the higher global satisfaction rating the slide-based course received, Beins experienced greater ease and effectiveness in delivering lectures and believed that students were more able to follow and understand his lectures.

For his comparative politics course, Jackson (1997) made extensive use of slides containing graphics such as pictures of world leaders, their national flags, and maps of their countries. His undergraduate students expressed satisfaction with the slides, found them helpful in understanding course material, and believed that the slides helped them remember what was presented in class.

Similar to Jackson's (1997) findings, Osberg and Basta (2001) found that most of their students (academic level not specified) believed that the slide-based lectures they presented were more engaging, increased student attention, increased student learning, and helped students memorize class material. Osberg and Basta also found that their teaching was revitalized by the inclusion of slides in their lectures.

When comparing the use of standard overheads with the use of slides that presented the same material, Ahmed (1998) reported the impression that electronic slide presentations had no greater effect on learning than did overhead transparencies. Ahmed contrasted her impressions following her classroom experience with the beliefs of colleagues that slides would improve student learning.

In conclusion, there is evidence that custom-designed graphics can improve the learning of prose when the goal is the recall of information contained in both the text and the picture (Anglin, 1986, 1987; ChanLin, 1998; Levie & Lentz, 1982; Peeck & Jans, 1987; van Dam et al., 1986). If the goal is the learning of all text content (illustrated and nonillustrated), it

appears that learning can be hampered by the inclusion of pictures (Rosinski et al., 1975; van Dam et al., 1986).

Should college-level instructors make greater use of electronic slide presentation technology? Research on the use of slides in the classroom, with and without clip art, is limited to subjective evaluations of student and instructor attitudes. Clip art is the most common type of picture placed on electronic slides (Rieber, 1994), but graphics used in published studies are custom made. One conclusion is clear: Before educators can follow Dwyer's (1978) advice to carefully weigh the pros and cons of including clip art on slides, additional research is needed.

The purpose of the present study was to investigate the impact of adding electronic slide presentations to the college classroom lecture. More specifically, the study attempted to determine how adding text only and text and clip-art slides to a classroom lecture affected student learning and student evaluations of the lecture.

METHOD

The study investigated how adding text-only and text and clip-art slides to a college classroom lecture would affect students. Two questions guided the investigation. How does adding slides (text-only and text and clip art) to a college classroom lecture affect (a) student 2-day postinstruction knowledge retention scores; and (b) student 4-week postinstruction knowledge retention scores?

Participants

The participants were 147 undergraduate students attending a private, 4-year liberal arts college in northern California, recruited from two General Psychology courses to participate in a study of "the impact of the ways professors teach on student learning."

Materials

Lecture Site. A classroom, with the capacity to seat 127 students (the classroom being used for two General Psychology courses), was used as the instructional lecture (IL) site.

Instructional Lectures. Three ILs were prepared for the study in consultation with the two seasoned professors teaching the General Psychology courses. The three lectures were (a) a standard lecture that did

not incorporate slides ("narration only"), (b) a lecture that incorporated the use of slides that contained only text ("narration with text-only slides"), and (c) a lecture that incorporated the use of slides that contained both text and clip-art pictures that were cosmetic in relation to the text in the slides ("narration with text and clip-art slides"). All narration was based on the same script. The two ILs that involved text on slides had identical text (size, color, and placement on the slide). Text plus clip-art slides were identical to text-only slides except for the addition of a clip-art graphic (see Butler, 2003).

A training session was held for the professors to practice the lecture script to ensure consistency of content in the lecture narrative. A laptop computer was used to guide all ILs. ILs in which slides were presented included the use of a ceiling-mounted video projector.

Knowledge Retention Measures. Student learning was measured 2 days following instruction through the use of five multiple choice questions on an in-class quiz and 4 weeks following instruction through the inclusion of five questions relevant to IL content on an in-class examination.

Procedure

Instructional Lecture Groups. Students from two General Psychology classes were invited to participate in the study 2 days prior to the experiment. At this time, each General Psychology student was given a copy of an informed consent form (see Butler, 2003) that was used as a means of informing students about the study and giving them a formal means of volunteering to participate.

A systematic random sampling with a random-start procedure was used to assign participants to one of the three IL groups: (a) narration only, (b) narration with text-only slides, or (c) narration with text and clip-art slides (Babbie, 2001). One class day prior to the experiment, each student was given a sheet of paper listing his or her name and the number of the room he or she was to go to at the beginning of the next class period.

As students from the first General Psychology class ($n = 54$) came to class the day of the experiment, their name was checked against a list of students assigned to each starting-point classroom. When students attempted to enter a room to which they were not assigned, a research assistant directed them to their assigned room.

Participants in the narration with text-only slides group were the first group to receive the IL; thus, they started the experiment in the class-

room normally used for the course and were given their 10-minute IL. Participants in the narration with text and clip-art slides group were seated in their starting-point classroom and were shown a short video on a psychology topic that was tangentially related to the IL. Participants in the narration-only group were seated in their starting-point classroom where they were shown a video on another tangentially related psychology topic.

After the narration with text-only slides group received their IL, the three groups rotated into new classrooms, and the narration-only group received their IL. A final rotation brought the narration with text and clip-art slides group into the IL room for their IL.

On the same day participants from the first General Psychology class received their IL, participants from the second General Psychology class ($n = 93$) received their IL and participated in study procedures that mirrored those of students in the first General Psychology class, with one exception: The order of the ILs was counterbalanced to minimize the effect of order on student-learning outcomes.

Two days later, at the beginning of their next General Psychology class period, participants took a 10-question quiz. Five of the questions measured their retention of material covered by the IL. The other five questions were related to the content of other class lectures. (Quizzes for the two General Psychology courses generally covered several days of content.)

Approximately 4 weeks after ILs were administered, participants took their third General Psychology examination. The last 5 of the 50 questions on the exam were related to the content of the IL and were used as an additional measure of student knowledge retention.

All General Psychology students who participated in the study did so as part of their regular class attendance. Scores on study questions included on 2-day postinstruction quizzes and 4-week postinstruction exams counted toward each student's grade; no extra credit was given. This approach was used to mimic the dynamics of the college classroom, especially students' motivation to put effort into listening to the lectures and correctly answering study-related questions on the quizzes and exams (Gall et al., 1996).

Students who elected not to participate in the study or who were not in class on the day of recruitment ($n = 16$) were required to attend an IL and two video presentations to gain direct access to the class content on which they were to be quizzed and examined. The quiz and exam scores of students who did not participate in the study *did* count toward their

grade in the course, but they were not included in data used for the study.

RESULTS

Demographics of the Three Instructional Lecture Groups

Participants in the three IL groups were statistically similar on all demographic characteristics measured: age ($M = 19$), $F(2, 144) = .905$, $p = .407$; class standings (*mode* = freshman), $\chi^2(2, N = 147) = 1.31$, $p = .518$; percentage of possible examination points prior to the experiment ($M = 77$ percent), $F(2, 144) = .083$, $p = .921$; gender (39 percent male, 61 percent female), $\chi^2(2, N = 147) = .441$, $p = .802$; and high school grade point average ($M = 3.3$), $F(2, 130) = .121$, $p = .886$.

Two-Day Knowledge Retention

Participants were asked to answer five lecture-based questions as part of a 10-point quiz 2 days after receiving their IL. The questions were moderately high in their internal consistency reliability (KR20 = .76) (Ryerson Computing and Communications Services, n.d.; The University of Arizona, n.d.).

A one-way ANOVA was used to evaluate how adding text-only slides and text and clip-art slides to an IL affected student 2-day postinstruction knowledge retention scores (Stevens, 1996). The independent variable of IL had three levels: (a) narration only (control), (b) narration with text-only slides, and (c) narration with text and clip-art slides. The mean 2-day knowledge retention scores for the three IL groups (narration only, 3.60; text slides, 3.70; and clip-art slides, 3.64) were nearly identical, and the ANOVA was not significant, $F(2, 132) = .051$, $p = .951$.

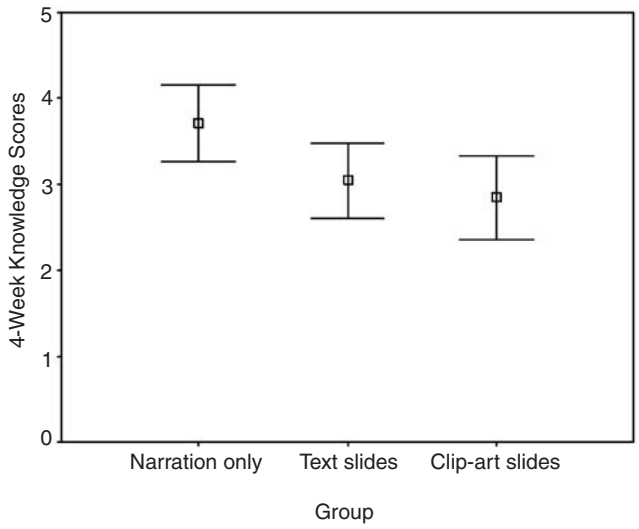
It is possible that differences did exist among the groups in their 2-day knowledge retention but that these differences were hidden by a ceiling effect. In order to avoid a reoccurrence of this problem with 4-week data, 4-week knowledge questions were rewritten with the goal of making them somewhat more difficult to answer correctly.

Four-Week Knowledge Retention

Participants were asked to answer five lecture-based questions as part of their 50-question final exam 4 weeks after receiving their IL. The questions were moderate in their internal consistency reliability (KR20 = .71) (Ryerson Computing and Communications Services, n.d.; The University of Arizona, n.d.).

A one-way ANOVA was used to evaluate how adding text-only and text and clip-art slides to an IL affected student 4-week postinstruction knowledge retention scores (Stevens, 1996). The independent variable of IL had three levels: (a) narration only (control), (b) narration with text-only slides, and (c) narration with text and clip-art slides. The dependent variable was the score of each participant on the five lecture-based questions included in a 4-week postinstruction final exam. Looking at Figure 3, it appears that the mean 4-week knowledge retention score for the narration-only group (3.71) is greater than those of the

FIGURE 3. Differences in four-week knowledge retention scores for narration only, narration with text-only slides, and narration with text and clip-art slides instructional lecture groups. Possible scores range from 0 to 5. Boxes represent the group means. Lines that extend from each box (whiskers) represent the 95% confidence intervals for the group means.



text slides group (3.04) and the clip-art slides group (2.84). It also appears that the means for the latter two groups are similar in size. This visual impression fits with the finding that the ANOVA was significant, $F(2, 139) = 3.702$, $p = .027$. The strength of the relationship between type of IL and scores on 4-week postinstruction questions, as assessed by η^2, was marginally moderate, with IL accounting for 5% of the variance in the student scores.

Because the overall ANOVA was significant, planned pairwise comparisons were used to identify which of the IL groups differed from the others in their effect on student 4-week postinstruction knowledge retention. Fisher's least significant difference method was used to protect against the risk of Type I error (Green et al., 2000).

Three planned independent-samples *t* tests were used to compare groups: (a) narration-only group versus narration with text-only slides group, (b) narration-only group versus narration with text and clip-art slides group, and (c) narration with text-only slides group versus narration with text and clip-art slides group (Munro, 2001).

As mentioned above, it appears in Figure 3 that the mean score for the narration-only group is greater than that of the text slides and the clip-art-slides groups, while the means of the latter two groups appear to be similar in magnitude. This visual impression is reflected in the finding that the mean retention score of students in the narration-only group of 3.71 was significantly higher than the mean score of 3.04 for students in the narration with text-only slides group, $t(89) = 2.15$, $p = .035$, and significantly higher than the mean score of 2.84 for students in the narration with text and clip-art slides group, $t(91) = 2.64$, $p = .01$. These results were surprising, not only because they ran counter to intuitive speculation but also because they were statistically significant in spite of the ceiling effect experienced by the narration-only group. The narration with text-only slides and narration with text and clip-art slides groups were not statistically different from each other, $t(98) = .60$, $p = .551$.

CONCLUSIONS

Adding a text-based electronic slide presentation with and without clip art to a college classroom lecture had no effect on student 2-day postinstruction knowledge retention, but negatively affected their 4-week postinstruction knowledge retention. Participants in the two slide-

based lecture groups were not different with respect to knowledge retention.

So it seems that when the primary goal of instruction is knowledge transfer, the use of slides and the addition of clip art to these slides can be detrimental. The most plausible explanation of this effect is that students are paying *too much* attention to the slide text, clip-art pictures, or other slide features such as color and layout (Rosinski et al., 1975). As a result, the capacity students have for encoding information contained in the lecture narration is used instead for encoding the clip-art material that is decorative rather than instructional. Without adequate encoding of the narration, any potential for dual coding (the encoding and linking of image and verbal codes) is severely limited, leaving the damage caused by reduced encoding of the narration without the potential compensatory power of interconnected dual codes.

It is also possible that students listening to a narration-only lecture while taking notes might create more interconnections among encoded bits of information. Students taking notes during slide-based lectures look back and forth between the slides and their notes. These students appear to be reading a few words of text, looking down at their notes, writing these words down, and then repeating the process. This "head-bobbing" approach to taking notes may result in students encoding slide text as isolated bits of information rather than as integrated ideas or concepts. The encoding of isolated bits of information could result in reduced understanding and recall of information contained on the slides and could also hinder attention to the narrated portion of the lecture. In contrast, students who take notes during narration-only lectures tend to keep their eyes on their notes while listening to the lecture. This process may allow students to write down and encode entire ideas and concepts and could lead to greater interconnectedness of encoded information. If this is the case, narration-only students will have an easier time accessing any given piece of information because that information can be accessed from many other reference points.

A limitation of the present study was that the lecture used for the study was only 10 minutes in length due to the time needed to cycle the three IL groups through the IL classroom in a single 50-minute class period. Although it appears that students gained knowledge from the lecture, in spite of its brevity, the effects of the three different lecture formats may have been different if a standard 50-minute lecture, or multiple 50-minute lectures, over the course of an entire term had been used.

College-level instructors need to reduce their dependence on intuition and to increase their reliance on empirical evaluation of new teach-

ing technologies. Intuition is an important ingredient in the selection of teaching strategies, but dependence on intuition alone is not adequate. The results of this study highlight the vulnerability of intuition-based decisions to distortion. The results also highlight how important it is for educators to be familiar with and to generate the empirical knowledge necessary for evaluating the efficacy of new teaching technologies.

It is also important for instructors to remember that the education bandwagon is not always headed in the right direction. New is not necessarily better, even if it looks better. Educators should feel free and be willing to question new teaching technologies as well as to place their support behind the evaluation of such technologies. As new teaching technologies are developed, marketed, and touted as the next best teaching tool, educators must put their research and assessment skills to use. Slides seem like a valuable teaching innovation. This intuition-based conclusion appears so obvious that the use of slides in the classroom has exploded without a single empirical study to test their pedagogical value. The duty of educators is to put new, and even old, teaching technologies to the test. Newer *can* be better, but novelty does not equal efficacy. Instructors must be able and willing to discover the difference.

The findings of the present study support the argument that the use of electronic slide presentations, with and without clip art, reduces student knowledge retention. If some educators believe that this disadvantage can be overcome through activities such as distributing hard copies of slides in advance of lectures or posting slides on the Web for student viewing, the onus is on them to show evidence of the realization of this potential. At this point in time, such evidence does not exist. The only assumption that can be made at this time is that electronic slide presentations, with and without clip art, *reduce* student learning.

REFERENCES

Ahmed, C. (1998, November). *PowerPoint versus traditional overheads: Which is more effective for learning?* Paper presented at the meeting of the conference of the South Dakota Association for Health, Physical Education and Recreation, Sioux Falls, SD.

Anglin, G. J. (1986). Prose-relevant pictures and older learners' recall of written prose. *Educational Communication and Technology Journal*, *34*(3), 131-136.

Anglin, G. J. (1987). Effect of pictures on recall of written prose: How durable are picture effects? *Educational Communication and Technology Journal*, *35*(1), 25-30.

Babbie, E. (2001). *The practice of social research.* Belmont, CA: Wadsworth/ Thomson Learning.

Beins, B. (1984). The use of slides in psychology classes: Do they help or are they an invitation to sleep? *Teaching Psychology*, *11*, 229-230.

Butler, M. (2003). Clip art or no clip art: A lesson from cognitive science for social work educators (Doctoral dissertation, University of Utah, 2003). *Dissertation Abstracts International*, *64*, 286.

ChanLin, L. J. (1998). Animation to teach students of different knowledge levels. *Journal of Instructional Psychology*, *25*, 166-175.

Dwyer, F. M. (1978). *Strategies for improving visual instruction: A handbook for the effective selection, design, and use of visualized materials*. State College, PA: Learning Services.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th ed.). White Plains, NY: Longman Publishers.

Green, S. B., Salkind, N. J., & Akey, T. M. (2000). *Using SPSS for Windows: Analyzing and understanding data* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Jackson, S. F. (1997, January). *Classroom use of PowerPoint*. Paper presented at the meeting of the Indiana University of Pennsylvania Technology Town Meeting, Indiana, PA.

Levie, W. H., & Lentz, R. (1982). Effects of text illustrations: A review of research. *Educational Communication and Technology Journal*, *30*(4), 195-232.

Levin, J. R. (1981). On functions of pictures in prose. In F. J. Pirozzolo & M. C. Wittrock (Eds.), *Neuropsychological and cognitive processes in reading* (pp. 203-228). New York: Academic Press.

Mayer, R. E., & Anderson, R. B. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, *83*, 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*, 444-452.

Munro, B. H. (2001). *Statistical methods for health care research* (4th ed.). New York: Lippincott.

Osberg, T. M., & Basta, J. C. (2001, August). *Implementing PowerPoint in the classroom: Advantages, obstacles, and student reactions*. Paper presented at the meeting of the American Psychological Association, San Francisco.

Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology*, *5*, 176-206.

Paivio, A., Rogers, T. B., & Smythe, P. C. (1968). Why are pictures easier to recall than words? *Psychonomic Science*, *11*, 137-138.

Peeck, J., & Jans, M. W. (1987). Delayed retention of orally presented text with pictorial support. *British Journal of Educational Psychology*, *57*(3), 412-416.

Rieber, L. P. (1994). *Computers, graphics, and learning*. Madison, WI: WCB Brown & Benchmark.

Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. (1975). Automatic semantic processing in a picture-word interference task. *Child Development*, *46*(1), 247-253.

Ryerson Computing and Communications Services. (n.d.). *Part 2: Exam analysis*. Retrieved October 15, 2002, from http://www.ccs.ryerson.ca/fac_staff/index.cfm?cblockID=235.

Samuels, S. J. (1967). Attentional process in reading: The effect of pictures on the acquisition of reading responses. *Journal of Educational Psychology*, *58*, 337-342.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

te Linde, J. (1983). Pictures and words in semantic decisions. In J. C. Yuille (Ed.), *Imagery, memory and cognition: Essays in honor of Allen Paivio* (pp. 117-129). Hillsdale, NJ: Lawrence Erlbaum Associates.

(The) University of Arizona. (n.d.). *Kuder-Richardson formula 20*, *KR20*. Retrieved October 15, 2002, from http://www.u.arizona.edu/ic/forms/Help/kr20_h.htm.

van Dam, G., Brinkerink-Carlier, M., & Kok, I. (1986). Influence of visual and verbal embellishment on free recall of the paragraphs of a text. *American Journal of Psychology*, *99*(1), 103-110.

Willows, D. M. (1978). A picture is not always worth a thousand words: Pictures as distractors in reading. *Journal of Educational Psychology*, *70*, 255-262.