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Individual Study, Interactive Multimedia, or Cooperative Learning: Which Activity Best Supplements Lecture-Based Distance Education?

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Distance education is the "fastest growing form of domestic and international education" (M. S. McIsaac & C. N. Gunawardena, 1996, p. 403). Unfortunately, research investigating effective use of distance education has not kept pace with implementation. In this study, the authors evaluated how lecture-based distance education could best be supplemented with various learning activities. Undergraduate volunteers participated in 1 of 3 post–distance-education lecture activities: individual study, cooperative learning, or interactive multimedia. Then they were tested on knowledge of lecture material and were asked how much they enjoyed the distance education experience. Results indicated that although the interactive multimedia group enjoyed the learning activity more than the cooperative learning and individual study groups, the cooperative learning group learned the most.

Higher education was once restricted to only a few locations (classrooms) and times (class periods). With increasing numbers of adult learners and the need for more affordable education choices (Wilson & Mosher, 1994), demands for educational opportunities have called for the creation of more convenient times and locations. One educational approach that has emerged to meet these needs is distance education, where the teacher and students are separated physically but are joined by a technologically based system that allows communication and education to occur (Ham, 1995). The present study investigates how distance education may be effectively enhanced with post-lecture learning activities.

"Distance education, structured learning in which the student and instructor are separated by time and place, is currently the fastest growing form of domestic and international education" (McIsaac & Gunawardena, 1996, p. 403). Distance education has encompassed everything from correspondence courses to instructional audio or video tapes, or both, to cable television to telecommunications to compressed video and audio systems (Froke, 1994; Gibson & Gibson, 1995). In simple terms, *distance education* is defined as "an organizational and technological framework for providing instruction at a distance. . . . When the teacher and student(s) are separated by geography, technology is used to bridge the gap" (Ham, 1995, p. 43). Recently, the generally accepted technology used to bridge the gap is video-based interactive instruction.

Traditional classroom educators who have not been trained in distance learning are often asked to teach distance education classes at their respective institutions. Most of them approach the task in much the same way as they would a traditional classroom situation. Although traditional techniques (lecture, chalkboard diagrams, slides, photographs, charts, and handouts) have their place in instruction, distance education introduces new challenges and several issues that may affect instruction such as determining appropriate clothing for video transmission to minimize distractions, developing more support materials and distributing them in a timely manner, ensuring test security, using available telecommunication technologies such as electronic mail and faxes during the instructional session, promoting student–teacher interaction using unfamiliar technology, and resolving technological emergencies at home and remote sites (Brodie, Bronson, Coble, & Gray, 1994; Gibson & Gibson, 1995; Office of Technology Assessment, 1989).

After teaching for 2 years in a video conferencing environment, Lawrence (1995) noted some differences between traditional classroom teaching and teaching at a distance. First, there is visual contact but only with one site at a time. Simultaneous visual contact with all participants does not exist. Second, the video conferencing environment discourages the expansiveness and spontaneity allowed by the proverbial blackboard approach. As a result, visuals and graphics have to be prepared in advance. Because of these differences, Lawrence recommended that teaching in the video conferencing environment be modified at the very least.

Instead of focusing on what can be done to enhance the distance education lecture, in the present study we explored ways in which the amount of learning and students' satisfaction with the overall distance education experience could be facilitated by using postlecture learning activities. McIsaac and Gunawardena (1996), in commenting on the current state of research on distance education, argued:

> It is time . . . to examine factors such as instructional design, learning and instructional theory, and theoretical frameworks in distance education, which when applied to learning, might account for significant differences in levels of performance. The questions that need to be asked are . . . how best to incorporate media attributes into the design of effective instruction for learning. (p. 421)

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Dede (1989) has similarly suggested that investigating the utility of learning activities combined with lecture-based distance education is essential. We chose two postlecture learning activities: (a) interactive multimedia, which involves incorporating media attributes (e.g., Karraker, 1992), and (b) cooperative learning, which has received the strongest support from the research literature (e.g., Johnson & Johnson, 1996).

Interactive Multimedia

With the advent of computer-based interactive multimedia, education has become more exciting for students of all ages. Dramatic reading improvements, drastic reductions in absenteeism and dropout rates, and an impressive improvement of analytical reasoning skills were all attributed to involvement in interactive multimedia learning introduced into school systems in California, Florida, and Ohio (Karraker, 1992).

Because of the many stages of development that interactive multimedia has gone through in the last several years, it is important to know what is meant by the loosely used term. *Interactive multimedia* is digitally integrated, organized information that includes text, graphics, and still images such as photographs, animation, audio, and motion video in a user-friendly interface on the computer. It allows the user to navigate at will to find and view information (Dyrli & Kinnaman, 1995; Galbreath, 1994). It increases both the quality and quantity of information that can be exchanged between the computer and the user (D. I. Barker, 1994).

The benefits of multimedia instruction for both education and business include interactivity through its user interface and flexibility of obtaining instruction in reference to scheduling, self-pacing, retention, availability, and type of learning environment (Chen, 1994). However, multimedia does have its limitations. A huge amount of computer memory storage is required for digital video—as much as 22.5 megabytes of storage for 1 s of video. In addition, video needs to be compressed and decompressed in order for the computer to process the motion along with graphics and text. Often, unless there is a hardware solution, computer processing slows down, which results in unacceptable video motion or speed of animation (Chen, 1994). In higher education, interactive multimedia software development is difficult because, in many instances, educators, scholars, and publishers who know the course content cannot program the software. Likewise, many programmers are often poorly versed in educational theory or methods (Kalmbach, 1994).

Regardless of its advantages or disadvantages, multimedia in education is having a definite impact on the way students learn (Chen, 1994). At both the elementary (T. A. Barker & Torgesen, 1995; Foster, Erickson, Foster, Brinkman, & Torgesen, 1994) and college levels (Liu & Reed, 1995; Miketta & Ludford, 1995), instruction in a multimedia format has been found to be advantageous to traditional instruction.

Cooperative Learning

Johnson and Johnson (1996) described cooperative learning as involving the use of small groups in instructional environments where students work together to maximize their own and each others' learning. There are four types of cooperative learning: formal, informal, base groups, and academic controversy. Formal cooperative learning involves students working together from one class period to several weeks, whereas informal cooperative learning involves students working in temporary, ad hoc groups that last from a few minutes to one class period. Cooperative base groups combine students of mixed abilities for at least 1 year to provide support for cognitive and social progress. Finally, academic controversy groups are formed when students disagree on an issue. Two students in the group are assigned the "pro" position and two are assigned the "con" position. Students discuss, reverse perspectives, and then meet to resolve the controversy. In the present study, we used informal cooperative learning because of the temporary nature of the experimental conditions.

In theory and practice, cooperative learning differs considerably from traditional classroom instruction (Sharan & Sharan, 1987). According to Johnson and Johnson (1996), the discipline of using cooperative groups involves positive interdependence, individual accountability, face-to-face promotive interaction, teaching members interpersonal and small-group skills, and structuring group processing. There is substantial evidence that students working cooperatively in small groups can master teacher-presented information better than students working on their own (Slavin, 1987). Students who participate in cooperative learning have outperformed students in traditional classrooms at the elementary (Stevens & Slavin, 1995), secondary (Nichols & Miller, 1994), and college levels (Franklin, Griffin, & Perry, 1994). In addition to increasing learning, cooperative learning has been shown to increase students' social skills (Stevens & Slavin, 1995) and perceptions of ability and valuing of content (Nichols & Miller, 1994) and to reduce students' anxiety (Keeler & Anson, 1995).

Given the increasing popularity of distance education combined with the lack of empirical research on its effective use, in the present study we investigated whether students would benefit from participating in either cooperative learning or interactive multimedia activities after a distance education lecture. The procedures we used for both the cooperative learning and interactive multimedia groups were based on what we believe usually happens in higher education classrooms. We simply wanted to see if either of these two learning activities would facilitate learning and lead to more satisfaction than typical individual study. We gave students in the individual study condition the same fact sheet as that given to the cooperative learning group. This sheet contained the same information that was presented in the interactive multimedia module to ensure that any differences could not be attributed to access to material. By doing this, we hoped to avoid the pitfalls associated with some experimental learning studies that use "sit-in-the-closet-and-do-nothing" control conditions (Levin, 1994).

Method

Design and Participants

One hundred fifteen undergraduates enrolled in five classes offered in the Department of Health, Physical Education, Recreation, and Sport at Mississippi State University in the Deep South in the fall semester of 1996 participated in the study for course credit. The five classes were PE1223: Personal Health; PE1313: Introduction to Physical Education; PE1783: Introduction to Athletic Training; PE3283: Athletic Training Practicum I; and PE4233: Biomechanics. Although these were intact classes, students in each class volunteered and were randomly assigned to one of the following groups: individual study group, cooperative learning group, or interactive multimedia group. There were 42 female and 73 male participants who ranged from 18 to 36 years of age. The ethnic composition of the sample was as follows: 23 African Americans, 90 Caucasians, 1 Native American, and 1 other (Brazilian). Classifications of the participants were as follows: 11 freshmen, 20 sophomores, 48 juniors, 35 seniors, and 1 graduate student. Ninety-one students had previous experience with cooperative learning, 23 students had previous experience with interactive multimedia, and only 4 students had previous experience with distance education—all at the high school level. Only 3 participants indicated no previous computer experience.

Materials

Several instructional materials were used in the study. There were assignment cards, a three-page fact sheet, a four-page worksheet, a four-page answer sheet, and an interactive multimedia learning module. The assignment cards were 3 in. × 5 in. (7.62 cm × 12.7 cm) notecards containing information concerning classroom (group) assignment. One third of the cards (for the cooperative learning group) also contained a number indicating the group in which each student would participate and the name of a role assigned to each group member—task master, researcher, checker, or recorder.

Students in the individual study and cooperative learning groups received a three-page fact sheet. It paraphrased the information covered in the distance education lecture. Students in the cooperative learning group also received a four-page worksheet that contained 31 questions. Most of these involved providing a short answer, making a list, or labeling a diagram. In addition to the worksheet, the checkers in each of the five cooperative learning groups received an answer sheet. The answer sheet was a correctly completed worksheet.

Students in the interactive multimedia group navigated through a computer-based multimedia module entitled "Heart Disease—Are You Willing To Take the Risk?" To ensure that the three experimental groups would not differ in terms of their access to information, the interactive module contained the same information as the three-page fact sheet. It was developed by the first author who had 5 years of experience in developing educational interactive multimedia modules. The module was developed in HyperCard 2.3 and was reviewed by three instructors who had previously taught hypermedia classes. It was organized into eight sections: basic functions of the heart, smoking, hypertension, cholesterol, stress, heredity, exercise, and multiple risk factors.

The module contained 57 color images (scanned or created), one color chart, 17 introductory or explanatory Quick Time movies containing computer-based audio and digital video (created with Adobe Premiere) or custom animations with audio (created with Macromedia Director), two specific requests for information interaction by the participants, at least six navigational buttons on each card with up to two additional menu buttons on other cards, and an interactive practice exam with immediate auditory and visual feedback. The practice exam contained the same information as the worksheet given to the cooperative learning group.

Instruments

The instruments were a prequestionnaire, a postquestionnaire, a pretest, and a posttest. The tests were developed under the guidance of the instructors whose classes were involved in the study. The prequestionnaire provided demographic information such as classification, sex, age, and students' previous experience with distance education, cooperative learning, interactive multimedia, and computers. On the postquestionnaire, students were asked to rate their level of satisfaction for the overall session (combination of the distance education lecture and the postlecture activity). A 0 indicated *very dissatisfied* and 5 indicated *very satisfied.* The pretest contained 25 multiple-choice items, each with three alternatives. Students were instructed to circle the correct answer. The posttest had the same questions as the pretest, except that the questions were in a different, randomized order. The posttest had a Kuder-Richardson reliability of .66.

Procedure

A preliminary meeting with the teachers of the five classes was held in May 1996 to discuss the participation of the students in the study, the content of the distance education session, and procedures for incorporating this activity into their courses. Three weeks after classes began for the fall semester, students were informed of the study and asked to provide informed consent to participate. They were given the prequestionnaire and pretest. All of this occurred during the students' scheduled class time. Students chose to participate during one of the times indicated—6:00 to 8:00 p.m. on either a Tuesday or Wednesday night 2 weeks later.

On the chosen night, students were seated in an electronic classroom. The distance lecture was transmitted from an electronic conference room located in an adjacent building and lasted approximately 25 min. This emulated a true distance education learning situation in that there was a remote site where the students were located and a transmission site where the instructor was located. Interaction was allowed at any time during the lecture. Students could push a button to activate a microphone to ask or answer questions. No interaction occurred the first night, and only two attempts to answer a question occurred the second night. The attempts consisted of one-word answers. The first response was correct, and the second response was incorrect. Both responses were made by the same student.

Before the lecture, assignment cards were randomly shuffled by the researcher and distributed to students after the lecture. Six facilitators (two for each of the three treatment groups) directed students and answered any questions that arose. The facilitators for each of the three groups accompanied their respective groups to the assigned classrooms. On arrival at the designated classrooms, the facilitators gave the students a 5-min break. After returning to the assigned classrooms, students were given 5 min of instructions on the procedures to follow. The facilitators were instructed not to teach any of the material that was covered in the lecture but only to assist the students with procedural questions. After the lead facilitator read typed instructions to the group, students were given 35 min to perform their particular learning activity and were then administered the postquestionnaire for 10 min, followed by the posttest for 20 min. Students and classroom teachers were debriefed on the purpose and findings of the study 2 weeks after the data were collected during their regular class periods.

Students in the individual learning condition studied the fact sheet and any notes that they may have taken during the lecture. Students in the cooperative learning condition used an informal cooperative learning procedure as outlined by Johnson and Johnson (1994). Students followed the guidelines of working cooperatively to achieve a joint learning goal in temporary ad hoc groups that lasted for a short period of time. Although it was difficult to determine whether the students accepted a mood conducive to learning or that they focused on the material to be learned, the worksheets were required to be completed by each student and turned in as a group. Students also received a fact sheet and could use any of their notes that they took during the lecture. Also, although the students did not help to set expectations for the class session, they did have to interpret the expectations required by the facilitators and fulfill those expectations. Students were responsible for ensuring that others in their group learned and understood the material taught. This was accomplished by each student being assigned a certain role in his or her group. The roles were read to the students by the lead facilitator as explained later in this section. The checker in the group was given an answer sheet. Finally, students provided closure to an instructional session by completing and turning in the postquestionnaire and posttest.

After the lead facilitator read the instructions, students assembled into the groups that were designated on the assignment cards. There were five groups with four students per group. Each of the four group members was assigned a role with the instructions given by the facilitator and repeated in writing on the back side of the assignment card. The four roles were as follows. The task master was instructed to focus the group's efforts on answering the questions on the worksheet. The researcher was instructed to find the answer to any question in the fact sheet if it could not be found either in students' notes or their copies of the fact sheet. The checker was instructed to check the accuracy of the group's answers using the answer sheet, and the recorder was instructed to make sure group members wrote the correct answer on their worksheets.

Students in the interactive multimedia condition assembled in a classroom equipped with Macintosh computers. The interactive multimedia module program was active on each computer and the two facilitators were prepared to help with any technical problems (fortunately, none occurred). Students accessed information in the module in any order that they desired. If students wanted to first know about stress, they accessed the stress section of the module rather than smoking, which was the first risk factor covered in the module, the lecture, and the fact sheet.

Results

We had originally planned to conduct a one-way analysis of covariance using the pretest as the covariate and the posttest as the dependent measure. However, the assumption of homogeneity of regression slopes was not supported. As recommended by Hinkle, Wiersma, and Jurs (1994), we conducted a factorial analysis of variance (ANOVA) using learning activity (individual study vs. cooperative learning vs. interactive multimedia) and pretest score (low vs. high scores as determined by scores below and above the median score) as between-subjects factors. If no interaction was found, we could then focus on the main effect of the learning activity. A one-way ANOVA was used to compare the satisfaction levels of the three groups. Fisher's least significant difference test was used as the follow-up test for each measure. For ease of interpretation, raw scores have been converted to percentage correct scores on the pretest and posttest.

Table 1 displays the means and standard deviations for each of the groups on the posttest. The results of a one-way ANOVA conducted on the pretest scores indicated no differences among the individual study ($M = 43.04$, $SD = 11.94$), cooperative learning ($M = 41.74$, $SD = 13.07$), and interactive multimedia groups ($M = 40.62$, $SD = 11.30$), $F(2, 112) = 0.38$, $MSE = 147.07$, $p = .69$. Using the posttest scores as the dependent variable, the main effect of previous knowledge (pretest score) was significant, $F(1, 109) = 20.59$, $MSE = 113.36$, $p < .001$. Not surprisingly, students who scored above the pretest median scored higher on the posttest than those who scored below the pretest median. Most importantly, the main effect of learning activity was significant, $F(2, 109) = 3.58$, $p < .05$. Tukey's honestly significant difference test was used to follow up this effect. The cooperative learning group ($M = 86.56$, $SD = 8.83$) scored higher than both the individual learning group ($M = 80.00$, $SD = 12.11$) and the interactive multimedia group ($M = 81.23$, $SD = 13.18$). The interaction effect of previous knowledge by learning activity was not significant, $F(2, 109) = 0.75$, $p = .47$.

Table 2 displays the means and standard deviations for groups on the satisfaction measure. There was a significant effect of learning activity for the overall session, $F(2, 112) = 7.07$, $MSE = .83$, $p < .01$. Students in the interactive multimedia group were more satisfied with the overall learning experience than the other two groups.

Discussion

The results of the present study suggest that as a postlecture activity, informal cooperative learning is better than both individual study and interactive multimedia when the goal is comprehension. However, if students' satisfaction with the learning experience is important, then interactive multimedia is better than both cooperative learning and individual study. Thus, each learning activity was better than individual study for one goal but not for both.

The failure of the interactive multimedia group to learn more than the individual study group may have been due to two things. First, most of the students had never used interactive multimedia before (including 31 of the 39 interactive multimedia students). Had they been provided

Table 1
Posttest Scores of the Three Learning Groups

Pretest score	Individual learning group	Cooperative learning group	Interactive multimedia group
Low			
M	74.60	83.58	76.60
SD	12.26	10.15	12.12
n	20	19	20
High			
M	86.35	89.40	86.11
SD	8.49	6.39	12.75
n	17	20	19

Table 2
Satisfaction Scores for the Overall Learning Experience

Statistic	Individual learning group	Cooperative learning group	Interactive multimedia group
M	3.38	3.56	4.13
SD	1.01	0.91	0.80
n	37	39	39

with extensive training, they may have performed better on the posttest. Second, the multimedia group members had only the information available to the other groups and were free to navigate through that information in any way they wanted. Several researchers have recommended that use of interactive multimedia should involve posing a problem to provide the learner with a focus rather than permitting unfocused navigational wandering (Anderson-Inman, Horney, Chen, & Lewin, 1994; Kinzie, 1990; Land & Hannifin, 1996; Misanchuk & Schwier, 1992). Recent research with intelligent tutoring systems (e.g., Corbett & Anderson, 1991; Shute & Regian, 1993) has shown that the reason these systems are highly effective for learning is that they can guide the presentation of information in a meaningful way. Instruction is provided based on a model of the student's performance and estimation of concept mastery. Perhaps our interactive multimedia module was a bit crude compared to other state of the art systems. As these other systems become more widely available, future research may indeed show that multimedia is an effective supplement to the kind of distance learning that was used in this study.

Although navigational freedom may have led to decreased learning as a result of unfocused wandering, it may also have contributed to the increased satisfaction of the interactive multimedia group. Learner control is an important feature of interactive multimedia, and this control may provide students with a liberated feeling that is not experienced when reading study notes or participating in cooperative learning. This trade-off in learning and satisfaction based on the degree of learner control is also an issue that deserves further investigation.

In reality, our study may have simply reflected the type of results educators may experience given what is currently being done with distance education, interactive multimedia, cooperative learning, and individual study. We need to stress, however, that our interactive multimedia condition did not reflect "best practice" as did the cooperative learning condition. If we would have given students in the interactive multimedia group the worksheet and the answer sheet, they would likely have performed better. The key question here, though, is what effect would that have had on their level of satisfaction with the distance education experience?

Also, our distance learning experience may not have best reflected what is currently being done because of its "one-shot" nature. Students basically did not interact with the instructor (only two responses from the same student). Perhaps as students become more accustomed to distance education environments, they will be more willing to interact with instructors.

We believe that the present study may offer some considerations for distance education instructors. First, student learning may be enhanced through the use of postlecture cooperative learning activities. Although interactive multimedia may increase students' satisfaction with the entire learning experience, instructors who are considering using multimedia as a postlecture activity should provide more structure and more training for students in how to effectively use interactive multimedia. Of course, more research is needed on this issue before formal recommendations can be made.

Both cooperative learning and interactive multimedia require additional resources for distance education instructors. There must be facilitators at remote sites for the cooperative learning groups. Worksheets and answer sheets must also be constructed. For interactive multimedia, there must be computers with lab monitors along with the created modules. Both learning activities require considerably more resources and work than individual study. Perhaps the best way to make efficient use of limited resources would be to use cooperative learning combined with interactive multimedia, as suggested by Johnson and Johnson (1996). Future researchers should examine the combined effect of cooperative learning and interactive multimedia to create a potentially more effective and enjoyable distance learning experience.

References

Anderson-Inman, L., Horney, M. A., Chen, D. T., & Lewin, L. (1994). Hypertext literacy: Observations from the ElectroText project. *Language Arts, 71,* 279–287.

Barker, D. I. (1994). A technological revolution in higher education. *Journal of Educational Technology Systems, 23,* 155–168.

Barker, T. A., & Torgesen, J. K. (1995). An evaluation of computer-assisted instruction in phonological awareness with below average readers. *Journal of Educational Computing Research, 13,* 89–103.

Brodie, K., Bronson, J., Coble, J., & Gray, D. (1994, Fall). *Distance learning interactive classroom faculty guide.* A document for the Office of Continuing Education and Learning Resource Center, Chesapeake College, Wye Mills, Maryland. Available World Wide Web URL: http://www.chesapeake.edu/Dislearn/facguide.html.

Chen, L. (1994). Digital multimedia instruction: Past, present, and future. *Journal of Educational Technology Systems, 23,* 169–175.

Corbett, A. T., & Anderson, J. R. (1991, April). *Feedback control and learning to program with the CMU Lisp Tutor.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Dede, C. (1989, July). The evolution of distance learning: Technology-mediated interactive learning. *Technologies for learning at a distance* (Science, Education, and Transportation Program for the Office of Technology Assessment). Washington, DC: Congress of the United States.

Dyrli, O. E., & Kinnaman, D. E. (1995). Part 4: Moving ahead educationally with multimedia. *Technology & Learning, 15*(7), 46–51.

Foster, K. C., Erickson, G. C., Foster, D. F., Brinkman, D., &

Torgesen, J. K. (1994). Computer administered instruction in phonological awareness: Evaluation of the DaisyQuest program. *Journal of Research and Development in Education, 27,* 126–137.

Franklin, G., Griffin, R., & Perry, N. (1994). Effects of cooperative tutoring on academic performance. *Journal of Educational Technology Systems, 23,* 13–25.

Froke, M. (1994). A vision and promise: Distance education at Penn State part 1—toward an experienced-based definition. *Journal of Continuing Higher Education, 42(2),* 16–22.

Galbreath, J. (1994). Multimedia in education: Because it's there? *TechTrends, 39 (6),* 17–20.

Gibson, C., & Gibson, L. (1995). Lessons learned from 100+ years of distance learning. *Adult Learning, 7,* 15.

Ham, R. (1995, March). Distance education: Teaching tools for the 21st century. *The Technology Teacher,* pp. 43, 45.

Hinkle, D. E., Wiersma, W., & Jurs, S. G. (1994). *Applied statistics for the behavioral sciences* (3rd ed.). Boston: Houghton Mifflin Company.

Johnson, D. W., & Johnson, R. T. (1994). *Learning together and alone* (4th ed.). Boston: Allyn and Bacon.

Johnson, D. W., & Johnson, R. T. (1996). Cooperation and the use of technology. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 1017–1044). New York: Macmillan.

Kalmbach, J. A. (1994). Just in time for the 21st century: Multimedia in the classroom. *TechTrends, 39(6),* 29–32.

Karraker, R. (1992). Crisis in American education: Can multimedia save the day? *New Media, 2*(1), 23–27.

Keeler, C. M., & Anson, R. (1995). An assessment of cooperative learning used for basic computer skills instruction in the college classroom. *Journal of Educational Computing Research, 12,* 379–393.

Kinzie, M. B. (1990). Requirements and benefits of effective interactive instruction: Learner control, self-regulation, and continuing motivation. *Educational Technology, Research and Development, 38,* 5–21.

Land, S. M., & Hannifin, M. J. (1996). A conceptual framework for the development of theories-in-action with open-ended learning environments. *Educational Technology Research and Development, 44,* 37–53.

Lawrence, B. H. (1995). Teaching and learning via videoconference: The benefits of cooperative learning. *Journal of Educational Technology Systems, 24,* 145–149.

Levin, J. R. (1994). Crafting educational research that's both credible and creditable. *Educational Psychology Review, 6,* 231–243.

Liu, M., & Reed, W. M. (1995). The effect of hypermedia assisted instruction on second language learning. *Journal of Educational Computing Research, 12,* 159–175.

McIsaac, M. S., & Gunawardena, C. N. (1996). Distance education. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 403–437). New York: Macmillan.

Miketta, J. B., & Ludford, D. (1995). Teaching with multimedia in the community college classroom. *T.H.E. Journal, 23,* 61–64.

Misanchuk, R. R., & Schwier, R. A. (1992). Representing interactive multimedia and hypermedia audit trails. *Journal of Educational Multimedia and Hypermedia, 1*(3), 355–372.

Nichols, J. D., & Miller, R. B. (1994). Cooperative learning and student motivation. *Contemporary Educational Psychology, 19,* 167–178.

Office of Technology Assessment. (1989). *Linking for learning. A new course for education* (ERIC Document Reproduction Service No. ED 310 765). Washington, DC: Congress of U.S.

Sharan, Y., & Sharan, S. (1987). Training teachers for cooperative learning, *Educational Leadership, 45(3),* 20–25.

Shute, V. J., & Regian, J. W. (1993). Principles for evaluating intelligent tutoring systems. *Journal of Artificial Intelligence in Education, 4,* 245–271.

Slavin, R. E. (1987). Cooperative learning and the cooperative school. *Educational Leadership, 45(3),* 7–13.

Stevens, R. J., & Slavin, R. E. (1995). The cooperative elementary school: Effects on students' achievement, attitudes, and social relations. *American Educational Research Journal, 32,* 321–351.

Wilson, J. M., & Mosher, D. N. (1994, June). *Interactive multimedia distance learning (IMDL): The prototype of the virtual classroom.* Paper presented at the meeting of the ED-MEDIA 94 World Conference, Vancouver, British Columbia, Canada. (ERIC Document Reproduction Service No. ED 388 303)

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