BEYOND NO SIGNIFICANT DIFFERENCES: A CLOSER LOOK AT THE EDUCATIONAL IMPACT OF COMPUTER-BASED INSTRUCTION

By

B. JEAN MANDERNACH

Department of Psychology, Park University

ABSTRACT

There is a host of research examining the equivalence of alternative modes of technology-facilitated educational delivery (such as computer-based or online instruction) and traditional classroom instruction. While various studies have promoted each of these modalities for specific populations or topic areas, the bulk of research supports relative equivalence between student learning as a result of any of these forms of instruction. Unfortunately, the majority of studies discuss "learning" as an outcome variable with little consideration to relevant components of learning such as depth of knowledge or level of understanding. The purpose of this study was to examine the educational impact (depth of knowledge) of different forms of instruction (computer-based, lecture, and readings) aimed at teaching basic, introductory-level concepts. Eighty-eight participants received informational material via computer, lecture, or a written article. Participants' knowledge of this material was assessed using three types of questions (multiple choice, fill-in-the-blank, and essay) that examined three levels of understanding (rote, application, and evaluation) of material from an introductory-level course. The results indicated that computer-based instruction and readings produced a more evaluative understanding of the material than did lecture regardless of question type, but failed to detect significant differences in rote or application level understanding. In addition, computer-based instruction and readings were significantly more efficient means of instruction than lecture. The implication of these findings for educators is discussed.

INTRODUCTION

As universities move forward to keep up with rapidly advancing educational technology, there is a growing emphasis to incorporate computers and technology-based multimedia into the classroom. The increasing reliance on technology is rapidly changing the face of higher education and, in response to the growing demand, many publishing companies now offer optional, supplementary computer-based resources to complement designated textbooks. This leaves individual instructors with the responsibility of determining which resources are most effective for meeting their instructional goals. To complicate the issue further, there is a plethora of research literature examining the equivalence of traditional face-to-face and computer-assisted educational delivery modes, but the available research is often contradictory, inconclusive, or targeting only a narrow population or target area (for a comprehensive overview of relevant research, see Russell, 2005). In addition, the existing literature typically discusses student learning as a generalized outcome with no attention to differences in the type of knowledge or depth of understanding. The purpose of this study was to examine the educational impact (depth of knowledge) of different forms of instruction (computer-based, lecture, and readings) aimed at teaching basic, introductory-level concepts.

Research Supporting Computer-Based Instruction

Several meta-analyses (Cohen & Dacanay, 1994; Fletcher-Flinn & Gravatt, 1995; Kulik, 1994; Kulik & Kulik, 1991; Kulik, Kulik & Shwalb, 1986 and Shachar & Neumann, 2003) summarize the results of hundreds of studies that compared the effectiveness of computer-based instruction to face-to-face instruction and found enhanced student learning in response to technology-mediated instruction. Kulik (1994) identified five major points emerging from classroom research on computer-based instruction:

> Learning outcomes are higher in classes that incorporate computer-based instruction than in

- classes that rely solely on traditional instructional methods
- Computer-based instruction is more efficient than traditional instruction
- Attitudes toward instruction are enhanced after receiving computer-based instruction
- Attitudes towards computer use are enhanced after receiving computer-based instruction
- Computer-based instruction does not enhance attitudes toward subject matter

Research Supporting Traditional Instruction

In direct contrast to these reports, other research (Brown & Liedholm, 2002; Efendioglo & Murry, 2000; and Hartzoulakis, 2002) has found superior learning gains for students participating in a traditional face-to-face classroom experience. In all these studies, students who were exposed to familiar, traditional lecture settings (including video-simulated lectures, see Efendioglo & Murray, 2000) scored significantly higher on outcome learning measures than students who completed learning activities in an isolated, technologically-mediated setting (including virtual classes and computer-based instructional simulations).

Research Supporting No Significant Differences in Instructional Mode

When examining comparative research in the educational equivalence of various modes of instruction, the largest body of research reports no significant differences in student learning as a result of traditional or computer-based instructional strategies. As indicated by Russell (2001), over 350 published studies indicate that student learning is not differentially impacted as a result of either classroom instruction or computer-mediated, distance learning technologies. Russell's summaries are further supported by several meta-analyses (Cohen, Ebeling & Kulik, 1981; Liao, 1992; and Machtmes, 2000) that statistically analyzed the range of comparative studies available; the results of these meta-analyses show no evidence to indicate that computer-assisted instruction is any more or less effective than traditional face-to-face instruction.

Summary

As indicated by the vast range of contradictory conclusions concerning the general effectiveness of computer-based instruction, it is difficulty (if not impossible) to make generalized statements about the value of technology-mediated instruction as an overall tool to promote student learning. The term computer-based instruction encompasses a wide variety of instructional uses, including drill-and-practice, tutorial, dialogue, management, simulations, enrichment, programming, logo, and interactive applications. These diverse uses, as well as rapid advances in programming and applications, eliminate broad conclusions about the effectiveness of computer-based instruction. As Kulik (1994) effectively highlighted, "we need to go beyond generic conclusions and make statements about the effectiveness of specific types of computer-based instruction" (p. 22).

Accordingly, the present study aimed to go beyond a general examination of student learning to look explicitly at the *depth or type* of learning gains that may be available via computer-based instruction. Specifically, the study compared the effectiveness of a typical computer-based instructional module, a traditional lecture and a written document on the level or depth of student understanding. Theoretically, if active learning results in better understanding, then the interactive components of computer-based instruction should enhance higher order thinking about the material. As such, outcome measures examined whether students who completed the computer-based instruction demonstrate a deeper or more evaluative level of knowledge than students who learned via traditional lecture. Another possible advantage to computer-based instruction is instructional efficiency (Kulik, 1994), so additional measures examined if students who learned via computer spent less time with the instructional material than students who listened to the lecture or completed the readings.

Method

Participants

Eighty-eight participants were recruited from the Introductory Psychology subject pool at a large university in the Midwest for participation in this study; participants received course credit in exchange for their participation. There were a mean of 29 participants in each of the three instructional conditions (computer-based, lecture, and readings); there were no between-group differences in gender, year in school, form of typical instruction, mean age (19.46 years), mean GPA (3.34), or pretest knowledge of topic.

Independent Variables

Methods of Instruction

Three methods of instruction (computer-based module, videotaped lecture, and readings) were utilized to teach general learning principles from a standard introductory psychology text. The content of the instruction was held constant in all three instructional units. A commercially available, interactive CD-ROM (offered as a textbook supplement by the publisher) provided the computer-based instruction (Coon, 1998). The computer-based unit incorporated interactive activities, video/sound clips, and multiple-choice review questions in addition to a text description of the concepts. The videotaped lecture was developed to match the instructional content of the computerized unit and was delivered by a professional actor with experience as a college psychology teacher. The readings consisted of text description of the concepts accompanied by illustrations. All activities and videos found in the computer-based unit were described in the videotaped lecture and reading versions of instruction. In addition, participants in the videotaped lecture and readings condition were given review quizzes to match the multiple-choice review questions found in the computerized unit.

Dependent Variables

Measures of Learning

A post-test measure was designed to assess various levels of understanding (rote, application, and evaluative) using various question formats (multiple-choice, fill-in-the-blank, and essay). All questions reflected typical knowledge-based assessment items based on a standard taxonomy of learning objectives (Bloom, Engelhart, Furst, Hill, & Kratwohl, 1956) that targeted various level of *understanding*[1].

Comment (DB1):
Terrific idea; got to see the table to be sure it is a good sample

Scoring was completed by a knowledgeable outside *investigator*[2] who was unfamiliar with the research hypotheses and blind to participants' instructional method. In order to maintain consistent scoring, a detailed scoring guide was utilized. In addition, a random sample of 80 items was scored by a second skilled grader to assess the quality of the learning measure. The percentage of agreement between graders was above 85%, providing evidence of reliable scoring.

Design and Analysis

The design of the study was a between-groups comparison of instructional methods. The learning in each group was compared using an analysis of variance with the post-test assessment as the dependent variable. The post-test assessment was broken down by question type (multiple-choice, fill-in-the-blank, and essay) and by level of understanding (rote, application, and evaluative) for additional analyses.

Procedure

Each participant completed a pre-test of content knowledge and was randomly assigned to an instructional condition. All instruction was delivered individually in private rooms. Participants were informed that they had unlimited time to review and master the material. The post-test was administered immediately following the instructional *unit*[3].

Results

An examination of the means of each instructional condition revealed a consistent pattern of findings with students learning via reading showing the greatest level of understanding, followed closely by students learning from computer-based instruction. As shown in Figure 1, students learning from either of these instructional methods showed increased understanding over students receiving information via lecture. This pattern of findings consistently emerged in several different partitions of the total data from the learning assessment. A series of between-groups

Comment (DB2): "Investigator" may not provide the information needed; why would one think this person is a reasonable judge? Any TA experience? Maybe you don't want to identify as undergraduate, but relevant experience grading other materials would be helpful hint that scoring was competent (beyond the reliability data).

Comment (DB3): Here again there is the issue of expectations; unlimited time within what frame of credit? Did people really have unlimited time or perceive that they did? You need to clarify this throughout the paragraph (that is, once for the whole paragraph).

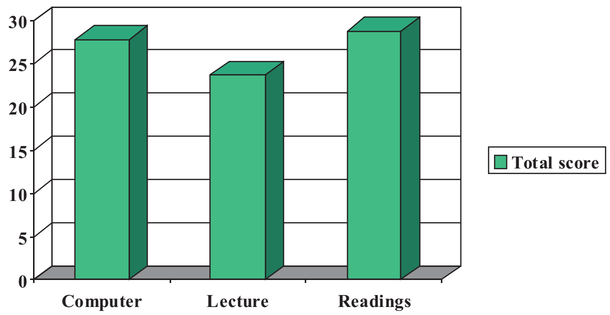

Figure 1. Mean total test score by instructional mode.

ANOVAs (.05 alpha level) were conducted to provide support for these findings. Means and standard deviations for each instructional condition are listed in Table 1, 2 lists the ANOVA results for all statistical analyses.

Students learning via reading demonstrated a more evaluative understanding than students learning via computer or videotaped lecture (see Figure 2). *A between-groups ANOVA on the level of understanding revealed a significant difference in student's evaluative understanding (F (2,85) = 5.612, p = .005, MSE = 6.76)*[4].

Means and standard deviations for each instructional condition	Computer		Lecture		Readings	
	Mean	SD	Mean	SD	Mean	SD
Pretest:	8.41	3.92	8.84	4.14	9.31	2.65
Multiple-choice	4.04	2.28	4.24	2.23	4.52	1.88
Essay	4.38	2.28	4.60	2.53	4.79	1.66
Posttest:	27.84	10.18	23.71	7.81	28.82	8.16
Rote:	9.57	4.22	8.59	3.51	9.63	3.45
Multiple-choice	2.61	.83	2.52	.78	2.74	.58
Fill-in-the-blank	2.07	.90	1.97	1.02	2.26	.82
Essay	4.89	3.12	4.10	2.47	4.63	2.69
Application:	9.82	3.86	8.22	3.12	10.13	3.18
Multiple-choice	2.14	.65	2.21	.68	2.39	.72
Fill-in-the-blank	2.14	.85	1.97	.68	2.19	.75
Essay	5.54	3.19	4.05	2.74	5.55	2.58
Evaluative:	8.41	2.98	6.86	2.43	9.06	2.38
Multiple-choice	1.07	.72	.66	.72	1.26	.89
Fill-in-the-blank	2.64	.56	2.55	.57	2.55	.57
Essay	4.73	2.55	3.66	1.88	5.26	2.08
Total multiple-choice	5.82	1.42	5.38	1.42	6.39	1.26
Total fill-in-the-blank	6.86	1.78	6.52	1.53	7.00	1.67
Total essay	15.16	8.25	11.81	6.01	15.44	6.56
Instructional time:	22.75	7.53	29.31	3.32	21.87	7.38
Test time:	24.68	7.24	21.11	7.03	24.59	8.01

Table 1. Means and standard deviations for each instructional condition

Comment (DB1): Throughout the results I would like each sentence to start with a prose description of the qualitative result; this first sentence only states that there was a difference and gives a lot of numbers, none of which are the means or other indication of difference. You need to make an argument with the figures showing that consistent pattern. I may need to see this in paper or with the figures embedded into the word document so I know what we have here. This long paragraph seems sterile to me without particulars.

Complete ANOVA results	F	df	p	MSE
Pretest	.46	2, 85	.636	13.01
Multiple-choice	.38	2, 85	.686	4.54
Essay	.27	2, 85	.765	4.73
Posttest	2.84	2, 85	.064	76.50
Rote	.72	2, 85	.489	13.94
Multiple-choice	.71	2, 85	.493	.54
Fill-in-the-blank	.79	2, 85	.455	.83
Essay	.61	2, 85	.549	7.66
Application	2.68	2, 85	.075	11.50
Multiple-choice	1.03	2, 85	.362	.47
Fill-in-the-blank	.73	2, 85	.484	.58
Essay	2.68	2, 85	.074	8.06
Evaluative	5.61	2, 85	.005	6.76
Multiple-choice	4.59	2, 85	.013	.62
Fill-in-the-blank	.26	2, 85	.774	.32
Essay	4.18	2, 85	.019	4.75
Total multiple-choice	4.12	2, 85	.020	1.86
Total fill-in-the-blank	.66	2, 85	.519	2.76
Total essay	2.45	2, 85	.092	48.70
Instructional time	11.87	2, 85	<.001	40.86
Testing time	2.06	2, 79	.134	55.56

Table 2. Complete ANOVA results

A Tukey HSD pairwise comparison showed that the evaluative knowledge of students who learned the material via readings (M = 9.06, SD = 2.38) was significantly higher than students receiving lecture instruction (M = 6.86, SD = 2.43); but there was no significant difference in evaluative knowledge between students learning via computer (M = 8.41, SD = 2.98) and the other two instructional conditions. In order to further examine differences in evaluative understandings, between-group ANOVAs were conducted on the type of question used to measure evaluative knowledge. A significant difference was found for both the multiple-choice (F (2, 85) = 4.59, p = .013, MSE = .62) and the essay (F (2,85) = 4.18, p = .019, MSE = 4.75) questions. Post hoc Tukey HSD comparisons revealed that for both the multiple-choice and evaluative questions, students who read the material (multiple-choice M = 1.26, SD = .89; essay M = 5.26, SD = 2.08) demonstrated a more evaluative understanding than students learning via lecture (multiple-choice M = .66, SD = .72; essay M = 3.66, SD = 1.88). Again, there was no significant difference in evaluative knowledge as demonstrated in multiple-choice or essay questions between students receiving computer-based instruction (multiple-choice M = 1.07, SD = .72; essay M = 4.73, SD = 2.55) and the other two conditions (see Figure 3).

Another between-groups ANOVA on question type revealed a significant difference in students' responses to multiple-choice questions (F (2,85) = 4.12, p = .02, MSE =

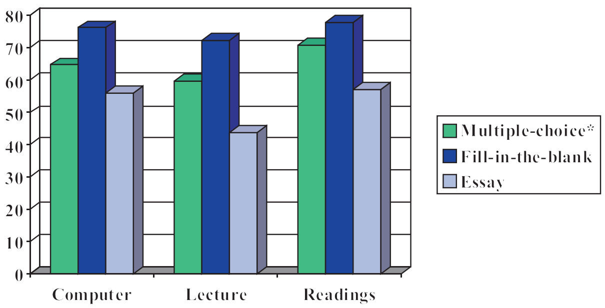

Figure 3. Mean test score by instructional mode and question type.

1.86). A Tukey HSD pairwise comparison showed that students who read the material scored significantly better on multiple-choice questions (M = 6.39, SD = 1.26) than students learning via lecture (M = 5.38, SD = 1.42). As reported above, a breakdown of multiple-choice questions by level of understanding revealed a significant difference for evaluative multiple-choice questions. As shown in Table 2, there were no other significant findings for post-test comparisons.

In an analysis of instructional time, a between-groups ANOVA showed a significant difference in the time students spent with the instructional material ($F(2, 85) = 11.87$, $p < .001$, $MSE = 40.86$). Post hoc Tukey's HSD comparisons revealed that students who learned via computer (M = 22.75 minutes, SD = 7.53) or readings (M = 21.87 minutes, SD = 7.38) spent significantly less time with the instructional material than students who listened to the lecture (M = 29.31 minutes, SD = 3.32); there was no significant difference in instructional time between students learning via computer or readings. To further examine the influence of instructional time, a Pearson's correlation analysis was conducted between instructional time and total post-test score; this analysis revealed no significant correlation ($r(88) = .069$, $p = .524$). While there was no significant difference in testing time ($F(2,79) = 2.06$, $p = .134$, $MSE = 55.56$), there was a significant positive correlation between testing time and total post-test score($r(82) = .472$, $p < .01$) indicating that increased time spent taking the test led to higher post-test scores.

Discussion[5]

Despite the large body of evidence indicating no significant differences between computer-based and traditional classroom instruction, it was hypothesized that students who learned via computer would demonstrate increased depth of understanding over students who listened to a lecture due to the interactive nature of computer-based instruction. While this pattern was repeatedly found throughout the results, the trend was not significant. The current research found that readings alone produced the greatest amount of learning followed closely by the computer-based instruction; both of these instructional methods produced considerably more student learning than listening to a traditional lecture.

Despite findings that support the readings as a slightly more effective instructional mode than computer-based instruction, instructors should be cautious about substituting readings in place of alternative technology supplements as there may be differences in students' enthusiasm toward the instructional mode. The learning outcomes clearly support reading as an effective instructional tool, but promoting students' active engagement with written material is a challenge. Students often report very little interest in reading assignments and may fail to complete assigned readings due to this lack of interest. No qualitative data was collected in the current study to examine students' attitudes or enthusiasm toward various instructional modes, but research (see meta-analysis by Kulik & Kulik, 1991; Fletcher-Flinn & Gravatt, 1995) indicates that many students find computer-based instruction more interesting and engaging than other instructional methods. It is possible that computer-based instruction does not provide any advanced instructional components, but simply presents the material in a more interesting manner. From this pragmatic perspective, the key is not whether learning outcomes are higher from readings or computer-based instruction but which instructional mode will promote the greatest student involvement. Thus, regardless of learning outcomes, there may be value in incorporating computer-based instruction over simple reading, as students may be more likely to actively engage in the material.

The hypothesis that students who learned via computer-based instruction would demonstrate a deeper or more

Comment (DB5): I need to see the new results section and the figures before I can really comment on the discussion.

evaluative level of knowledge than students who learned via traditional lecture was also not fully supported. Students learning via computer did show a trend toward a more evaluative understanding of the material, but this trend did not reach significance. Surprisingly, students who read the material demonstrated the deepest or most evaluative understanding of the material. In addition, no significant differences were found between the instructional modes on either rote or application levels of understanding.

Unlike a lecture, computer-based instruction gives student the opportunity to learn material in a nonlinear fashion. Students are able to review, skip ahead, repeat sections, and practice skills; these instructional opportunities may provide a basis for which students are able to monitor their own learning and adjust the instructional material to meet their progress. An unexpected discovery was the high level of learning gained from simply reading the material. At first glance, this finding seems somewhat counterintuitive due to the assumption that students need assistance (lecture) in order to learn novel material. But two components of the reading experience in this study make it unique: 1) students had no distractions during the readings (conditions which are quite rare for the typical student), and 2) students were given review questions at several points within the reading (review questions that they needed to answer before moving on). In addition, reading is a familiar instructional form to students. It is possible that in the future, as students become more familiar with the nonlinear instructional structure of computer-based instruction, they will have the knowledge and expertise to take full advantage of the instructional capabilities of a computer. But currently, reading (linear instruction) is a much more comfortable and familiar instructional strategy; so, in retrospect, it is not completely surprising that reading produced greater levels of understanding.

A major difference between computer-based instruction and lecture or readings is the opportunity for the student to actively engage with the instructional material (through interactive or exploratory exercises). It is possible that a standard paper-and-pencil assessment (as used in this study) may not be adequate to detect potential differences in learning. Specifically, the one-on-one interaction available in computer-based instruction may enhance application or skill knowledge that is better demonstrated through skill-based measures. The interactivity provided by computer-based instruction may increase skills that are not measurable through standard assessment (see Mason & Bernstein, 2001).

As hypothesized, computer-based instruction was more efficient than lecture in that students spent less time with the computer-based instructional unit than they did listening to the lecture. In addition, students learned as much, if not more, in less time. This has important implications for instructors, as they may be able to cover more material in less time providing increased time for other educational opportunities. It was interesting to note that while the lecture condition required significantly more instructional time than the other two instructional conditions, students who learned via lecture spent considerably less time testing. While it can be argued that the apparent results are more a function of testing time than instructional mode, students learning via computer and readings were apparently more engaged in the material as evidenced in the increased time spent testing. These findings effectively echo previous research that reports increased instructional efficiency (Kulik & Kulik, 1991; Cohen & Decaney, 1994; Fletcher-Flinn & Gravatt, 1995) for computer-based instruction than for traditional instruction, with 91% of 32 studies finding that computer-based instruction was more efficient (taking only 2/3 as much time) as traditional instruction.

These findings have important implications for instructors looking for instructional strategies to maximize student learning. While computer-based instructional supplements may not produce superior learning gains compared to other forms of instruction, the novelty of this instructional delivery method may foster increased student interest in course material over more traditional instructional strategies; this. Thus, it appears that promoting active engagement with the material, whether this occurs via targeted readings, computer-based instruction or other innovative instructional methods, is essential for student mastery of new information. In addition, computer-based supplements may encourage students to prepare more thoroughly for class by providing an efficient means of preparation, thus allowing valuable class time to be spent on more advanced activities.

References

[1]. **Bloom, B. S., Engelhart, M. D., Furst, E., Hill, W. H., & Kratwohl, D. R. (1956).** Taxonomy of Educational Objectives, Handbook 1: Cognitive Domain. New York: David McKay Company, Inc.

[2]. **Brown, B. W. & Liedholm, C. E. (2002).** Can web courses replace the classroom in principles of microeconomics? American Economics Review, 92, 444-448.

[3]. **Clark, R. E. (1994).** Assessment of distance learning technology. In E. Baker & H. O'Neil (Eds.), Technology Assessment in Education and Training (pp. 63-78). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

[4]. **Cohen, P. A, & Dacanay, L. S. (1994).** A meta-analysis of computer-based instruction in nursing education. Computers in Nursing, 12(2), 89-97.

[5]. **Cohen, P., Ebeling, B., & Kulik, J. (1981).** A meta-analysis of outcome studies of visual-based instruction. Educational Communications and Technology Journal.

[6]. **Coon, D. (1998).** From Essentials of Psychology. Copyright 1994, 1991, 1988, 1985, 1982, 1979 West Publishing Company; copyright 1998 Brooks/Cole Publishing Company, Pacific Grove, CA, a division of International Thomson Publishing Inc. By permission of the publisher.

[7]. **Efendioglo, A. & Murray, L. W. (2000).** Education at a distance: Teaching executives in China. T.H.E. Journal, 27 (6).

[8]. **Fletcher-Flinn, C. M., & Gravatt, B. (1995).** The efficacy of computer-assisted instruction (CAI): A meta-analysis. Journal of Educational Computing Research, 12(3), 219-242.

[9]. **Hartzoulakis, B. (2002).** Investigating computer mediated instruction in a Greek State Lykeio. Unpublished doctoral dissertation available at http://users.att.sch.gr/hartzoulakis.

[10]. **Kulik, J. A (1994).** Meta-analytic studies of findings on computer-based instruction. In E. Baker & H. O'Neil (Eds.), Technology Assessment in Education and Training (pp. 9-33). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

[11]. **Kulik, C., & Kulik, J. A. (1991).** Effectiveness of computer-based instruction: An updated analysis. Computers in Human Behavior, 7, 75-94.

[12]. **Kulik, C., Kulik, J. & Shwalb, B. (1986).** The effectiveness of computer-based adult education: A meta-analysis. *Journal of Educational Computing Research*, 2, 235-252.

[13]. **Liao, Y. K. (1992).** Effects of computer-assistant instruction on cognitive outcomes: A meta-analysis. *Journal of Research on Computing in Education*, 24 (3), 367-380.

[14]. **Mason, B. J., & Bernstein, D.** (November/December 2001). Is instructional technology worth the time? Your answer may depend on your assessment. Psychology Teacher Network, 11 (5), 8 and 15.

[15]. **Machtmes, K, & Asher, J. W. (2000).** A meta-analysis of the effectiveness of telecourses in distance education. *The American Journal of Distance Education,* 11 (1), 29-46.

[16]. **Russell, T. (2001).** The No Significant Difference Phenomenon (5^{th} Edition). The International Distance Education Certification Center.

[17]. **Russell, T. (2005).** No Significant Difference Phenomenon. Available online at www.nosignificant difference.org.

[18]. **Schmeeckle, J., Bernstein, D. J., & Fudge, M. (1999).** Effectiveness of multimedia computer-assisted instruction. Unpublished manuscript.

[19]. **Shachar, M. & Neumann, Y. (2003).** Differences between traditional and distance education academic performances: A meta-analytic approach. International Review of Research in Open and Distance Learning, 4 (2).

[20]. **Watkins, G. L. (1998).** Achievement and attitudes with CD-ROM instruction. *College Student Journal,* 32(2), 293-301.

ABOUT THE AUTHOR

B. Jean Mandernach, Ph.D, has served as an Associate Professor of Psychology and Online Learning at Park University since 2001. Her research focuses on enhancing student learning through assessment and innovative online instructional strategies. In addition, she has interests in examing the perception of online degrees and the development of effective faculty evaluation models. She received her B.S. in Psychology from the University of Nebraska at Kearney, an M.S. in experimental psychology from Western Illinois University, and PhD in social psychology from University of Nebraska at Lincoln.