Basturk, R. (2005). The Effectiveness of Computer-Assisted Instruction in Teaching Introductory Statistics. *Educational Technology & Society*, 8 (2), 170-178.

The Effectiveness of Computer-Assisted Instruction in Teaching Introductory Statistics

Ramazan Basturk, Ph.D.
Pamukkale University, Egitim Fakultesi
Incilipınar, Denizli 20020, Turkey
Tel: +90 258 2125555 / 282
Fax: +90 258 2125524
rbasturk@pamukkale.edu.tr
rbasturk@hotmail.com

ABSTRACT

The focus of this study is to demonstrate and discuss the educational advantages of Computer Assisted Instruction (CAI). A quasi-experimental design compared learning outcomes of participants in an introductory statistics course that integrated CAI to participants in a Lecture-only introductory statistics course. Reviews of participants' identical midterm and final exams scores demonstrated that participants in Lecture-plus-CAI section obtained higher averages on midterm and final exams than participants in the Lecture-only sections and these higher averages likely were because of their better performance on concepts and practices that were taught in both regular lecture and CAI course. In addition, when the topics of the introductory statistics course moved from descriptive statistics to inferential statistics, the learning gap between Lecture-only and Lecture-plus-CAI is increased. Findings suggest participants' learning capacity of the introductory statistics could be improved successfully when CAI used as a supplement to regular lecture in teaching introductory statistics course.

Keywords

Computer assisted instruction, Teaching introductory statistics, Teaching in higher education

Introduction

Introduction to statistics courses serve as a general introduction to descriptive and inferential statistics theory and practice. In traditional classroom-based statistics courses, much of the learning comes from reading the selected particular textbook, attending lectures and taking notes regularly. Recent technological developments, however, offer instructors an additional method for teaching introduction statistics' content and practice. Computer-assisted instruction (CAI) continues to increase, eventually offering several advantages. Some of the benefits of using CAI include emphasis on active learning, enrichment of collaborative learning, encouragement of greater students independence and task-based teaching (Worthington et al., 1996; Spinelli, 2001; Prvan et al., 2002).

According to Worthington et al. (1996), computerized study guides can impact and improve students' overall level of mastery. Also, they emphasize that testing may be improved if students complete tests on computer screens and receive immediate feedback about their performance.

Learning Statistics

According to Prvan et al., (2002), the range of learning and assessment activities used in statistics classes has been extended to include group discussions, 'real life' simulations, problem solving and worksheets. They emphasize that this has take place because of recent discussion about the critical role of assessment in statistics education (Garfield and Gal, 1999; Prvan et al., 2002). They believe that "assessment activities usually focus on the *task* or *statistical idea* and learning activities also need to include an emphasis on the *students'* understanding of *learning statistics"* (Prvan et al., 2002, p. 68). They also argue that " focusing on the students' knowledge, rather than on the lecturer's ideas of important content, is the characteristic of a flexible learning environment that encourages students to develop higher conceptions of learning" (Prvan et al., 2002, p. 68).

Petocz and Reid (2001) showed that students experience learning in statistics in six qualitatively different ways. They pointed out that these ways of experiencing learning in statistics move from a disjointed conception such as "doing required activities in order to pass or do well in testing" towards more holistic conceptions for example "using statistical concepts in order to understand areas beyond statistics" or "using statistical concepts in order to change students' views". Using in-depth interviews, Petocz and Reid (2001) have found these very different ways of experiencing learning in statistics in students at both the first and third years of tertiary study. They strongly believe that statistics is not a 'spectator sport'. They concluded, "Students learn statistics only if they actually practice statistics through a whole range of statistical activity supported by an appropriate computer package and discussion" (Petocz and Reid, 2001, p. 69). What they found is, obviously, not a new discovery, and the recent statistics education literature contains many references to the use of laboratory and group activities in statistical learning (Spinelli, 2001; Harrington, 1999; Nicholson 1998; Rossman and Chance 1998; Steinhorst and Keeler 1995; Prvan et al., 2002).

Computer Assisted Instruction

Several researchers have studied CAI in teaching statistics, for example: Mathematical statistics, biostatistics, social statistics and even business statistics with different level (e.g., Spinelli, 2001; Harrington, 1999; Warner and Meehan, 2001; Thyer et al., 1997; Oswald, 1996). Some of the aspects of CAI were also studied in the investigations, including teaching statistics with laboratories (Prvan et al., 2002), and using spreadsheets, for example EXCEL, instead of particular software programs such as Minitab or SAS (Spinelli, 2001; Warner and Meehan, 2001). Recently, researchers have begun to combine and compare CAI with programmed instruction/distance learning approaches (e.g., Harrington, 1999; Thyer et al., 1998).

On the other hand, literature review shows that only a few studies have particularly investigated CAI in teaching *introductory statistics* (Nicholson, 1998; Roiter and Petocz, 1996; Steinhorst and Keeler, 1995). These studies illustrate that investigating CAI in teaching *introductory statistics* is very important because after taking introductory statistics courses, most of undergraduate and graduate students do not take any further statistics courses because of negative feelings and anxiety towards statistics (Garfield and Ahlgren, 1988; Peterson, 1991; Rosenthal, 1992). Students frequently consider that their quantitative methods and statistics courses are more difficult than their major subjects (Murtonen and Lehtinen, 1999). It is a well-known fact that one of the common nicknames of the statistics course is "sadistics" (Forte, 1995; Rosenthal, 1992). Perney and Ravid (1991, p. 2) stated in their research "Statistics courses are viewed by most college students as an obstacle standing in the way of attaining their desired degree. It is not uncommon to see students who delay taking the statistics courses until just before graduation. . . College professors who teach the research and statistics course are all too familiar with the high level of anxiety exhibited by the students on the first day of the term." Students often have low motivation about introductory statistics courses, particularly "if they cannot see the direct relevance of the course to their own real interests" (Wild, 1995, p.57). A survey of heads of biology departments in universities in the UK (A'Brook and Weyers, 1996) cited lack of motivation and an inability to see the relevance of statistics to biology as a factor limiting students' ability to learn statistics. In many universities around the world, introductory statistics courses are taught to a very large class from a range of discipline backgrounds, so examples cannot be made specific to an individual's subject area.

According to Worthington et al., (1996), many design issues arise when evaluating the efficacy of CAI. They pointed out that one of the most pernicious is possible selection bias when comparing two classes that receive different treatments. After a thorough review of literature, Harrington (1999) emphasized the quality of relationship between student and instructor during the instruction needs to be observed and accounted. Duncan, (1993) recommended that some participant variables that should be controlled: Interest in the subject, prior knowledge of an area, generalized anxiety (Tobias, 1987), and computer anxiety (Lambert and Lenthall, 1989). Liefeld and Herrmann (1990) controlled academic major, number of previous courses in the major, score on an English aptitude test, and semester grade point average in their relational research. Literature shows that some researchers have matched groups for equality on critical variables. For example, Underwood and Underwood, (1987) matched groups on IQ scores, pretest of ability to classify objects and reading ability. Trowbridge (1987) took into account, grade point average, gender, age and family income in his research.

This research responds to Duncan's (1993) and Worthington et al., (1996) methodological suggestion by examining the major impact of CAI through the use of quasi-experimental design (Compbell and Stanley, 1966; Cook and Campbell, 1979). Campbell and Stanley stated that quasi-experimental studies are "well worth employing where more efficient probes are unavailable" (1966, p. 205). To determine if students who completed one credit hour CAI session in addition to attending traditional lectures outperform students who only attend regular lectures, two different sections of introductory statistics courses were matched on confounding variables recommended by Tobias (1987); Trowbridge (1987); Liefeld and Herrmann (1990); Duncan (1993) and Worthington et al., (1996).

The impact of CAI participation was assessed with identical Midterm and Final exams for both groups. All items in Midterm and Final examination were covered in lecture and text. However, some items in both exams were also addressed by CAI experiences. As a result, both testing scores produced two indices of student outcomes: General examination score and examination score for CAI-supplemented items. It is predicted that students with the Lecture-plus-CAI section would outperform students in the Lecture-only section.

Methods and Techniques

Participants

Participants were graduate level students during all six quarters of the last two academic years at a Carnegie I Research University. In the first meeting of the course, a survey included five questions distributed to the participants. Questions in the survey were: Gender, age, academic major, degree pursued and number of statistics courses taken. During the first meeting of the lecture portion of the course, the professor explained that a one credit hour lab was scheduled and recommended. The students were then registered for the introduction statistics course without Computer-assisted learning (Lecture - only; n = 140) or with Computer-assisted learning (Lecture-plus-CAI; n = 65).

Procedure

Quasi-experimental design was used in this research. Both courses had several features in common. All were taught by the same instructor and had the same objectives, content, and homework assignments. The instructor was an experienced professor who has been teaching the three credit hour introductory statistics courses since 1970. Different editions of the same textbook (Gravetter and Wallnau, 2000) have been used in this class for more than eight years. The instructor worked with two doctoral level assistants across seven different offerings of the course that were trained to teach the CAI portion. With the exception of the two graduate assistants, the CAI components were identical from quarter to quarter. Course content included *descriptive statistics, frequency distribution, central tendency and variability, hypothesis testing, t tests, correlation, regression and non-parametric statistics (chi-square).*

Students in all courses took the same multiple-choice Midterm and Final exams. Both exams consisted of 62 multiple-choice questions. Of the 62 questions of the Midterm and Final examinations, 50 items tested *generalized learning* (Hannafin and Carney, 1991; Worthington et al., 1996), however, 12 items (those questions reflecting in the CAI session) tested *domain-specific learning* (Worthington et al., 1996). While Midterm examination was administered after the 7^{th} week of the course (middle of the quarter) to each session, Final examination was administered to each section at the end of the quarter, (15^{th} week). Generalized learning items included definitions, interpretations and discriminate of terms and concepts, calculations of statistics, and interpretations of results.

Students in the Lecture-plus-CAI section attended 40-minute class each week and completed systematically computerized exercises and tutorials. After learning concept and theory in Lecture-only part of the course, students who choose Lecture-plus-CAI section came to the computer lab and lab instructors show them how to make practice on real data set. For example, students learn and understand theoretical base of the measure of central tendency and what it means in the Lecture-only class. And then in Lab, students learn how to run measure of central tendency, get computer outputs, analyze and interpret them appropriately. Software used to provide these exercises was a data analysis package, SPSS (Statistical Package for Social Sciences).

SPSS as a Laboratory Software Program

SPSS introduced the first mainframe statistical software package to appear on a personal computer. In addition, **SPSS** was the first package released of statistical products for the Microsoft Windows personal computer operating system. **SPSS** recently received the 2002 Illinois High Tech Award for statistical software innovation. It is used in statistical education particularly for social science courses in areas such as psychology, sociology and education. According to Prvan et al., (2002), **SPSS** will carry out almost all statistical analyses required at a professional level, and certainly covers all that would be needed in a first statistics course. It is particularly good for analysis of questionnaire data.

Constructivism and Relational Learning Theory

Additional one-credit hour computer laboratory was developed to help students engage with statistical ideas supported by ***constructivist*** and ***relational learning*** theories. The constructivist view, the path of Dewey, Piaget and Vigotsky among others, suggests that there is no such thing as knowledge "out there" independent of the knower, but only knowledge we construct for ourselves as we learn (Dewey, 1938). Learning is not understanding the "true" nature of things, nor is it remembering weakly perceived perfect ideas, but rather a personal and social construction of meaning out of the mystifying array of sensations that have no order or structure besides the explanation that we fabricate for them. According to Prvan et al., (2002), the relational view suggests that students understand learning only in relation to their perception of their learning situation and the subject area. Relational learning theory agrees that learning can be done through assimilation and accommodation where old information can be adapted to create new experience by facilitating learning through the arrangement of information. Since learners have different personalities, general aptitudes and knowledge of a subject area, they will progress at different rates. Therefore, effective learning can occur when students engage their interest with the content. When interest is associated to learning, the information will be remembered and applied in real life experiences (Marton and Saljo, 1979; Petocz and Reid, 2001; Prosser and Trigwell 1999; Ramsden, 1992).

The application of learning statistics using SPSS may benefit students by empowering them to develop their own understanding of statistics concepts. Students will have the opportunity to learn by constructing their own ideas and knowledge from the statistical software experiences, with supportive direction from the lab instructor. According to Packard et al., (1993), students who are actively involved in their own learning usually become more independent learners and problem solvers.

Results

Comparing for Matched Sections

We used to control same confounding variables that may effect why students choose one course over another. Demographic variables used to identify any systematic differences between two different sections included age, gender (Trowbridge, 1987; Worthington et al., 1996), prior knowledge of an area (Tobias, 1987), academic major (Liefeld and Herrmann, 1990) and degree pursued. Mean age for Lecture-only was 27 and Lecture-plus-CAI was 28. Standard deviations for both sections were 3. The 140 Lecture-only students consisted of 91 Male and 35 Female students. Of the 65 Lecture-plus-CAI students, 33 were Male and 32 were Female. Specific data for gender, students' educational major areas and degree pursued are presented in Table 1. There was no difference in gender between Lecture-plus-CAI and Lecture-only groups, χ^2 (1, N = 205) = 1.76; p > .05. For prior knowledge of statistics, survey distributed during the first meeting of the course was analyzed. All participants indicated that this course is the first course about statistics and any of them did not take any statistics courses in their academic background before.

For academic major, The 140 Lecture-only students consisted of 22 Educational Policy & Leadership (P&L), 7 School of Teaching & Learning (T&L), 67 School of Physical Activity and Educational Services (PAES), 4 Social Sciences (SOCIAL), 26 Health Sciences (HEALTH) and 14 Others (OTHERS). Of the 65 Lecture-plus-CAI students, 9 were majoring (P&L), 9 (T&L), 14 (PAES), 11 (SOCIAL), 8 (HEALTH) and 14 (OTHERS) students. Similarly, students' academic major did not differ between two groups; χ^2 (5, N = 205) = 10.66; p > 0.05.

Table 1. Gender, Major, and Degree Pursued comparisons between two Groups

		Groups				
		Lecture-plus-CAI		Lecture-only		
		n	%	n	%	χ^2
Gender						
	Male	33	51	91	65	1.76*
	Female	32	49	49	35	
Major						
	P&L	9	14	22	15	10.66*
	T&L	9	14	7	5	
	PAES	14	22	67	48	

	SOCIAL	11	17	4	2	
	HEALTH	8	11	26	19	
	OTHERS	14	22	14	10	
Degree Pursued						
	Master	41	63	97	69	0.78*
	Ph.D.	24	37	43	31	

* Not significant, p > 0.05

Since this course is the graduate level course, participants were divided into those who pursued Master or Ph.D. degree. For degree pursued, The 140 Lecture-only students consisted of 97 Master and 43 Ph.D. students. Of the 65 Lecture-plus-CAI students, 41 were master and 24 were Ph.D. students. There was no difference in degree pursued between Lecture-plus-CAI and Lecture-only groups, χ^2 (1, N = 205) = 0.78; p > 0.05.

Performance

In order to compare the Lecture-plus-CAI and Lecture-only groups' Midterm and Final exam performance, results were analyzed using independent-samples t tests. These analyses revealed a significant difference between the two groups, t (204) = 5,09; p < .05, for midterm and t (204) = 5.83; p < .05 for final exam performance. The sample means are displayed in Table 2, which shows that subjects in the Lecture-plus-CAI scored significantly higher on Midterm and Final exam performance than subjects in the Lecture-only (for Subject in the Lecture-plus-CAI, M = 43.40, SD = 7.47 for midterm and M = 48.76, SD = 6.89 for final and Subject in the Lecture-only, M = 38.03, SD = 7.62 for midterm and M = 33.28, SD = 7.45 for final exam performance).

Table 2. Comparisons of Course Performance by Lecture Types and Testing Periods

	Testing Periods							
	Midterm Exam				Final Exam			
Lecture Types	n	M	SD	t	n	M	SD	t
Lecture-plus-CAI	65	43.40	7.47	5.09*	65	48.76	6.89	5.83*
Lecture only	140	38.03	7.62		140	33.28	7.45	

* Significant, p < 0.05.

Midterm and Final exams contained 12 critical items related to *domain-specific learning*, which were covered in the CAI exercises as well as in the book and lecture. These questions were analyzed separately from questions covered only in the *generalized learning* (reading textbook and attending the lecture). These analysis revealed a significant difference between the two groups, t (204) = 6,39; p < .05, for Midterm and t (204) = 17.46; p < .05 for Final exam performance. The sample means are displayed in Table 3, which shows that subjects in the Lecture-plus-CAI scored significantly higher on Midterm and Final exam performance than subjects in the Lecture-only (for Subject in the Lecture-plus-CAI, M = 7.16, SD = 1.45 for Midterm and M = 9.00, SD = 1.68 for Final and Subject in the Lecture-only, M = 5.83, SD = 1.25 for Midterm and M = 4.93, SD = 1.23 for Final exam performance).

Table 3. Comparisons of Domain-Specific Items' Performance by Lecture Types and Testing Periods

	Testing Periods							
	Midterm Exam				Final Exam			
Lecture Types	n	M	SD	t	n	M	SD	t
Lecture-plus-CAI	65	7.16	1.45	6.39*	65	9.00	1.68	17.46*
Lecture only	140	5.83	1.25		140	4.93	1.23	

* Significant, p < 0.05.

Figure 1 specifically shows that subjects in the Lecture-plus-CAI increased their scores from Midterm to Final exam performance. On the other hand, subjects in the Lecture-only decreased their scores from Midterm to Final exam performance. These results can be explained by the topics covered on Midterm and Final exam. Midterm exam topics include descriptive statistics, specifically *introduction to statistics, scales of measurement, frequency distribution, measure of central tendency and measure of dispersion.* However, Final exam topics include foundations of inferential statistics, specifically *normal distribution, standard distribution, probability and samples, the distribution of sample means, hypothesis testing, t statistics, correlation, regression and nonparametric tests (Chi-Square).* This result shows that when topics moved from Midterm to Final, in other words, from *descriptive statistics* to *inferential statistics*, the learning gap between Lecture-only and Lecture-plus-CAI is increased.

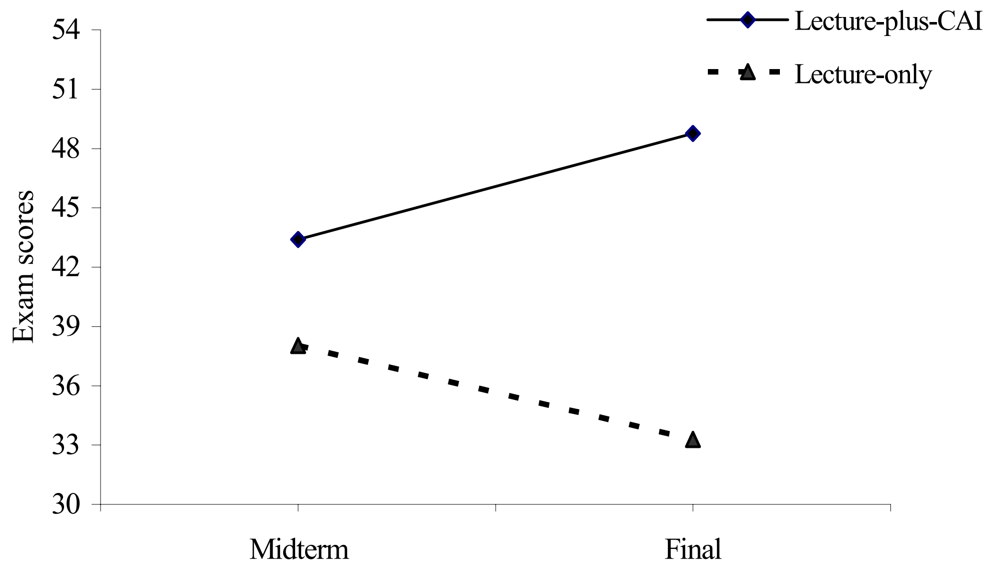

Figure 1. Participants' Midterm and Final Exam Performance by Lecture Types

Discussion

The purpose of this paper was to gather evidence that might support further investigation in the use of CAI to teaching introductory statistics course. According to Yilmaz (1996), traditional methods of teaching introductory statistics are generally viewed as being ineffective because they fail to establish a clear link between statistics and its uses in the real world. To be more effective, using computers with software programs in the introductory statistics course would be one of the important ways to improve student knowledge about statistics and its usefulness in real life. It is a fact that emphasis on real-world applications with the computers is becoming more prevalent in introduction statistics courses at many colleges and universities, including this course at Carnegie I Research University.

According to Hornby (1995), the opportunity to use computers in teaching statistics provides hands on activities, supports cooperative learning, provides active/constructive learning experiences and produces greater peer interaction. Moreover, one-hour laboratory provides opportunities for students to engage with statistical concepts within a learning environment supported through problem-based learning and exchange of ideas, irrespective of the particular package that is being used.

In testing the effectiveness of CAI, several variables were controlled in this research. We inspected student characteristics (age, gender), academic major, degree pursued and number of statistics courses taken (see Duncan, 1993; Liefeld and Herrmann, 1990; Tobias, 1987; Trowbridge, 1987; Worthington et al., 1996). Analyzes indicated that all variables concerning reasons for taking the class did not differ between the two sections.

One of the important and new findings of this research in the literature is that when introductory statistics' topics moved from descriptive statistics (specifically, *introduction to statistics, scales of measurement, frequency* *distribution, measure of central tendency and measure of dispersion*) to inferential statistics (*normal distribution, standard distribution, probability and samples, the distribution of sample means, hypothesis testing, t statistics, correlation, regression and nonparametric tests*), the learning gap between Lecture-only and Lecture-plus-CAI is increased.

Additional time spend in the computer lab might have accounted for better performance of participants in the Lecture-plus-CAI session on the Midterm and Final examination, but this is unlikely. The items in the Midterm and Final exams were divided to two groups. One group was a general question, *generalized-learning* (Hannafin and Carney, 1991; Worthington et al., 1996) and the other group was a CAI specific question, *domain-specific learning* (Worthington et al., 1996). We were able to see whether additional class time spent in computer lab improved *generalized learning* or *domain-specific learning*. Basically, all of the increased performance was attributable to domain-specific performance on the items covered in Midterm and Final exams. Participants in the Lecture-plus-CAI session, on average, answered five more items correctly than did students in the Lecture-only session however, students in the Lecture-plus-CAI session correctly answered two more of the critical items covered in the Lecture-plus-CAI questions on Midterm. For Final, participants in the Lecture-plus-CAI class, on average, answered thirteen more items correctly than did students in the Lecture-only class however, students in the Lecture-plus-CAI session correctly answered four more of the critical items covered in the Lecture-plus-CAI questions. In addition, number of corrected items was increase from Midterm to Final examination in the Lecture-plus-CAI session. This result suggested that it was not additional time spent that affected performance. Rather, additional time spent in computer lab interpreted into gains in learning that component part of the course; this results is matching with Castellan (1993) and Worthington et al., (1996) study.

This research shows that **SPSS** is a useful tool for teaching introductory statistics course. **SPSS** could be used as a first statistics package, especially for psychology, social science or education students. Prvan et al., (2002) indicated that **SPSS** is particularly good with questionnaire data and produces high quality output (e.g. in cross tabulations), so it is attractive for these particular groups of students. This findings support the result of Prvan et al., 2002 study that examined practical comparison of Minitab, Excel and SPSS.

Finally, Lecture-plus-CAI demonstrated in this paper was part of a Total Learning Environment for the students, and was intended to help students develop their understanding of statistical concepts and ideas (Reid and Petocz, 2001). According to Prvan et al., (2002), statistical laboratories need to be used as part of an environment that supports student dialogue, investigation and judgment. They emphasized that "their strength lies in their close connection with the "experience" of a statistician, that is, working as a numerical detective with "messy" data to solve real problems in a collegial environment" (Prvan et al., 2002, p. 74).

References

A'Brook, R., & Weyers, J. (1996). Teaching of statistics to UK undergraduate biology students in 1995. *Journal of Biological Education, 30* (4), 281-288.

Castellan, N. J., Jr. (1993). Evaluating information technology in teaching and learning. *Behavior Research Methods, Instruments & Computers, 25,* 233-237.

Campbell, D. T., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research*, Boston: Houghton Mifflin.

Cook, D. D., & Campbell, D. T. (1979). *Quise-experientation design, and analysis issues for field settings*, Chicago: Rand McNally.

Dewey, J. (1938). *Experience and Education,* New York: Kappa Delta Pi.

Duncan, N. C. (1993). Evaluation of instructional software: Design considerations and recommendations. *Behavioral Research Methods*, *Instruments & Computers, 23*, 324-327.

Forte, J. (1995). Teaching statistics without sadistics. *Journal of Social Work Education*, *31* (2), 204-308.

Garfield, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for Research in Mathematics Education, 19* (1), 44-63.

Garfield, J. B., & Gal, I. (1999). Assessment and statistics education: Current challenges and directions. *International Statistical Review, 67* (1), 1-12.

Gravetter, F. J., & Wallnau, L. B. (2000). *Statistics for the behavioral sciences* (5th Ed.), Minneapolis-St. Paul, MN: West Publishing Company.

Hannafin, M. J., & Carney, B. W. (1991). Effects of elaboration strategies on learning and depth of processing during computer-based instructions. *Journal of Computer-Based Instruction, 18,* 77-82.

Harrington, D. (1999). Teaching statistics: A comparison of traditional classroom and programmed instruction/distance learning approaches. *Journal of Social Work Education, 35*, (3), 343-352.

Hornby, P. E. (1995). *Using a computerized laboratory as a springboard for transforming a traditional lecture course.* Paper presented at the 9th annual conference on undergraduate teaching of psychology, March 22-24, Ellenville, NY, USA.

Lambert, M. E., & Lenthall, G. (1989). Effects of psychology courseware use on computer anxiety in students. *Computers in Human Behavior, 5*, 207-214.

Liefeld, J. P., & Herrmann, T. F. (1990). Learning consequences for university students using computerized mastery testing. *Educational Technology, Research & Development, 38,* 19-25.

Marton, F., & Saljo, R. (1979). On qualitative differences in learning: I. outcome and process. *British Journal of Educational Psychology*, *46*, 4-11.

Murtonen, M., & Lehtinen, E. (1999). *Difficulties in research methodology studies experienced by social science students*. Unpublished manuscript.

Nicholson, J. (1998). Extending the use of statistical packages in an elementary statistics course to enhance understanding. *Paper presented at the 5th International Conference on Teaching Statistics ICOTS5*, June 21-26, Singapore.

Oswald, P. A. (1996). Classroom use of the personal computer to teach statistics. *Teaching of Psychology, 23*, 124-26.

Packard, A. L., Holmes, G. A., & Fortune, J. C. (1993). *A Comparison of Three Presentation Methods of Teaching Statistics*. ERIC Document Reproduction Service No. 365 696, Chicago, IL.

Perney, J., & Ravid, R. (1991). *The Relationship Between Attitudes Towards Statistics, Math Self-Concept, Test Anxiety and Graduate Students' Achievement in an Introductory Statistics Course*. Unpublished manuscript, National College of Education, Evanston, IL.

Peterson, I. (1991). Pick a sample. *Science News*, *140,* 56-58.

Petocz, P., & Reid, A. (2001). Students' experience of learning in statistics. *Quaestiones Mathematicae*, Supplement 1, 37-45.

Prosser, M., & Trigwell, K. (1999). *Understanding Learning and Teaching: The Experience in Higher Education,* UK: Society for Research into Higher Education

Prvan, T., Reid, A., & Petocz, P. (2002). Statistical laboratories using Minitab, SPSS and Excel: A practical comparison. *Teaching Statistics, 24* (2), 68-75.

Ramsden, P. (1992). *Learning to teach in higher education*, London: Routledge.

Reid, A., & Petocz, P. (2001). Using professional development to improve the quality of assessment tasks and student learning environments. In. C. Rust (Ed.), *Improving student learning strategically,* Oxford: Oxford Brookes University, 161–167.

Roiter, K., & Petocz, P. (1996). Introductory statistics courses - a new way of thinking. *Journal of Statistics Education, 4* (2), retrieved April 2, 2005, from http://www.amstat.org/publications/jse/v4n2/roiter.html.

Rosenthal, B. (1992). No More Sadistics, No More Sadists, No More Victims. *UMAP Journal*, *13,* 281-290.

Rossman, A. J., & Chance, B. L. (1998). Workshop statistics: Dissemination and assessment. *Paper presented at the 5th International Conference on Teaching Statistics ICOTS5*, June 21-26, Singapore.

Spinelli, M. A. (2001). The use of technology in teaching business statistics. *Journal of Education for Business, 77* (1), 41-45.

Steinhorst, R. K., & Keeler, C. M. (1995). Developing material for introductory statistics courses from a conceptual, active learning viewpoint. *Journal of Statistics Education, 3* (3), retrieved April 2, 2005, from http://www.amstat.org/publications/jse/v3n3/steinhorst.html.

Tobias, S. (1987). Learner characteristics. In R. Gagne (Eds.), *Instructional technology: Foundations,* Hillsdale, NJ: Lawrance Erlbaoum, 207-231.

Thyer, B. A., Polk, G., & Gaudin, J. G. (1997). Distance learning in social work education: A preliminary evaluation. *Journal of Social Work Education, 33,* 363-367.

Thyer, B. A., Artelt, T., Markward, M. K., & Dozier, C. D. (1998). Evaluating distance learning in social work education: A replication study. *Journal of Social Work Education, 34,* 291-295.

Trowbridge, D. (1987). An investigation of groups working at the computer. In Berger, D. E., Pezdek, K. & Banks, W. (Eds.), *Applications of cognitive psychology: Problem solving, education and computing,* Hillsdale, NJ: Lawrance Erlbaum, 47-57.

Underwood, G., & Underwood, J. D. M. (1987). The computer in education: A force for change? In Blacker, F. & Osborne, D. (Eds.), *Information technology and people: Designing for the future,* Letcworth, England: British Psychological Society, 167-190.

Warner, C. B., & Meehan, A. M. (2001). Microsoft Excel as a tool for teaching basic statistics. *Teaching of Psychology, 28* (4), 295-298.

Wild, C. J. (1995). Continuous improvement of teaching: A case study in a large statistics course. *International Statistical Review, 63,* 49-68.

Worthington, E. L. Jr., Welsh, J. A., Archer, C. R., Mindes, E. J., & Forsyth, D. R. (1996). Computer-Assisted Instruction as a supplement to lectures in an introductory psychology class. *Teaching of Psychology, 23*, 175-181.

Yilmaz, M. R. (1996). The challenge of teaching statistics to non-specialist. *Journal of Statistics Education, 4* (1), 1-9.