



A Comparison of Computer-Assisted Instruction and the Traditional Method of Teaching Basic Statistics

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Journal of Statistics Education Volume 16, Number 1 (2008),
www.amstat.org/publications/jse/v16n1/ragasa.html

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Key Words: descriptive statistics, multimedia, learning

Abstract

The objective of the study is to determine if there is a significant difference in the effects of the treatment and control groups on achievement as well as on attitude as measured by the posttest. A class of 38 sophomore college students in the basic statistics taught with the use of computer-assisted instruction and another class of 15 students with the use of the traditional method from the University of the East, Manila (SY 2003-2004) were the focus of this study. The research method used was the quasi-experimental, non-equivalent control group design. The statistical tool was the Multiple Analysis of Covariance. The researcher made use of the CD-ROM prepared by Math Advantage (1997) to serve as the teaching medium for the experimental group. The following summarizes the findings of the study. The achievement posttest of the treatment group has higher estimated marginal means than the control group and it is reversed in the attitude posttest. Using Hotelling's Trace for the multivariate test, the achievement pretest, attitude pretest, and the two groups have a significant effect on the dependent variables, achievement posttest and attitude posttest. Using covariates to control for the effects of additional variables that might affect performance the attitude pretest accounts for about 56% of the variability in the two groups while achievement pretest about 15%. Levene's test shows that the homogeneity of variances assumption between the two groups is met for achievement posttest but not for attitude posttest. The univariate effects for achievement posttest that are significant are achievement pretest, college entrance test overall score, and groups. The univariate effects that are significant for attitude posttest are attitude pretest and high school general weighted average.

1. Introduction and Review of Related Literature

The study of statistics can be tedious especially because of a lot of formulas to work with and computations that are long and difficult to use. Computer-assisted instruction (CAI) could be of great help because of the drill-and-practice, tutorial, or simulation activities offered either by themselves or as supplements to traditional teacher directed instruction. ([Cotton, 2001](#)). Cotton found in her study that computer software provides many instructional benefits and CAI can have a much greater impact on student learning.

In a classroom utilizing CAI, students often **work independently or in pairs at computers around the room**. Software effectively guides students through a series of interrelated activities and instruction, addressing a variety of learning styles.

Working in pairs could also facilitate learning. [Davidson and Kroll \(1991\)](#) found in their study that students in cooperative environments developed more positive attitudes towards mathematics than students in traditional environments. [Johnson and Johnson \(1985, 1986a, 1986b\)](#) advocate cooperative learning not only for the positive effect it has on student performance but also for the positive effect it has on motivation, classroom socialization, the student's confidence in learning, and attitude toward the subject being learned.

Mathematical aptitude has a lot to do with successful performance in an introductory statistics course and together with aptitude is a positive attitude toward mathematics. A successful student must gain quantitative and graphical insights along with mathematical and analytical abilities ([Härdle, Klinke, and Marron 1999](#)).

Research in mathematics education has shown that the computer facilitated the learning of concepts and computations of statistical formulas ([McCoy, 1996](#)). Students of mathematics courses were more motivated, self-confident, joyful and the subject became more meaningful with CAI ([Rochowicz, 1996, Funkhouser, 1993](#)).

The use of a CD-ROM tutorial is ideal to support traditional classrooms. The pedagogy of a teacher's text extends into a highly visual, hands-on learning environment that is available any time. CD-ROM methods for teaching oral medication administration, [Jeffries \(2001\)](#) generate higher satisfaction and greater cognitive gains for the multimedia group.

In a study by [Christopher L. Aberson et al. \(2002\)](#) of Humboldt State University, he found out that students ($n = 84$) enrolled in introductory and intermediate statistics courses overwhelmingly rated the tutorial as clear, useful, and easy to use. Students who used the tutorial outperformed those who did not on a final examination.

[Michael Szabo's \(2001\)](#) study showed that much research has been focused on the effectiveness of CAI, which is demonstrated through improved test scores ([Williams & Brown, 1990](#)). Effectiveness has also been measured through "heightened affective responses, or better attitudes, reduced learning time, higher course completion rates, an increased retention duration, and finally cost" ([Williams & Brown, 1990, p. 214](#)). Generally the effectiveness of CAI has been determined by comparing CAI with traditional classroom instruction ([Clark, 1985](#)).

[Nickerson \(1995\)](#) points out that while technology does not promote understanding in and of itself, it is a tool that can help students view learning as a constructive process and use simulations to draw students' attention. It provides a supportive environment that is rich in resources, aids exploration, creates an atmosphere in which ideas can be expressed freely, and provides encouragement when students make an effort to understand ([delMas, et al 1999](#)).

[Anderson-Cook, C.M. and Dorai-Raj, Sundar \(2003\)](#) found in their study on the use of applets in statistics courses that students in introductory statistics classes react very positively to the applets, both in terms of enjoying being able to experiment with them as well as being better able to discuss the concepts relating to statistical power.

Researchers have also found that CAI enhances learning rate i.e., students learned the same amount of material in less time than the traditionally instructed students or learned more material given the same amount of time. ([Cotton, 2001](#)). Moreover, students receiving CAI also retain their learning better ([Cotton, 2001](#))

Most researchers concluded that the use of CAI leads to more positive student attitudes than the use of conventional instruction. This general finding has emerged from studies of the effects of CAI on student attitudes as cited by [Cotton \(2001\)](#).

In what follows the treatment group consists of those who received the CAI and worked in teams and the control group received the traditional method of teaching some selected topics of basic statistics. The detailed description of the treatment and control groups is found in Section 3.

2. Research Problem

This paper aims to find out if teaching basic statistics with the use of computer- assisted instruction helps students achieve better in the subject and have a better attitude towards mathematics. The objectives of the study are:

1. To determine if there is a significant difference in the effects of the treatment and control groups on achievement as measured by the posttest.
2. To determine if there is a significant difference in the effects of the treatment and control groups on attitude as measured by the posttest.

3. Research Methods

The CD-ROM prepared by Math Advantage (1997) served as the teaching medium for the experimental group. It is a self-paced and individualized solution with easy step-by-step inter active tutorial courseware for students from high school to college levels.

Two students shared one computer. They discussed the text they read in the monitor. Solutions to the problems were clarified between the two of them. This is to say that the treatment involved collaborative work between two students. This combination of collaborative work and the CAI is what distinguishes the treatment group. When the two collaborating students did not understand the text of the CD-ROM or the solution to a given problem, they called the teacher for clarification. Aside from these group consultations there were three lecture hours out of the 12 hours of the whole experiment.

The first chapter of the CD-ROM consisted of descriptive and inferential statistics, population and sample, and random sample. The second chapter was on statistical representations of data: grouped data, frequency distributions: class limits, relative frequency distribution, percentage frequency distribution, cumulative frequency distribution, relative cumulative frequency distribution, percentage cumulative frequency distribution, graphs, bar chart, histogram, pie graph, ogive, frequency polygon, percentiles, deciles, and quartiles. In each of the subtopics there were 2 or 3 sample questions, which Math Advantage calls Practice. At the end of the chapter was an examination. Two students worked on the same quiz.

The traditional method consisted of lectures given by the teacher, recitation, and class activities involving the topics discussed during the class. The topics were the same as those given to the experimental group. A local textbook entitled "Basis Statistics" written by professors of the University of the East; Raymond Ang, Wilma Dechavez, Lotta Billones, and Ailene Diansuy was used by the students. Each one had a copy of this book. At the end of each lesson there were activities and practice problems that the students worked on. Some of these problems were done in class and the others were given as homework to be submitted the following day. The students were allowed to use hand held calculators.

The samples for this study were the 53 sophomore students of the University of the East who were enrolled in Basic Statistics in the first semester 2003-2004. 38 were in the experimental group and 15 in the control group. There were actually 20 students in the control group but only 15 took the pretest and the posttest.

There were equal number of male and female in the experimental group while 60% were female in the control group and the other 40% were male. The students were grouped by the registrar's office, the experimental group being a blocked section of information technology students while the control group was a free section consisting of a mixture of students from different courses. Because students were not randomly assigned to class, covariates were measured for subjects in order to allow adjustments for systematic factors that might also affect performance.

The 20-minute achievement pretest was given on July 1, 2003. The test was to assure that both groups had the same knowledge, if any of basic statistics. Then the treatments were given for the two groups, the control group was taught using the traditional method of teaching and the experimental group the computer-assisted instruction. After the treatment the 20-minute achievement posttest was given on July 22. An attitude inventory was also administered as a pretest and a posttest.

The achievement pretest and the achievement posttest were one and the same test. The achievement test was a teacher made test. It was composed of 20 multiple choice test. The reliability index was computed by the researcher using the Kuder Richardson 20 (KR20) formula and the reliability index is 0.55. For hard tests the reliability index of 0.49 and above is reliable.

The mathematics attitude inventory was the questionnaire that Dr. Milagros Ibe validated and tested for reliability using the DOST Scholars as subjects. This same questionnaire was used in the thesis, "Some Factors Affecting the Ability to Solve Word Problems in Second Year High School Algebra" ([Ragasa, 1987](#)).

4. Analysis of Data

This study used SPSS 11.5 (Statistical Package for Social Sciences version 11.5) to compute for the multiple analysis of covariance (MANCOVA). Specifically the one-way MANCOVA was used because it involves 2 continuous dependent variables, ACHPOST (achievement posttest) and ATTPOST (attitude posttest), 1 categorical independent variable with 2 levels i.e., GROUP = 1 (treatment group) and GROUP = 2 (control group) and 6 continuous covariates, ACHPRE (Achievement pretest), ATTTPRE (attitude pretest), CETTOT (overall college entrance test), CETMATH (college entrance mathematics test only), HSGWA (high school general weighted average), HSMATH (grade in high school mathematics). The covariates were gathered to allow adjustment for prior differences among groups because random assignment was not possible. Means were *adjusted* for the influence of the covariate.

Table 1 Between-Subjects Factors

GROUPS	N	
	1	38
2	15	

[Table 1](#) shows that there were 38 students in the experimental group (labeled Group 1) who were taught Basic Statistics using CAI and 15 students in the control group (labeled Group 2) who were taught basic statistics using the traditional method of teaching.

Table 2 Descriptive Statistics

	GROUPS	Mean	Std. Deviation	N
ACHPOST	1	12.1053	2.88322	38
	2	9.8667	2.19957	15
	Total	11.4717	2.87298	53
ATTPOST	1	90.5000	16.29583	38
	2	94.4667	17.80396	15
	Total	91.6226	16.65975	53

[Table 2](#) shows that the mean score of the post-test of the achievement test for the group taught using CAI was 12.1053 with standard deviation 2.88322 while the group taught with traditional method has a mean of 9.8667 with standard deviation of 2.19957. On the other hand the attitude posttest of the treatment group is 90.5000 while that of the control group is 94.4667, a difference of 3.9667.

The Multivariate Analysis of Covariance or MANCOVA ([Table 3](#)) was performed to determine if there are significant differences between the treatment and control groups, after adjusting for several covariates, with respect to their effect on both achievement posttest (ACHPOST) and attitude posttest (ATTPOST). If there is a significant difference, this means that there exists some linear combination of ACHPOST and ATTPOST for which the groups differ, after adjusting for covariates. Given that there is a significant difference, separate ANCOVAs (Table 5) are then run to determine which of the dependent variables (possibly both) differ across the two groups. The result (Table 5) shows that the groups differ with respect to ACHPOST but not ATTPOST.

MANCOVA assumes that the distribution of the errors is bivariate normal with mean 0 and the same covariance matrix for both the treatment and the control groups. Levene's test in Table 4 is used to verify this assumption.

The multivariate tests section in Table 3 simultaneously tests each factor effect on the dependent groups. Hotelling's Trace for multivariate significance tests is commonly used for two dependent variables. In this study ACHPRE p(.026)<.05, ATTPRE p(.000)<.05, and GROUPS p(.006)<.05 have a significant effect on the dependent variables ACHPOST and ATTPOST.

Table 3 Multivariate Tests using Hotelling's Trace

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter
Intercept	.039	.849(b)	2.00	44.00	.435	.037	1.698
ACHPRE	.181	3.975(b)	2.00	44.00	.026	.153	7.950
ATTPRE	1.294	28.459 (b)	2.00	44.00	.000	.564	56.919
HSMATH	.126	2.768(b)	2.00	44.00	.074	.112	5.536
CETTOTAL	.117	2.564(b)	2.00	44.00	.088	.104	5.129
HSGWA	.135	2.977(b)	2.00	44.00	.061	.119	5.954
CETMATH	.012	.269(b)	2.00	44.00	.765	.012	.539
GROUPS	.263	5.797(b)	2.00	44.00	.006	.209	11.593

a Computed using alpha = .05

b Exact statistic

c Design: Intercept+ACHPRE+ATTPRE+HSMATH+CETTOTAL+HSGWA+CETMATH+GROUPS

Table 4, the Levene's test tests the assumption that each dependent variable has similar variances for the two groups. It is generally considered that if the Levene statistic is significant at the .05 level or better, then the null hypothesis that the groups have equal variances is rejected. In practice, people often consider p-values below 0.01 as evidence of a serious assumption with the equal variance assumption. For this data the homogeneity of variances assumption between the two groups is met for ACHPOST, $p(.583) > .05$. However, for the ATTPOST, $p(.015) < .05$ but p is greater than 0.01. Hence the homogeneity of variances assumption is considered met.

Table 4 Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
ACHPOST	.306	1	51	.583
ATTPOST	6.380	1	51	.015

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a Design: Intercept+ACHPRE+ATTPRE+HSMATH+CETTOTAL+HSGWA+CETMATH+GROUPS

The F test appears in the separate ANCOVAs computed on each of the dependent variables of [Table 5](#). The F test tests the null hypothesis that there is no difference in the means of each dependent variable for the different groups formed by categories of the independent variables. This section gives the MANCOVA effects for each covariate. The univariate effects for ACHPOST that are significant are ACHPRE ($p=.014 <.05$, CETTOT ($p=.033 <.05$), GROUPS ($p=.002 <.05$) and the univariate effects that are significant for ATTPOST are ATTPRE ($p=.000 <.05$) and HSGWA ($p=.043 <.05$).

Table 5 Separate ANCOVAs on each of the Dependent Variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power (a)
Corrected Model	ACHPOST	150.571(b)	7	21.510	3.474	.005	.351	24.317	.939
	ATTPOST	9176.698 (c)	7	1310.957	11.224	.000	.636	78.571	1.000
Intercept	ACHPOST	1.351	1	1.351	.218	.643	.005	.218	.074
	ATTPOST	191.180	1	191.180	1.637	.207	.035	1.637	.240
ACHPRE	ACHPOST	40.518	1	40.518	6.544	.014	.127	6.544	.707
	ATTPOST	283.237	1	283.237	2.425	.126	.051	2.425	.332
ATTPRE	ACHPOST	2.027	1	2.027	.327	.570	.007	.327	.087
	ATTPOST	6542.976	1	6542.976	56.021	.000	.555	56.021	1.000
HSMATH	ACHPOST	18.104	1	18.104	2.924	.094	.061	2.924	.387
	ATTPOST	241.408	1	241.408	2.067	.157	.044	2.067	.291
CETTOTAL	ACHPOST	29.935	1	29.935	4.834	.033	.097	4.834	.576
	ATTPOST	94.631	1	94.631	.810	.373	.018	.810	.143
HSGWA	ACHPOST	6.903	1	6.903	1.115	.297	.024	1.115	.178
	ATTPOST	509.005	1	509.005	4.358	.043	.088	4.358	.533
CETMATH	ACHPOST	2.965	1	2.965	.479	.492	.011	.479	.104
	ATTPOST	3.923	1	3.923	.034	.855	.001	.034	.054
GROUPS	ACHPOST	68.999	1	68.999	11.143	.002	.198	11.143	.904
	ATTPOST	22.431	1	22.431	.192	.663	.004	.192	.071
Error	ACHPOST	278.636	45	6.192					
	ATTPOST	5255.755	45	116.795					
Total	ACHPOST	7404.000	53						
	ATTPOST	459352.000	53						
Corrected Total	ACHPOST	429.208	52						
	ATTPOST	14432.453	52						

a Computed using alpha = .05

b R Squared = .351 (Adjusted R Squared = .250)

c R Squared = .636 (Adjusted R Squared = .579)

5. Summary and Conclusions

The results of the study show that the combination of computer-assisted instruction and collaborative work improves learning without a significant effect on attitude. Due to some limitations of the study the results cannot be generalized. For one, the subjects of the study consisted of 35 mostly Information Technology majors in the treatment group who might be expected to respond favorably to CAI while the control group consisted of 15 students though a few in the computer science course the majority is a mixture of students from social sciences. Another limitation is the fact that it was conducted in one and a half months of one semester in one institution.

Nevertheless the following results could encourage other researchers to repeat the study taking care that the limitations mentioned above are eliminated. The univariate effects for achievement posttest that are significant are achievement pretest, the total score of the college entrance test, and the group effect. The univariate effects that are significant for attitude posttest are the attitude pretest and the high school general weighted average.

The Hotelling's Trace for the multivariate test shows that achievement pretest, attitude pretest, and the two groups have significant effect on the dependent variables achievement posttest and attitude posttest. The Levene's test shows that the homogeneity of variances assumption between the two groups is met for achievement posttest but not for attitude posttest.

It is interesting to note that in this study the mean score of the posttest of the achievement test of the treatment group is significantly higher than that of the control group. On the other hand there is no significant difference in the mean score of the attitude posttest of the treatment group and the control group.

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Unpublished Manuscript

Ragasa, C. Y. (1987). "Some factors Affecting the Ability to Solve word problems in Second Year High School Algebra". (A thesis requirement for Master of Arts in Teaching Mathematics, University of the Philippines, Diliman)

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