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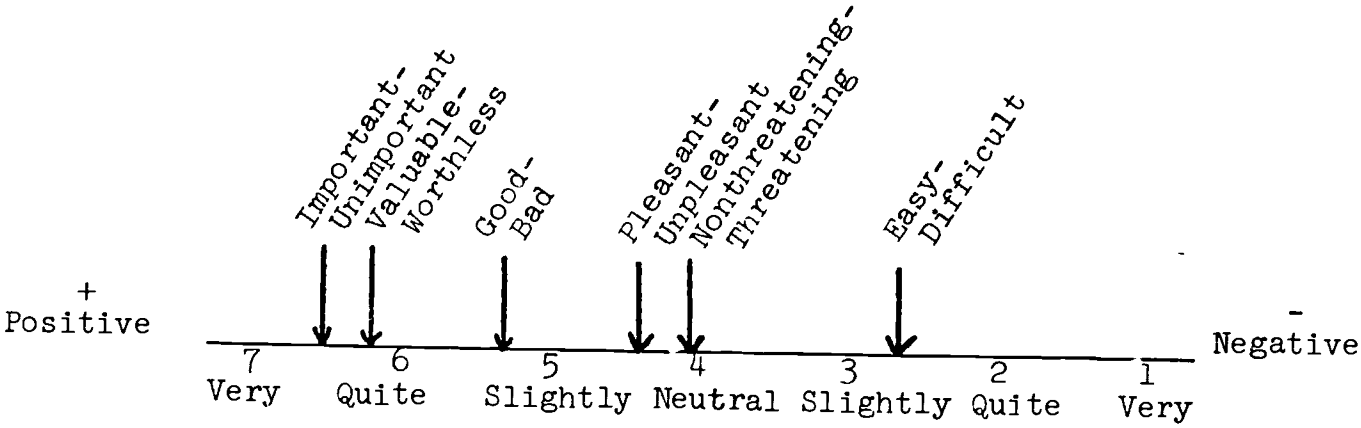
ABSTRACT

The effectiveness of a computer simulation model as an alternative means of teaching research methodology to students was investigated. Four sections of an introductory course on the subject were included in the study. Two were taught through the use of the simulation system, while the remaining sections were taught in the traditional lecture mode of instruction. The simulation was designed to teach skills and concepts in problem definition, hypothesis generation, sampling, research design, data analysis, interpretation and reporting, and the application of those skills and concepts via the simulation problem. Results of the study indicate that the simulation approach was very successful in terms of both attitudes and skill levels in research methodology. The data suggest that students in the experimental groups gained additional skills when compared to the traditional sections. However, the lack of a closely controlled experimental environment suggests a number of potential caveats that should be investigated before further conclusions are drawn. (Author/DGC)

not threatened by them. However, students in all sections felt these concepts were more than a little difficult, 2.8 on the 7-point easy-difficuty scale.

Figure 1

Average Scores on Six Attitudinal Items
For All Groups and All Concepts



Using only the post test data, collapsing over items and ranking the mean scores, the Friedman Two-way Analysis of Variance yielded a significant difference among the Concepts. Table 1 indicates that groups consistently perceived the concepts in the same relative rank order.

Table 1

Concept Ranking of Four Areas for the Four Class Sections

	Groups				
	Lecture		Experimental		
Concepts	1	2	3	4	$\bar{R}$
Educational Research	1	1	1	2	1.25
Behavioral Experiments	2	2	2.5	3	2.37
Computers	3	3	2.5	1	2.37
Statistics	4	4	4	4	4

Simulation: An Alternative
In Teaching Educational Research

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Universities are constantly striving to identify viable educational alternatives to the traditional lecture format utilized by most college professors. With the advent of computer hardware in the educational arena, there has been increasing interest in its application to the solution of educational problems and in the development of new and alternative strategies in instructional methods. The objective of this study was to ascertain the effectiveness of a computer simulation as such an alternative in teaching a course in research methodology.

A major problem confronting the use of available hardware is the great shortage of and lag in the development of accompanying software, i.e., computer programs, and accompanying textbooks and materials, to allow adequate experimentation with the available hardware. Suppes (1972) and Daley (1971) have clearly indicated this as a major problem area in spite of the fact that technical competence, skills and hardware are available. However, Collett (1972), of the University of Michigan, has developed a computerized simulation of a city school district with many of its accompanying problems. One of these problems, dealing with the remediation of children in seventh grade mathematics was operationalized and has been used to teach an introductory course in research methodology.

Four sections were tested to compare the effectiveness of the simulation experience with the traditional lecture mode of instruction. Students in this course came from many educational programs and were master's or beginning doctoral level students. In general, they were naive with respect to specific research and/or statistical skills. This course was their introduction to the scientific method as a basis for inquiry.

The computer simulation was used to teach two sections of the course while two other sections were taught in a traditional lecture mode. Students were not aware of any differences among the section offerings before enrolling except for times when the classes were offered. The instructors were not identified in the list of course offerings but one instructor taught the two "lecture" sections and another instructor taught the two "simulation" sections.

The simulation was designed to teach skills and concepts in problem definition, hypothesis generation, sampling, research design, data analysis, interpretation and reporting, and the application of these skills and concepts via the simulation problem.

Small working groups were created within the experimental classes in order to implement the simulation. Class lecture time was reduced by a factor of .5, and the instructor utilized the remaining class time to work with the individual groups. The instructor acted as an available resource, for consultation with the small groups. However, there were no requirements for students to attend lectures or to arrange these small group meetings with the instructor.

Methodology

Measures of attitudes, skill, knowledge and performance on a criterion task were obtained for all four sections of the course. The data were analyzed through a series of factorial analyses of variance, several one-way analyses of variance, and the Walsh Test of differences. Individual scores, as well as summated scores, were used as dependent variables.

Pretest information on attitudes toward computers, educational research, statistics and behavioral experiments was gathered from all students in the four sections of the class. Similar information was collected again at the conclusion of the ten-week course.

In addition, measures of student learning were obtained through the use of a series of common items on the four final examinations. These common items covered the areas of problem definition, hypothesis construction, sampling, research design, statistical analysis, and interpretation of results.

The experimental groups were also required to prepare "journal articles" based on the simulated studies they conducted.

Due to the fact that intact groups were used in this study, no causal inferences can be ascribed to the experimental manipulation. This limitation must be considered in the interpretation of the results of the study.

Results

A. Results of Assessment of Attitude Changes

A pre-/post-course questionnaire concerning perceptions of the four basic conceptual areas was administered to students in the four sections of the research methodology class. There were 39 students in the experimental sections and 69 students in the lecture sections of the course.

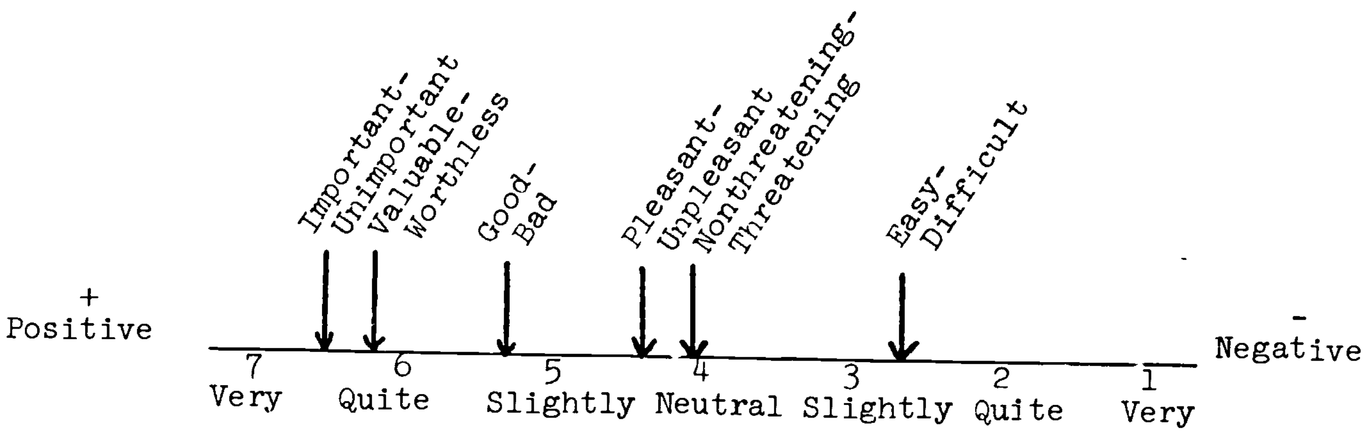
One purpose of this survey was to document student reactions in the two experimental sections of the class and to compare the affective levels of these students with those of students in the two sections taught in the traditional lecture format. A second purpose of this survey was to elicit the strength of student attitudes, and to note changes over time, toward specific methodological concepts basic to this course: educational research, behavioral experiments, computers and statistics.

These four concepts were rated on each of six paired objective scales: important-unimportant, pleasant-unpleasant, valuable-worthless, non threatening-threatening, good-bad, and easy-difficult.

Collapsing the data, over concepts and groups and using post-test results, students in all sections considered the conceptual areas important, valuable and good. (See Figure 1) Attitudes were nearly neutral concerning the pleasantness of the concepts, and the scores did indicate that students were not threatened by them. However, students in all sections felt these concepts were more than a little difficult, 2.8 on the 7-point easy-difficuty scale.

Figure 1

Average Scores on Six Attitudinal Items For All Groups and All Concepts



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Statistics	4	4	4	4	4

Table 1 (continued)

χ^2=9.22 p=.013

Group Ranking of Class Section for Four Concepts

	Groups			
	Lecture		Experimental	
	1	2	3	4
Educational Research	3	4	1	2
Behavioral Experiments	3	4	2	1
Computers	4	3	2	1
Statistics	3	4	2	1
$\bar{R}$	3.25	3.75	1.75	1.25

χ^2 =10.20 p=.0027

The ANOVA score obtained for the main effect of Concepts was χ_r^2 = 9.22, p = .013. This indicates that the difference in scores among the conceptual areas was statistically significant, although all ratings were positive. The conceptual area evoking the most positive attitudinal response was Educational Research, with Behavioral Experiments close behind. Computers were rated third, and students reported their least positive responses in the area of Statistics.

When the Friedman Test was applied to the attitude data for the Groups, a signficant difference was uncovered (χ_r^2 = 10.20, p = .0027). Differences among the four sections in their perceptions of the four conceptual areas were significant.

The second lecture section consistently evidenced more negative attitudes than did the other groups. The two experimental sections were nearly equal in attitude strength and were also slightly more positive than the first lecture section.

Using the binomial test it was determined that of the 16 pre-post differences, 13 of 16 had increased in a positive fashion. The probability of this occurring by chance is equal to p=.0106. Therefore, it can be concluded that in general there was a positive shift in reported attitudes among the students from pre instruction to post instruction (see Table 2).

Table 2

Pre-/Post-Course Mean Scores
In Four Conceptual Areas*

Concepts	Time	Lecture 1	Lecture 2	Experimental 1	Experimental 2	Concept Means
Educational Research	Pre-test	4.99	4.78	5.20	5.17	5.03
	Post-test	5.08	5.03	5.33	5.26	5.17
Behavioral Experiments	Pre-test	5.09	4.70	5.08	4.82	4.92
	Post-test	4.99	4.98	5.00	5.25	5.06
Computers	Pre-test	5.06	4.72	4.80	4.94	4.88
	Post-test	4.73	4.84	5.00	5.30	4.97
Statistics	Pre-test	4.56	4.36	4.58	4.76	4.57
	Post-test	4.63	4.48	4.68	4.78	4.64
Group Means	Pre-test	4.92	4.64	4.91	4.92	
	Post-test	4.85	4.83	5.00	5.15	

* Scale: 7=very positive, 4=neutral, 1=very negative

Further, analysis of the pre-/post-course attitude changes by Means of the Walsh test revealed that in general attitude shifts were definitely more positive among the two experimental sections than among the two lecture sections ($\chi^2 = 5.8526$, df = 1, $p < .01$). Through analysis of the summated raw scores for each concept and each group, it was possible to discern significant differences in changes in attitudes over time among the four groups toward the four basic conceptual areas.

Using the Walsh Test of differences, the following statistically significant differences in attitude changes were discovered.

In the area of educational research, the experimental sections began the course with significantly more positive attitudes than did the second lecture section. All four groups gained in positive attitudes toward educational research by the end of the ten-week course, with the second lecture showing the greatest net increase.

The first lecture section and the first experimental section began the course with significantly more positive attitudes toward behavioral experiments than did the second lecture section. However, both the high-scoring groups registered declines in positive feelings during the quarter, so that the three groups ended the course in research methodology with virtually identical overall attitude scores in this conceptual area. The second experimental group showed the greatest increase in positive affect in this area.

The data analysis also supports the conclusion that the second experimental section ended the course with significantly more positive attitudes toward computers than did either of the two lecture sections.

The second experimental section began the course with significantly more positive attitudes toward statistics than did the second lecture section. However, the second experimental section had the smallest positive increase in attitudes during the quarter, and there were no significant differences in attitudes among the four groups in this conceptual area at the end of the course.

In summary, use of the computer simulation to teach this course in research methodology yielded affective results which were equivalent to or more positive than the affective levels exhibited by students in the traditional lecture presentation of the course with respect to the concepts under study. However, all four sections produced positive affect toward the four concepts of educational research, behavioral experiments, computers and statistics.

B. Results of Assessment of Knowledge and Skills

The basic objectives in all four sections of this research methodology course were the same; only the means by which instructions were given differed between the lecture and simulation sections. In order to assess differences in the level of knowledge and/or skill attained by students in this research methodology course, a performance measure was constructed and administered at the end of the ten-week course.

The instructors agreed to use a set of 17 common items on their examinations, covering the following course objectives: Defining the Problem, Research Design, Sampling, Interpretation of the Data Analysis and Report Writing. A detailed analysis of each of these examination items appears in Table 3.

(see following page)

Table 3
Chi Square Analysis of Common Examination Items
For Lecture and Experimental Sections
Of Research Methodology Course

Objectives	Item	Lecture Sections f_c	Lecture Sections $\%_c$	Experimental Sections f_c	Experimental Sections $\%_c$	L-E χ^2
Report Writing	a	42	61	22	56	.21
Defining the Problem	b	64	93	33	85	1.02
	c	64	93	23	59	18.17**
Sampling	d	58	84	35	90	.28
	e	61	88	12	31	37.79**
Research	f	67	97	28	72	12.78**
	g	64	93	34	87	.38
	h	63	91	38	97	.70
	i	13	19	18	46	9.08**
	j	44	64	12	31	10.82**
	k	61	88	32	82	.84
	l	46	67	20	51	2.48
	m	38	55	9	23	10.45**
	n	66	96	38	97	-
	o	67	97	37	95	-
	p	68	99	37	95	.26
Interpretation of Data	q	60	87	31	79	1.09

f_c=Frequency of correct response

$\%_c$=Percent of correct response

**=Differences significant at $p < .01$

The data show that performance on the common items, across all objectives, reflected no significant differences between the lecture and simulation sections on 11 of the 17 items. On five of the items, the lecture sections were significantly superior and on the remaining item the simulation sections were significantly superior. In general, one experimental section scored consistently, but not significantly, higher than the two lecture sections and the other experimental section scored consistently lower than the two lecture sections (data not shown).

A summary analysis of the significance of differences in the number of summated correct responses across items on course objectives to the common examination items by the experimental and lecture sections is shown in Table 4.

Table 4
Analysis of Significance of Differences
In Number of Correct Responses on Common Exam Questions
Of Experimental and Lecture Sections, by Course Objectives

Course Objectives	Experimental Section (N=39) f_c	Experimental Section (N=39) $\%_c$	Lecture Section (N=69) f_c	Lecture Section (N=69) $\%_c$	X^2
Defining the Problem	28.0	72	64.0	93	17.17*
Research Design	27.5	71	54.3	79	9.13*
Sampling	23.5	60	59.5	86	18.76*
Interpretation of Data Analysis	31.0	79	60.0	87	1.09
Report Writing	22.0	56	42.0	61	.21

*Chi Square values are significant at the .01 level of confidence

f_c=Average frequency of correct responses

$\%_c$=Average percent of correct responses

On three of the five course objectives covered by the common examination items, the lecture sections fared significantly better than the experimental groups: Sampling, Defining the Problem and Research Design. There was no significant difference between the two groups in the areas of Interpretation of Data Analysis and Report Writing.

In addition to these five objectives, noncommon examination items also covered the areas of: Hypothesis Construction, Data Analysis, Validity, Reliability and the Philosophy of Science. The data are presented in Table 5.

Table 5
Average Number and Percent of Correct Responses On Examination Questions of Experimental And Lecture Sections, by Course Objectives

Course Objectives	Experimental Sections (N=39)		Lecture Sections (N=69)	
	f	%	f	%
Defining the Problem	29.4	75	49.4	72
Hypothesis Construction	28.5	73	46.5	67
Sampling	29.0	74	40.5	67
Research Design	25.8	66	48.2	70
Data Analysis	28.6	73	43.3	63
Interpretation of Data Analysis	27.0	69	46.2	67
Report Writing	28.5	73	49.8	72
Assessing Validity	19.0	49	36.0	52
Philosophy of Science	16.0	41	43.0	62
Assessing Reliability	-	-	52.7	76

Only the examination for the lecture sections included items on the assessment of reliability. On the nine objectives covered by both examinations, the experimental sections performed better on six: Defining the Problem, Hypothesis Construction, Sampling, Data Analysis, Interpretation of Data Analysis and Report Writing. The lecture sections performed better on the Sampling, Validity and Philosophy of Science Items. The differences in performance levels between the groups were not significant in any of the course objectives.

It should be emphasized that the means, standard deviations and reliabilities of the total exams were very similar across sections. Students in all sections displayed a high level of understanding of and ability to apply the concepts they learned in this course.

Summary

Results of the data analysis indicate that the alternative to the traditional mode of university teaching met with a great deal of success, reflected not only in student attitudes but in the measures of knowledge and skill attainment in the area of research methodology.

Unfortunately, only the experimental sections completed the criterion task, i.e., the preparation of a "journal article" based upon the computer simulated study. Performance on this task was at a very high level. The students demonstrated that they could attack a problem, define the parameters and limits of the problem, create and implement sampling and research designs, select appropriate variables and instruments upon which to collect data, appropriately analyze and interpret the data results and finally communicate their efforts in writing in the form of a journal article. The quality of the work of these students, who began the course with no research skills or experience at the beginning of the quarter, gives some evidence of the power of simulation.

There is ample evidence that simulation is not only a viable alternative to the traditional classroom instructional mode, but that students in the course spend long hours gaining additional skills in research methodology, beyond that of the comparison group.

It should be remembered, in interpreting the results, that this study was limited by the lack of control over the research situation and by the use of intact groups. Due to the limitations, no causal inferences may be ascribed to the experimental manipulation.

Some of the ramifications suggested by this educational inquiry are:

1. Significant amounts of learning occur when the computer simulation method of teaching is applied.
2. There is an increase in the student's positive affect toward educational research and evaluation.
3. The student is able to sit at the computer console and generate data, as opposed to the tedious task of actually collecting data or generating hypothetical data.
4. For students in the simulation class, there are many real-life research situations.
5. The cost of simulation is minimal.

6. The student proceeds at his own pace, thereby reducing many logistic problems.

7. The simulation method provides an opportunity for students to learn from each other as well as from the instructor.

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