

A COMPARISON OF TELEVISION AND TRADITIONAL
LECTURE TECHNIQUES IN UNDERGRADUATE
ENGINEERING EDUCATION

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INTRODUCTION

Purpose

The primary purpose of this report is to present the results of an educational experiment conducted in the School of Industrial Engineering using televised lecture materials. A secondary purpose is to document the present state of recorded television instruction, describe the existing equipment, and discuss the difficulties being encountered in continued use of recorded materials.

Motivation for this Study

Both effectiveness and efficiency are desired characteristics of the teaching-learning process. Generally, the faculty is primarily concerned with effectiveness, although this notion may be somewhat vague because of poorly defined goals and objectives as well as inadequate criteria for evaluating goal attainment. Administrative personnel are concerned with efficiency and effectiveness in that their problems are largely those of resource allocation. Although any classification of the responsibilities of the engineering educator is arbitrary, most would probably agree that the following should be included.

- Effective teaching
- Scholarly productivity (including research)
- Service in the professional community
- Personal professional development

From the standpoint of the administrative decision maker both long and short range goals of the institution and department must be translated into an operational plan and strategy, and such a strategy has a direct interface with the faculty. As the administrators seek to encourage the faculty to make their respective effort allocations in order to increase the institutional rate of change towards institutional objectives, many "trade-offs" are obviously necessary.

The major issue in this report is the teaching process. The instructor should be concerned with the effectiveness of his teaching, and the criteria should relate to changes in students towards the goals and objectives of the curriculum and course. An ideal situation is undoubtedly one where highly qualified, experienced faculty members teach small undergraduate classes where free interchange is encouraged; however, this alternative has been usually found to be infeasible particularly where there is extensive involvement in graduate programs and research.

In seeking a solution, several approaches have been used. These range from the use of graduate teaching assistants for undergraduate courses with relatively small sections, to the use of large group lectures with no interchange permitted - a lecture technique. The latter is both frustrating and somewhat unacceptable to most engineering educators.

This paper presents the results of an experiment in which a different approach was tested. A faculty member made Video tapes of three lectures per week, and semi-notes¹ were prepared for each lecture session.

¹ Partial notes. See Zumwalt, G. W. "Semi-Notes: An Aid for the Engineering Lecture", Journal of Engineering Education, Vol. 54, No. 5, pp. 182-185.

In addition, the large groups, to whom the lecture tapes were shown, were divided into small groups for a three hour problem lab session. This session was divided into two parts. The first hour was attended by a faculty member who reviewed the previous week's lecture, answered questions and encouraged informal interchange, and the second part was attended by a graduate teaching assistant who answered questions relating to the preceding week's homework problems. Again, informal interchange was encouraged.

The following points provided the rationale for this approach: (1) the large session groups do not provide for feedback and thus little is lost by using video taped lectures, (2) small group interchange permits student exposure to the faculty, and thus "concept learning" is facilitated, (3) problem solving emphasizes the "active learning" experience, and (4) this approach initially appeared to be consistent with faculty desires for effectiveness and the administration's desire for efficiency.

Learning Principles²

Some principles of learning which have been proposed include motivation, organization, variability, verbalization, feedback, contiguity, and active learning.

Motivation relates to the desire to learn, and it is a known fact that one has difficulty in learning material which does not interest him; however, most students are taught to want to do well in school, and thus they have some

² This section is largely based on the reporting of: W. J. McKeachie, "Research on Teaching at the College and University Level," Handbook of Research on Teaching, Edited by L. N. Gagne), American Educational Research Assn., Rand McNally, 1963.

motivation for achievement in the absence of subject matter interest. Predominance of negative motives may cause the student to work hard to avoid undesirable consequences, but a common result is that the student does as little work as possible to get by, and he fails to develop a real interest in the subject. An interesting study comparing fear and hope motivation was presented by Atkinson and Litwin [3].

Katz [16], Katona [15] and others have demonstrated that organization is a significant factor in learning, McKeachie [20] notes that:

"Teaching which helps students find a framework within which to fit new facts is likely to be much more effective than teaching which simply communicates masses of material in which the student can see no organization."

The ability to extrapolate from one problem situation to another is called variability. In order to learn to apply principles in new and unusual situations, it is necessary to experience new, unstructured problems in varying contexts. Wolfe [30] demonstrated that repetitive drill is less effective than varying problems in developing ability to deal with unstructured problems.

Some research has suggested that verbalization can help the student shorten the learning process.

Feedback of the results of practice or problem solving is a necessary condition for learning skills (see Woodworth & Schlosberg [31]); however, it is generally recognized that feedback is most effective when it is contiguous to the response being learned. McGeoch & Irion [19] demonstrated that active learning is more effective than passive learning; however, one danger of student centered discussion is that results are not apparent.

Research on Teaching Methods³

In reviewing the literature of teaching methods research, the engineer becomes immediately aware of an alarming fact. Very little of the research has been conducted in the environment of engineering education. Although many of the results have been sufficiently general to extrapolate between academic disciplines, the absence of research by engineering educators should be a matter for some concern. There are some individuals in the engineering academic community who feel that the demonstrated high performance of engineering graduates is because of this lack of concern and expenditure of effort for educational research, and some convincing arguments can be offered to support this position. One such argument is that when the proper subject matter is presented in a reasonable sequence, the methods used in teaching have little real influence on student learning.

The effectiveness of lecture vs. discussion methods has frequently been compared in the literature. In cases where the information measured could have been obtained from a textbook, Remmers [22], Spence [26], Bane [4], Ruja [23], Eglash [11], and Husband [14] found small and for the most part insignificant differences between the two methods. When problem solving ability and concept learning have been measured, the results have not been so simple. In a comparison of lecture-demonstration to developmental discussion in a college science course, Barnard [5] found the effectiveness of lecture-demonstration superior on a test of specific information but inferior on measures of problem solving ability and scientific attitude. Dawson [9] reached similar conclusions in a soil science course.

³ Ibid.

Course objectives must be clearly established to make any statement about the superiority of lecture or discussion.

Several studies were reported where lecture and discussion methods have been combined. Studies by Lifson et.al. [18], Warren [29], Klapper [17] and Becker et.al. [6] all seem to favor a combination method in that the best features of both methods are combined. McKeachie [20] noted that:

"In a course in which the instructors wish not only to give information but also to develop concepts, the use of both lectures and discussions would thus seem to be a logical and popular choice. . . . By participating actively in discussion, the students should not only learn the generalizations but should also begin developing skill in critical thinking."

In reported studies comparing small to large class size there has been no consistency in conclusions. Of fifty-nine experiments reported by Hudelson [13], forty-six favored large classes; however, most differences were insignificant and most of the measures related to knowledge. Macomber and Siegel [25] used measures including achievement, critical thinking, problem solving skill, and attitudes towards instruction. The only significant differences favored smaller classes, but most differences were insignificant. Nachman and OPOCHINSKY [21] found that small classes performed better than large classes on pop quizzes but there were no differences on the final examinations.

In summary, it has been found that large lecture classes are not inferior to smaller classes if traditional achievement tests are used as a criterion. When other measures are used, large lectures tend to be inferior to small classes. Both instructors and students view the learning process as most effective in small classes. In fact, the main relationship is probably with teaching method rather than class size. McKeachie [20] notes:

"... one would expect class size to be of minimal relevance in television teaching, of slight importance in lecturing, but of considerable significance in discussion teaching."

There has been considerable interest in television as a teaching medium; however, most of the research has dealt with television used as a substitute for conventional teaching rather than used in conjunction with conventional teaching. There have been a few exceptions to this.

Carpenter and Greenhill [7] report results of several experiments and Pennsylvania State University. Chemistry and Psychology courses were involved, and the researchers indicate little loss in student learning when classes are taught by television rather than conventional methods. There were no significant differences.

It has been noted by several researchers that students have a less favorable attitude towards television classes compared to conventionally taught classes. One of the few studies involving engineering students was conducted at Purdue by Seibert and Honig [24] in 1959. Television was found to be inferior to conventional instruction. Student reactions have been strongest in the better students; however, Macomber and Siegel found that students disliked television less than large lectures. Attitudes towards television tend to become more negative as the novelty wears off. McKeachie [20], who has done extensive research on this subject, notes that:

"In 20 of 26 well-controlled experiments reviewed, conventional classes were superior to television classes in achievement. Although few of the differences were statistically significant by themselves, simple application of the sign-test indicates that the differences were not random... When one weighs heavily the necessity for accomodating higher education to large numbers of students; however, the differences between television and conventional instruction seem very small."

The extensive development of "off campus" centers for continuing education and graduate education has naturally stimulated the utilization of television and other electronic communications media. In the more complex systems, two way voice communication is provided with students having a complete video picture of the remote classroom. Other systems involve two way voice communication with a video projection of notes during the note writing process. Simpler systems have only two way audio communication. Recorded materials have been used in connection with some of these presentations, and in a few cases, there has been total reliance on recorded materials. In these cases, of course, one way communication is provided.

The more favorable response to television obtained from students in continuing education and graduate education is quite likely due to the fact that they generally have more positive motivation and a mature attitude towards learning. Several papers of interest [1, 2, 8, 10, 12, 27, 28] have indicated that these techniques have apparently been quite effective.

THE EXPERIMENT

Study Objectives

The objectives of this study were: (1) to investigate the differences between students viewing "live" lectures and those viewing lectures on television monitors, and (2) to produce a set of good quality video tapes for possible future use.

The course selected was entitled "Applications of Probability", and it is commonly scheduled in the first quarter of the junior year for all industrial engineering students. Other engineering students elect the course, and students from mathematics, physics, and psychology are also frequently enrolled. The course is a four credit course with three, fifty minute lectures and one three hour problem - discussion laboratory scheduled each week. The course description is given below.

"This course emphasizes the application of the theory of probability and random variables in the analysis of industrial systems. In particular, probabilistic aspects of problems in queueing, reliability, maintenance, production, and logistics will be treated."⁴

The course objectives as stated in the detailed course documentation are (1) to present sufficient theory and application of probability for the student to develop facility with the use of random variables in the modeling of processes, and (2) to provide the probability background as well as an

⁴ General Catalogue - The Georgia Institute of Technology - 1967-1968, p. 123.

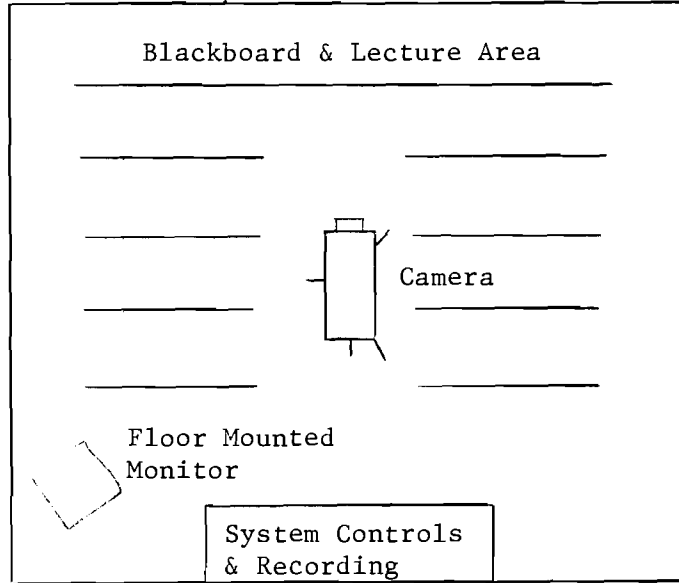
introduction to sampling topics required for the student to progress to the study of statistical methods during the following term.

Method

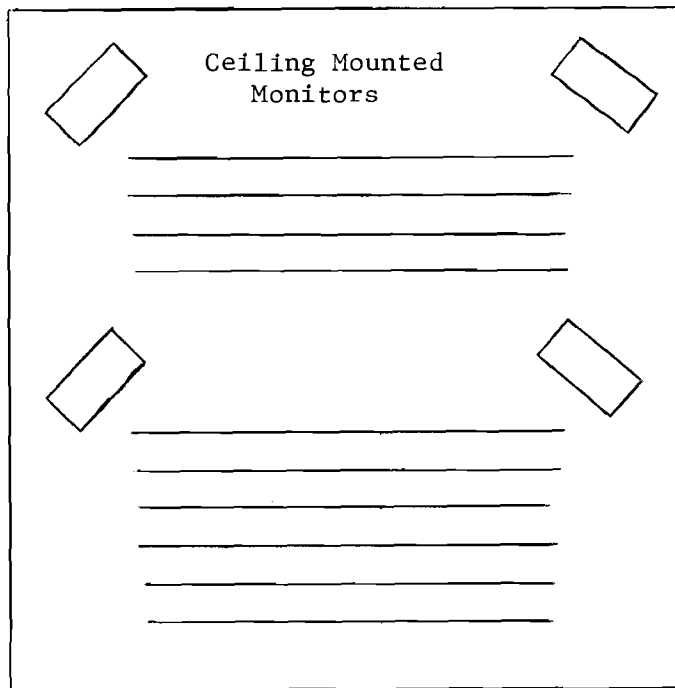
The study was conducted over a two quarter period. In each quarter, the lecture session was scheduled for only one period (10 MWF); however, the group was evenly divided into smaller laboratory groups with various meeting times. A roll was provided for each laboratory group. Using the laboratory rolls, one half of each laboratory group was randomly assigned to a control group and the other half to an experimental group. The controls viewed the lecture "live" while it was being recorded, and the experimental group simultaneously viewed the lecture on monitors in a remote location (see Figure 1). Both groups were provided with semi-notes for each lecture session.

The laboratory groups were small (15-20), and they were conducted in an informal manner with course discussion, problem discussion, and an occasional demonstration. In the first term, the faculty member giving the lectures taught one laboratory group, and the other two groups were taught by another faculty member. In the second term, a different approach was taken. The first hour of each three hour laboratory session was met by the lecturer, and a graduate student conducted the last portion, working problems with the group.

The equipment used was of good quality. During the first quarter, the lecture group was not split until after the fifth lecture due to the fact the equipment installation was delayed because of several unforeseen events. The system was operated by a technician who had no



Classroom Arrangement For The Control Group



Classroom Arrangement For The Experimental Group

Figure 1. Classroom Arrangement

previous experience with video systems, and camera operating skills were developed by the technician and a graduate assistant as the experiment progressed. During the second quarter, generally high quality tapes were produced which indicates that the experimental group had good quality video during that quarter. The equipment used is described in Table 1, and a block diagram is shown in Figure 2 for the equipment arrangement. Figures 3, 4, 5, and 6 present photographs of equipment and classroom arrangements. Funds for the equipment purchase were obtained from the Federal Government through Title VI of the Higher Education Act. Matching funds were provided by the Georgia Institute of Technology.

Table 1. Equipment Specification

<u>Item</u>	<u>Type</u>
1. RECORDER	AMPEX VR 660B VIDEO TAPE RECORDER 2" (WITH EDICON)
2. CAMERA	GENERAL PRECISION -"GPL 900" PRECISION
3. LENS	"VIEWFINDER" CANON ITV ZOOM C-16 25-100 mm 1:1.8
4. TRIPOD	HERCULES "QUICK SET"
5. MONITORS	CONRAC 4 CEA - 25/Y WITH M-9 CEILING MOUNT 1 CEA - 25/Y WITH PEDESTAL MOUNT
6. MIKE	ELECTRO VOICE MODEL G47A DYNAMIC MICROPHONE
7. MIKE MIXER & PREAMPLIFIER	McMARTIN LX-40A
8. AMPLIFIER	McMARTIN LT250A
9. TAPES	MEMOREX 2" HELICAL SCAN TAPE

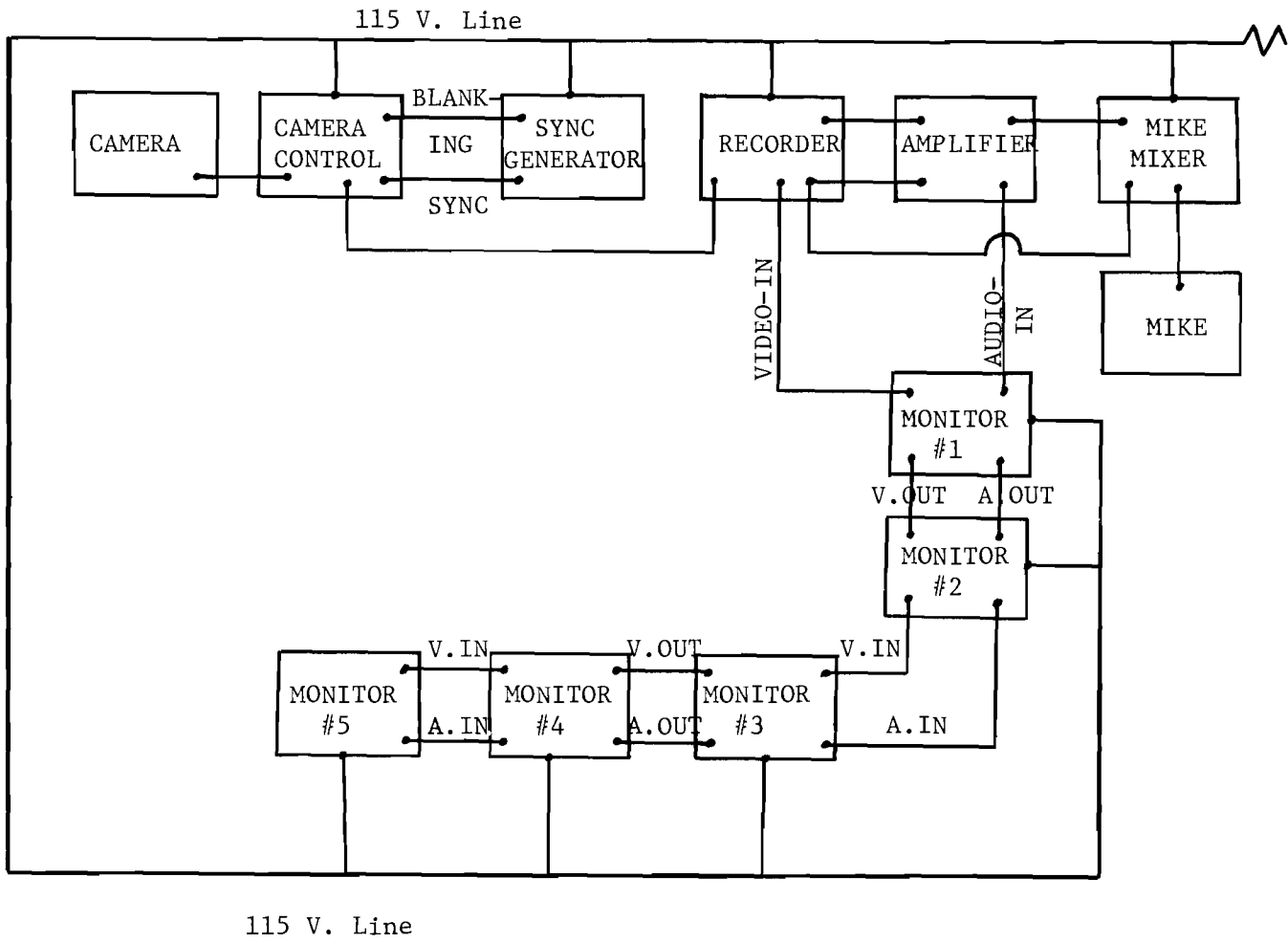


Figure 2. Block Diagram for Equipment Arrangement



Figure 3. Control Group

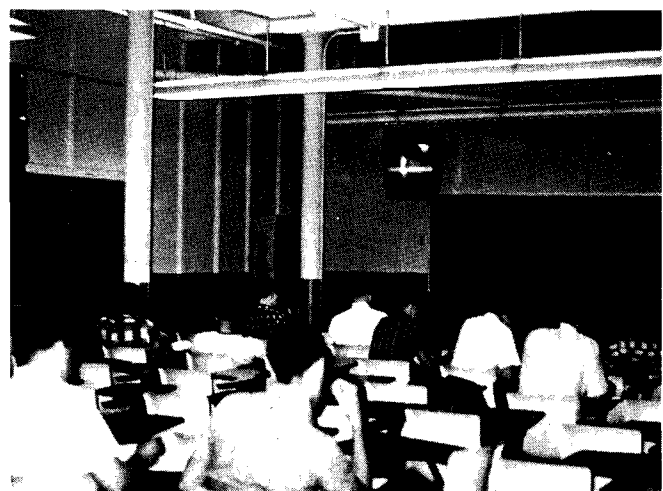


Figure 4. Experimental Group

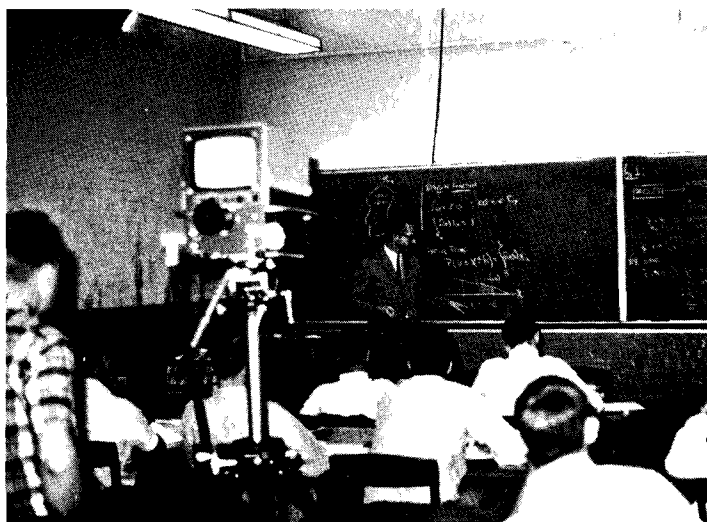


Figure 5. Camera Arrangement

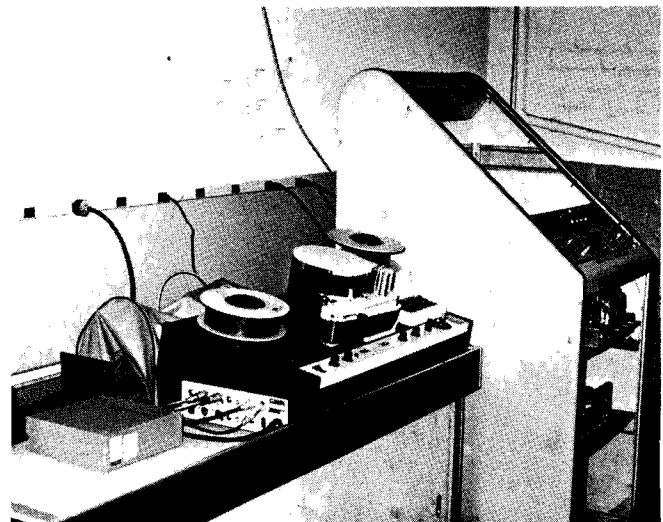


Figure 6. Recording Equipment

Measurements

Five scores were recorded for each group. These were on the following tests:

1. Final Examination: A three hour examination designed to measure achievement. The examination consisted of problems. (0-100 Scale).
2. Mid Term Examination: A one hour examination designed to measure achievement. The examination consisted of problems. (0-100 Scale).
3. Take Home Quiz 1: One week allowed. The quiz contained several problems of a more unstructured nature as well as several problems much more difficult than those typically covered in lecture and text. This quiz was designed to measure both achievement and variability. (0-100 Scale).
4. Take Home Quiz 2: Same as above.
5. Laboratory Score: A Combined measure from homework evaluation, recitation, and occasional lab quizzes. Achievement was the primary attribute measured.(0-100 Scale).

The combined course measure was calculated as follows:

Combined Score = 0.4 (Final Examination) + 0.2 (Mid Term) + 0.15 (Take Home Quiz 1) + 0.15 (Take Home Quiz 2) + 0.1 (Laboratory Score)

RESULTS, ANALYSIS AND CONCLUSIONS

Results

The resulting scores are shown in Table 2. The value \bar{x}_i is the mean for group i , where $i = 1$ for the control group and $i = 2$ for the experimental group. Likewise, s_i represents the standard deviation for group i and n_i represents the number of students taking the particular examination.

Table 2. Student Scores From Two Terms

	Final Exam		Mid Term Exam		Take Home Quiz 1		Take Home Quiz 2		Laboratory Score		Combined Score	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
TERM 1												
\bar{x}_i	65.4	66.7	43.4	45.6	83.0	84.3	73.1	72.7	55.8	57.5	65.4	66.2
s_i	17.3	15.2	15.0	14.8	10.0	10.9	15.7	16.8	19.6	14.8	8.75	10.4
n_i	25	24	25	25	26	25	25	24	25	24	25	24
TERM 2												
\bar{x}_i	49.6	51.4	50.0	50.8	79.2	80.5	79.2	78.6	80.0	80.0	63.3	63.4
s_i	13.1	17.2	17.6	23.0	14.9	10.0	15.0	18.4	4.6	4.9	8.9	12.8
n_i	14	16	17	16	17	17	16	16	14	16	14	16

In the first term two students withdrew with passing scores, and combined scores were calculated only for those students who completed the term.

In the second term one student withdrew in the first week of the quarter and one withdrew with a passing score after the mid term exam. In addition, one student elected to accept a failing score and not attempt either the second take home quiz or the final examination. He was not included in the analysis. Also, one graduating senior was automatically exempt from the final examination and thus no combined score was calculated.

Analysis

In each term, each pair of population standard deviations was compared* at the 0.10 significance level using an F test. In each case there was failure to reject any of the hypotheses of equality. Likewise, each pair of population means was compared** at the 0.10 significance level using a t test. Again, there was failure to reject any of the hypotheses of equality.

* Test statistic: $s_2^2/s_1^2 = F$; Rejection Region $F > F_{0.05, v_2, v_1}$ and $F < F_{0.05, v_2, v_1}$, where $v_1 = n_1 - 1$ and $v_2 = n_2 - 1$.

** Test statistic:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \sqrt{\frac{(n_1-1) s_1^2 + (n_2-1) s_2^2}{n_1 + n_2 - 2}}}; \text{ Rej. Region } |t| > t_{0.05, n_1+n_2-2}$$

It is felt that the following points are noteworthy. In both terms, the experimental group did slightly better (on the average) than the control group; however, the differences are non-significant. Also, the mean scores for the experimental group were better than the mean for the control group on each measurement with exception of the second take home quiz. It should also be noted that the variances are large and thus the power of the test of equality of means is low. For instance, in the first term, on the combined score, if the population means had in fact differed by as much as ten points, the probability of failing to reject the hypothesis of equality (which was the conclusion) is approximately 0.6. McKeachie [20] has noted that this is a general problem in educational experiments. It should also be noted that the very fact the presentation method was different could have caused the experimental group to react with enthusiasm, and the presence of a camera in the room with the control group could have hindered the learning process for the controls, although the students claimed this was not the case.

In order to reduce the large variation, an attempt was made to block out the differences between students. In order to do this, an index was calculated for each student to measure how well he had done in previous courses. The three quarters prior to the quarter in which the student enrolled in the experimental course were used as a base. The index, X_{ij} for the j^{th} student in the i^{th} group was calculated as shown below for the

$$X_{ij} = (\text{Total Quality Points})/(\text{Total Hours Credit}); i=1,2; j=1,2,\dots,n_i$$

three quarters prior to enrollment in the experimental course. An analysis of covariance was conducted where Y_{ij} was the combined score for student j of group i . The regression was for Y on X with results shown in Tables 3-4.

Table 3. Analysis of Covariance Table for Term 1

Source of Variation	Deg. of Freedom	Sums of Square & Products (Corrected)			Deviations about Regression			
		$\sum X^2$	$\sum XY$	$\sum Y^2$	$\sum Y^2 - (\sum XY)^2 / \sum X^2$	Deg. of Freedom	Mean Sq.	F
Among Groups	1	0.48	-2.75	15.69				
Within Groups	45	7.18	69.72	4272.27	3595.81	44	81.72	1.31
Total	46	7.66	66.97	4287.96	3703.18	45		
Difference For Testing Among Adjusted Group Means					101.37	1	107.37	

Table 4. Analysis of Covariance Table for Term 2

Source of Variation	Deg. of Freedom	Sums of Square & Products (Corrected)			Deviations about Regression			
		$\sum X^2$	$\sum XY$	$\sum Y^2$	$\sum Y^2 - (\sum XY)^2 / \sum X^2$	Deg. of Freedom	Mean Sq.	F
Among Groups	1	0.06	0.73	7.98				
Within Groups	25	10.29	77.21	3156.29	2576.94	24	107.37	0.01
Total	26	10.35	77.94	3164.27	2577.45	25		
Difference For Testing Among Adjusted Group Means					0.91	1	0.91	

In neither case was there a significant difference between group means. The extremely small value for F in the second term was a matter of some concern. After some further analysis, it was concluded that the Analysis of Covariance model was not appropriate for the data in this term.

There were several students for whom the previous three quarters transcript data were not available. These students were omitted from this analysis.

Conclusions

In viewing the results of this experiment, the only conclusion to be drawn is that there is no basis for concluding that ETV is either more effective or less effective than large, live lectures when the effectiveness measures are those described herein.

From the standpoint of the instructor, neither large lectures nor televised lectures produce a rewarding teaching experience when compared to small group lectures; however, some compensation for this can be made by structuring courses to provide small, informal, laboratory sessions in which the faculty member is at least partially involved.

Student reactions to televised lectures are highly mixed. There is an indication that the learning experience, as perceived by the student, is more rewarding when there is personal contact with the individual giving the taped lectures; however, most all students prefer small, personal classes and labs. This was indicated by a survey via questionnaire (see Figure 7) used after the basic experiment was completed. During the quarter in which the questionnaire was distributed, all lectures were being presented by video tape and a team approach (faculty member and graduate assistant) was used for two of three laboratory sections. The faculty person was the same individual who gave the video tape lectures. In the third laboratory section, the entire session was presented by a faculty member but not the same individual giving the taped lectures. The results of the survey are shown

Instructions

1. Seriously consider the way in which IE 335 is presently being given.
2. Answer the following question, deliberately considering the alternatives:

Which of the following methods would you prefer if you could make a choice in selecting IE 335.

- a.) Small group lectures by a graduate student with no television and the graduate student also running the labs.
- b.) Large (50-100) group lectures by a faculty member with no television and small labs with graduate student running the lab.
- c.) The present arrangement.

Figure 7. Student Preference Questionnaire

below:

	<u>Lab Section Conducted by Lecturer with a Grad. Asst.</u>	<u>Lab Section Conducted by Other Faculty Member</u>
No. Students	37	16
Favoring (a)	16 (43%)	9 (55%)
Favoring (b)	4 (11%)	5 (32%)
Favoring (c)	17 (46%)	2 (13%)

Combining the results, most students preferred graduate assistants to both large lectures and televised lectures.

Although the efficiency of the teaching is increased to some extent by utilizing ETV there are some "phantom" savings, and adequate workload adjustments should be made to compensate for this. To illustrate, consider, for example, the case of a faculty member who has taped a series of lectures and who meets several laboratory sections for a part of the session. The lectures have 50-100 students, all of whom bring their daily questions and problems to the lecturer who taped the sessions. In addition, quizzes and examinations must be prepared for the entire group. The amount of time required (associated with lecture activity on tape) is roughly equivalent to that required to lecture for a class of 20-30 students using conventional techniques.

It should be noted that there are some side benefits from using taped materials. The lecturer tends to feel more obligation to present materials in a highly organized manner, and this is a factor in favor of ETV. Another benefit arises from the fact that tape playbacks are highly useful in analyzing lecture style and method of presentation. Many teachers could likely benefit from taping a few lectures each year for personal viewing.

In final conclusion, the only positive claim to be made for recorded TV instruction is that it is more efficient than conventional techniques. There is apparently no loss of effectiveness when standard achievement type measures are used; however, both faculty and students perceive the teaching and learning experience respectively as less rewarding.

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