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ABSTRACT

This paper describes a new technique for using videotaped educational materials that could form an important part of a satellite based educational delivery system. The method uses videotapes of regular classroom courses for the instruction of small groups of remote students who are assisted by paraprofessional tutors. The method is called the Tutored Videotape Instruction (TVI) technique. The paper is developed as follows: There is first a brief description of the technique followed by a set of guidelines used to develop the program. Next are described experiments in which the TVI format is compared to both classroom instruction and "real time" television. The factors that appear to be most important for the success of the TVI technique are isolated, and an estimate of program costs and the value of developing a satellite based TVI program is presented. (Author/WBC)

TUTORED VIDEOTAPE INSTRUCTION

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## ABSTRACT

The purpose of this paper is to describe a new technique for using videotaped educational materials that could form an important part of a satellite-based educational delivery system. The method uses videotapes of regular classroom courses for the instruction of a small group of remote students (typically 3 to 10) who are assisted by a paraprofessional tutor as they watch the tape. For this reason the method is called the Tutored Videotape Instruction (TVI) technique.

The paper is developed as follows. We first give a brief description of the technique, after which we present a set of guidelines that were used for the development of the program. We then describe a number of experiments in which the TVI format has been compared to both classroom instruction and "real time" television. From these experiments we attempt to isolate the factors that appear to be most important for the success of the TVI technique. We conclude with an estimate of program costs and a brief assessment of the value of developing a satellite-based TVI program.

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## I. INTRODUCTION

Sometime in the early 1920's, shortly after radio broadcasting was first proven to be economically feasible, Robert Hutchins is said to have predicted that this new technology would undoubtedly have a dramatic impact on education. Subsequent events have shown that his assessment of the educational potential of radio was probably correct, but for a variety of reasons, this potential failed to materialize. Later, in the early 1950's, instructional television was introduced with a similar fanfare. However, with a few notable exceptions, its potential has also failed to materialize; and since many of the problems inherent in conventional educational radio and television will not be solved by the use of a satellite, it seems entirely possible that satellite-based educational delivery could also become an expensive failure. It is therefore important to begin with a brief analysis of why it is that technological aids to education seldom seem to live up to their potential.

There is of course a different set of reasons in each case, though inconstant financing and the competition with commercial interest are surely among the most pervasive. However, important as these factors are, there seems to be a still more basic problem. The proponents of media-based education describe this problem as a failure of the educational establishment to involve itself seriously with instructional technology. As a result, they say, the <u>changes in the design of the educational system</u> that must be made before instructional technologies can be used effectively in the educational process have not been forthcoming. This is a valid criticism. However the educational establishment makes a counter-argument that is also true: effective classroom teachers regularly capitalize on unexpected, unplanned opportunities for the achievement of specific goals. As Jackson [12] says, "stray thoughts, sudden insights, meandering digressions and other unpredicted events constantly ruffle the smoothness of the instructional dialogue. In most classrooms, as every teacher knows, the path of educational progress could be more easily traced by a butterfly than by a bullet". Jackson concludes from this that education is best served by tools that can be readily adapted to a wide variety of educational tasks with a minimum of advanced planning. Blackboards and books provide, at low cost, an impressive standard of flexibility, especially when they are compared to most electronics media. Furthermore, despite honest efforts to use electronics media over an extended period of time, many teachers have still been unable to see a clear improvement in learning as a result of their rather considerable effort. Hence electronics media are generally judged by teachers to be inappropriate educational tools for the majority of circumstances.

If we accept both of these criticisms as valid, we are led naturally to seek out those media that can provide the intellectual flexibility that is essential for effective education without requiring a major change in teaching styles; and to apply these media to situations where the changes in the educational system that are necessary to accomodate the media can be easily made. In this paper we describe a new technique for using videotaped educational materials that seems to meet all of these criteria. The method makes use of unrehearsed, unedited videotapes of regular classroom courses, which can be produced at very low cost. These videotapes are then used for the instruction of a small group of students (typically 3 to 10) who are assisted by a paraprofessional tutor as they watch the tape. For this reason the method is called the Tutored Videotape Instruction technique, and will be referred to as the TVI technique in what follows. It will be clear as the paper unfolds that satellites could be used to deliver the TVI materials to remote sites and to provide the communication link between students, tutors and teachers that is occasionally required. However, radio and slow-scan television, or telephones and the U.S. mail can also provide the necessary service, and these alternatives to satellite delivery should be carefully considered since the objective is to provide the best education at the lowest cost.

The TVI method was originally developed to provide course work in science and engineering to off-campus graduate students at Stanford University. The technique is based on the common-sense notion that students can learn more effectively if they are given the opportunity to freely stop the lectures to discuss important concepts before continuing with the material which the lecturer wishes to present. Data taken over the past three years show that learning is most effective when the videotaped lectures are stopped frequently (e.g., every 5 to 10 minutes for a period of approximately 3-5 minutes). Interactions of this frequency and duration are of course impossible in a conventional classroom situation. The data also show that learning is most effective when a small group of students and the tutor watch the tape together. A single student, with or without a tutor, does not learn as effectively as he/she would in a small group.

The TVI technique responds to the education needs of the students by combining the positive features of lectures with those of small group discussions in which the lectures are used directly to provide the basis for discussion. The lectures provide for depth and continuity in the subject matter, while the tutorial discussions provide a means for making the lectures respond to individual needs and differences. Students watching the videotaped lectures feel free to ask questions to both the tutor and other students, and to make spontaneous comments about points of interest in the lecture. In addition, since the videotapes are of an actual classroom, the TVI students hear all of the comments and questions asked in class and profit from these exchanges as well. In effect the TVI format permits the students and the tutor to manage the lecture themselves, and thereby create an intellectually stimulating environment which enhances learning and creates a positive attitude toward both the subject and the group.

It will perhaps be clear from this brief description that, while the program to be described relies heavily on the use of video technology, that is probably not its most distinctive feature. Rather, the technology permits us to concentrate attention on some of the most important parameters in the learning process and to begin to understand their effects more precisely. In fact what has been found would seem to be applicable in a wide variety of circumstances. It certainly extends well beyond university lecture courses and is in some ways independent of whether technological aids are used in the instructional process.

The program was designed to utilize insofar as possible the experience which has been gained over the past two decades concerning the question of how technology can be used most successfully in education. An attempt to summarize this experience led the author to develop a set of guidelines that could assist educators in planning for the successful use of technology in education [1]. Because these guidelines form the basis of the program to be discussed, it is appropriate to begin with a brief discussion of them.

## II. GUIDELINES FOR THE SUCCESSFUL APPLICATION OF TECHNOLOGY TO EDUCATION

Interest in the use of technological aids to education (particularly television) is largely an outgrowth of efforts whose main roots can be traced to the late 1940's and early 1950's. Following the widespread penetration of commercial television, the Ford Foundation and later the Federal government funded a variety of experiments whose overall purpose was to study the possible impact of television on the educational process. These experiments were organized to include a complete range of educational institutions from elementary school to university and took as their major emphasis the question of whether students could learn as well from television as from conventional classroom teaching. Surveying the results of 421 experiments carried out during the period from 1950 to 1960, Chu and Schramm [2] concluded that, across all grade levels from kindergarten through a Baccalaureate degree, and for essentially all types of subject material, students could learn as well from television as from conventional instruction.*

Viewed in its most positive light, this result suggests that access to education can be expanded substantially by communications technology, and indeed this policy has been urged by educational study groups and implemented by both private and public educational institutions for some time, and at substantial expense. However, the educational effectiveness of classroom instruction is itself a matter of increasing concern, and in this light the "no significant difference" finding does not provide a forceful stimulus to promote the application of communications technology to educational problems.

This latter perspective leads naturally to the question of whether educational technology has ever established a clear-cut superiority over in-class instruction. Consideration of this question led us to compare some of the most successful ventures in educational technology (such as Sesame Street, Chicago City TV College, The Open University in Britain, the Australian School of the Air, and the Bavarian Telekellog) with some of the least successful ventures. From this comparison we attempted to abstract a set of guidelines that describe the conditions that seem most likely to insure a successful application of technology to education. These guidelines are surely in need of further refinement and modification; nevertheless, they do provide a

*Specifically, they found that television was favored in 63 of the experimental comparisons, conventional teaching in 50, and 308 showed no significant difference.

useful starting point for designing new programs.

The guidelines are as follows:

1. The educational program should be planned for a specific target audience.
2. Specific educational objectives that are relevant to the needs and interests of the target audience must be clearly defined.
3. Technologies should be chosen in terms of the topic to be presented. Frequently different technologies are used to present different parts of a course, the choice being determined from a consideration of which technology is most effective for the material being presented. It is desirable (though also expensive) to use both knowledge and media specialists to prepare and produce the programs.
4. Educators who have a clear interest in learning and using the instructional characteristics of various media must be selected and trained.
5. Clear and careful provision for personal interaction is important for retention of student interest.
6. Evaluation and feedback over a period of months or years must be used to monitor the educational effectiveness of the program and to change instructional materials and methods to suit learner needs.

A brief elaboration of these guidelines is given in the Appendix to this paper, where they are used to describe two ventures near the ends of the educational spectrum (Sesame Street and the Chicago TV College). In particular it is shown there that the guidelines provide some means for estimating the time scale and financial resources required to start a new venture. However, since our present interest is in describing a new technique for educational delivery, we will limit our attention for the time being to the question of educational effectiveness.

From the standpoint of educational effectiveness, the guideline that is perhaps most frequently overlooked is the one relating to personal interaction, especially where the use of television is concerned. Television (including lectures that are videotaped for subsequent playback) is most frequently used as a direct substitute for live lectures in large classes or as a means for individuals to view lectures or programs at sites that are remote from the point of origination. These applications are developed primarily to solve the important problems of cost and access, respectively, the assumption being made that courses delivered by television will be as effective as conventional education. However, the experiments that led to this conclusion tested only factual information gained over a relatively brief period of time. Furthermore these experiments identified some characteristic weaknesses of television as an educational medium. In particular, as noted by Schramm [3], it doesn't stop to answer questions; it doesn't readily permit classroom discussion; it is an inefficient medium for conducting drill; it doesn't adjust very well to individual differences; and it tends to encourage a passive form of learning.

These are very serious weaknesses. They can be removed to some degree by using radio talkback to connect remote sites to the television classroom [4] or by establishing a regular telephone contact between students and faculty, as the Chicago TV College and others after them have done. However these techniques for promoting student-faculty interaction do not provide a really effective remedy for the major weaknesses described above. It is critically important for students to be able to stop a lecture or a program when they have questions. When a lecture is stopped, it is highly desirable for it to remain stopped long enough for the question to be clearly answered. It is also highly desirable if the answers to the most important questions can be developed as a result of active discussion amongst a small group of students. Finally it is important that questions and discussions be used to determine background deficiencies of individual students, so that effective remedial action can be taken.

Basically the major weaknesses of "live television" (including videotapes that are simply replayed from start to finish) are all related to the fact that it cannot provide the quality of personal interaction among both students and faculty that is available in an effective classroom. The concept of the TVI intellectual community, consisting of a small group of students, an on-site paraprofessional tutor and a course faculty member, was invented in an attempt to circumvent the major deficiencies of televised instruction. What we seek to do is to provide small groups of students with the high-quality personal interaction that they need to learn effectively. What we have found is that the TVI intellectual community can provide a means of achieving this goal.

## III. EXPERIMENTS WITH TUTORED VIDEOTAPE INSTRUCTION

In this section we will describe a number of experiments that we have carried out to evaluate the educational effectiveness of the tutored videotape instruction format. All of the experiments to be discussed have been concerned with the delivery of engineering and science courses where the objectivity of the material makes it relatively easy to measure the effectiveness of the method. We believe the method can be extended to a much larger range of subjects and audiences, though there is insufficient data available at present to permit us to define this range of applications with any accuracy. Our description of experiments is therefore intended primarily to provide the reader with some general ideas about how the TVI format can be set up and evaluated.

The TVI technique was originally conceived as a means of providing courses to off-campus engineering students employed at a Hewlett Packard plant in Santa Rosa, California, approximately 100 miles north of Stanford. The Hewlett Packard management wished to provide the same continuing Honors Cooperative graduate engineering opportunity that is available to HP employees (and those of other companies) at plants near Stanford, where engineering courses given on the Stanford campus are televised to plants within a 50-mile radius of the University by the Stanford Instructional Television Fixed Service network.

The TVI technique was developed to fulfill this need. Since the courses of interest were already being televised, it was a simple matter to videotape the classes live with no further production requirements. It should be noted that an operating TV system is not a prerequisite for the technique to be described, though it was very helpful in this case because it both facilitated the initial experiments and made a thorough comparison between the TV students and the videotape students possible.

It was intended from the outset that satisfactory performance in the courses would result in credit toward a Master's degree in Electrical Engineering from Stanford. Toward this end the Santa Rosa students were required to complete the same homework as students on campus, with all papers being graded by the same teaching assistant who graded the papers of the on-campus and regular TV students. To further facilitate the comparison of student performance, the off-campus students were required to come to the campus to take the same exams as the on-campus students, in the on-campus environment.

A. Program Design for the Santa Rosa Experiment. The main features of the program developed for the Santa Rosa experiment can be most simply described in terms of the guidelines listed above.

1. Target Audience - Industrially-based students carrying full time job responsibilities. In some cases the students had been studying for a Master's degree before they were moved to Santa Rosa, in which case their academic qualifications were essentially identical to those of on-campus students. However, students at Santa Rosa whose academic credentials were known to be inadequate for admission to the Stanford graduate school were also included.

2. Educational Objectives - The students were known to be interested in graduate training leading to a Master's degree. A clearly important factor in their success is that their employer shared this objective, in both its financial and academic aspects.

3. Range of Media Employed. Half-inch reel-to-reel videotapes of live classes made by a trained student production staff as the class is being conducted. The classroom modifications that are necessary for this purpose are described by Pettit and Grace [4]. Basically the studio classrooms

are organized to produce a minimum impact on the teaching styles and preferences of the instructors. Half-inch reel-to-reel equipment is used to permit the clear reconstruction of a given TV frame at the remote sites.

Videotapes were mailed to Santa Rosa along with class notes, homework assignments and other materials that were handed out to the on-campus students. Videotapes and homework were returned to Stanford in approximately one week. On-site tutors contacted the on-campus faculty by telephone after the videotapes were watched to discuss problems and obtain supplementary material if necessary.

4. Media-sensitive Educational Staff. Faculty whose courses are to be televised are given a brief training session to familiarize them with the capabilities of the television network and suggestions concerning how these capabilities can be used effectively (e.g., effective organization of blackboard space, use of a desk pad as an alternative to the blackboard, effective preparation of demonstrations, and so on).

In addition, Stanford staff members who are responsible for the TVI program visit each site to choose the tutors (from among the company's staff) and to instruct them in the use of the videotape as an educational medium. An alternative that is presently being explored is to use staff members from local educational institutions who have indicated an interest in the program.

In nearly all cases so far, the tutors have been practising engineers without prior experience in teaching. They are chosen primarily on the basis of two criteria; viz., (a) a sensitivity to students and an ability to draw them into a fruitful discussion of issues, and (b) a personal interest in reviewing the subject to be presented. Other criteria, such as recent exposure to the course with evidence of high quality performance, were found to be significantly less important than the criteria just mentioned.

The tutor's main functions are (a) to initiate and encourage stopping the videotape playback for the immediate resolution of problems; (b) to answer questions that cannot be resolved by the class (if possible); and

(c) to contact the on-campus instructor to obtain answers and supplementary material if necessary.

Tutors are also encouraged to visit the on-campus faculty once or twice per quarter to become familiar with the course syllabus and to discuss any recurring problems that their students have. It is also useful to point out that the tutor is not responsible for grading homework or assigning course grades. His function is simply to help his students learn as effectively as he can.

5. Personal Interaction. Students and tutors alike are urged to stop the videotape whenever they have problems or questions or whenever some particularly important concept has been presented. Certain obvious cues are frequently used by the tutor to initiate these discussions. For example, each time a substantive question arises in the on-campus class, the tape is stopped and the TVI class attempts to generate the answer before the taped lecture proceeds.

In addition to extensive group interaction during the lectures, students are encouraged to discuss problems with each other and with the tutor outside the viewing period. Since the tutors and students are known to each other through their common employment, there is ample opportunity for and little inhibition to such active discussion and mutual assistance.

6. Evaluation and Feedback. Careful records are maintained of TVI student performance on both homework and examinations. The performance of TVI students is regularly compared to that of (i) regular on-campus students in the classroom and (ii) local off-campus students taking the same courses by live television. These latter students also have an audio talk-back connection that permits them to ask questions of the instructor while the class is actually in progress.

The homework and test performance of the TVI students is analyzed by the Stanford TVI staff and the results are discussed with the tutors by telephone. Corrective measures are suggested when necessary. In addition course evaluation questionnaires are obtained from the TVI students to assess their attitudes and reactions to the program.

B. Initial Experimental Results. After the first two quarters of operation, the TVI experimental program was evaluated by comparing the course performance of the remote TVI students to that of both the on-campus and the HP students taking the same courses by live television. One result of this evaluation is shown in Fig. 1, using data gathered during the autumn and winter quarters of the 1973-74 school year. This figure shows the grade point averages of the TVI students for all courses taken under the program plotted against an abscissa of admission qualifications, the latter parameter being derived from a composite of corrected undergraduate grade point average (UCGPA) and the quantitative component of the Graduate Record Examination score (GREQ). (The correction to the undergraduate GPA was based on prior history of performance of students from the same school in doing graduate work at Stanford.) Also shown in Fig. 1 are similar data for on-campus graduate students taking the same courses as the TVI students. The regression line of Fig. 1 shows the best linear least-mean-square fit to the on-campus student data, from which the average expected performance may be obtained for a student with given input qualifications. It is apparent that all of the TVI students performed significantly better than expected, based on the on-campus regression line. While the admissions qualifications were on the average poorer than the typical Stanford Graduate Engineering student, the average performance in the courses examined was actually better than the on-campus average; in fact, the TVI students with the two lowest admission qualification scores would not have been admitted to the Stanford Graduate School based solely on these qualifications, but on the basis of their TVI performance have subsequently been admitted and have completed their MS degree programs with creditable graduate GPA performance. It is also useful to mention that for the first two quarters of the program the TVI students were required to come to the campus to take the same examinations as the on-campus students in the same physical setting. While this was occasionally a hardship for the TVI students, it did eliminate a number of factors that might otherwise have been used to minimize the performance of the TVI students (e.g., failure to perform under competitive test pressures).

A second evaluation of TVI student performance during the first two quarters of the 1973-74 school year is shown in Fig. 2, in which the off-campus industrial videotape student grades are compared both with on-campus classroom students and industrial students watching the same courses by live television. To provide a basis for comparison, the 302 on-campus students taking the courses under evaluation achieved a grade point average (GPA) of 3.38 out of a possible 4.00, which is typical of graduate electrical engineering students at the Master's level. The industrial students participating in the same courses by live television with audio talkback capability to the classroom had a GPA of 3.19, still quite acceptable but significantly below the on-campus students. The limited sample of TVI students taking the same courses by videotape with local tutors achieved an astonishing 3.67 GPA. The TVI students thus outperformed their industrial counterparts, who had comparable job situations and academic backgrounds but were using live television, by almost half a grade point. They also outperformed the on-campus students by almost a third of a grade point. This result is made even more remarkable when we recall that several of the TVI students had marginal academic qualifications that would have made their admission to the Stanford graduate program very unlikely. It is also interesting to note that the performance of students at Santa Rosa in the videotape courses without local tutors was substantially below that of all the other groups, although the data in this case was very limited.

These results raise several questions that deserve some comment:

(1) Clearly the total number of courses taken by students studying from videotape without a tutor is so small that the result has no statistical significance. However, a similar result has been obtained recently by Anderson [5] in a much larger experiment. In particular he finds that both student satisfaction and course performance tend to decrease as the delivery method is changed from on-campus lectures to live TV to non-tutored videotape.

(2) It is frequently argued that the industrial experience of the TVI students accounts for their outstanding performance. However, the TVI students are drawn from the same population as the students studying from live

TV, whom they outperformed, so industrial experience and/or motivation cannot account for these results. Furthermore, experiments to be described shortly show that on-campus TVI students also outperform on-campus students who attend the regular lectures. Hence the effectiveness of TVI is not limited to industrially-based off-campus students.

(3) It is also natural to question the degree to which the results may be due to a Hawthorne effect. However, as will be indicated in the next section, the Santa Rosa TVI students have continued their superior performance for three years. It seems somewhat unlikely that the Hawthorne effect can be made to persist for this period of time. And in any case, if the Hawthorne (or any other) effect can be used to improve performance over a full MS program, then we have used it to our advantage.

C. Continuation of the TVI Industrial Program. Because of the initially encouraging results with the Santa Rosa industrial TVI students, University permission was granted to continue the program and to incorporate TVI courses into an accredited graduate degree program. New students at the Santa Rosa plant of Hewlett Packard entered the program in both 1974 and 1975. At the end of the 1975-76 school year, after three years of operation, there have been 28 industrial students at Santa Rosa who have taken a total of 1191 quarter-hours of graded course work with an overall GPA of 3.34. Some of these students were interested only in occasional courses as a means of upgrading their professional skills in particular areas and had either already completed or did not wish to pursue a graduate degree. Eighteen Santa Rosa TVI students have been admitted to degree candidacy, and of these ten have now completed their MSEE degrees with an overall GPA of 3.42. If we exclude from this group four students whose academic qualifications were below those normally required for Stanford admissions, the resulting GPA for the graduating industrial TVI students at Santa Rosa is an impressive 3.59, considerably above the overall average for Stanford MSEE graduates with comparable backgrounds. The four formally "unqualified" students had a very respectable average GPA of 3.16.

In the 1974-75 school year the TVI program was further expanded to include a Hewlett Packard plant in San Diego, and in the Spring quarter, the Hewlett Packard plant in Boise, Idaho, adding some new dimensions to the program. In particular, the academic backgrounds and interests of the industrial students at these locations were very different from the Santa Rosa students, who were all electrical engineering majors as undergraduates. By comparison, eight of the ten engineers taking courses at San Diego had their undergraduate degrees in such fields as Mechanical Engineering, Physics, Computer Science and Chemical Engineering. With such varied backgrounds and in some cases marginal undergraduate grades the role of the local tutor became especially important for locating and filling gaps in assumed prior knowledge. Perhaps for this reason the San Diego plant has made the most thorough use of the technique of stopping the videotape for active class discussion and participation, sometimes spending as much as two hours to complete the 50 minute lecture. Of the 10 participating students at San Diego, 7 have now been admitted to the Stanford MSEE program and to date have completed 87 quarter hours of course work with an overall GPA of 3.17. The Boise industrial students also have varied backgrounds and academic preparation; however the Boise plant is sufficiently new that the program has not yet reached the necessary level of stability to permit meaningful data to be gathered.

The situation at the Sandia Corporation (Albuquerque) is also different from the three HP locations, and adds some new dimensions to the evaluation of TVI as an instructional methodology. Sandia has a highly developed inhouse continuing education program, and most of the professional engineers either have advanced engineering degrees or do not wish to pursue an MSEE degree at Stanford. Instead, the program has been used as a continuing education opportunity in selected areas by mature professionals, usually only taking a few courses of particular interest, or in a few cases as a means of preparation for and entry into a Stanford Ph.D. program. Few of the Sandia students have requested formal admission to the Stanford graduate program; nevertheless, the results of the program seem to have been favorable. By the ned of the 1975-76 year a total of 423 graded quarter-units have been completed by Sandia students with an overall GPA of 3.58.

In summary, during the first three years of operation of the TVI program, a total of 1803 quarter-units of graded course work, plus a considerable number of ungraded seminars, have been completed by industrial students. Their overall GPA for this work is 3.37. Furthermore their response to the technique is very enthusiastic. On the basis of these results it seems reasonable to conclude that, for science and engineering courses, the TVI format is <u>at least</u> as good as the other methods of delivery with which it has been compared. It can be clearly superior to these other methods, despite inadequate background preparation on the part of the students, if the course tutor is carefully selected and effective group interaction is achieved. We believe the method can be used effectively for other types of courses though we have no data to support this hypothesis. We have, however, used the technique in two on-campus experiments to determine whether full time graduate students could also profit significantly from the TVI approach. These experiments will be described in the next section.

D. <u>On-Campus TVI Experiments</u>. The first set of experiments was performed over two successive quarters in a graduate Electrical Engineering course that was large enough that several TVI groups (varying in size and with different tutors) could be formed for performance comparison with the large live lecture class. The course itself was taught by a faculty member who had already established a reputation as being a particularly effective instructor for both on-campus and industrial TVI students. Three TVI groups were formed, two of these being led by the same tutor. The tutors were chosen from a set of students who had performed equally well in the course during the previous year. Both tutors were very interested in the subject and were also interested in teaching as a career. However, their possible teaching styles were judged to be somewhat different. Where one tutor tended to answer questions directly when the tape was stopped, the other tended to encourage his group to find the answer themselves. The first tutor was given a group of six students (labeled Group III in the following Figures). The second tutor was given two groups of students, one with twelve members (identified as Group I) and one with six (identified as Group II).

At the outset it was thought that better controls in this case would permit more sophisticated statistical analysis of the TVI comparative educational effectiveness. It was found, however, that for a variety of possible reasons (small sample size, variation in tutor effectiveness, use of volunteers in the TVI groups, etc.) significant overall improved educational effectiveness could not be shown with high statistical reliability. However, as illustrated by Fig. 3, the data unequivocally support the hypothesis that the TVI method is at least as good as live instruction for all of the TVI students. Furthermore, for students with lower admissions qualifications, the TVI method of teaching was found to be significantly more effective than in-class teaching. In fact the regression line for TVI students in Figure 3 suggests that the course performance is essentially independent of the standard measures of academic ability. This finding, which agrees with the TVI results obtained with the off-campus industrial students, becomes even more important in view of the fact that the "lower ability" group in this study had undergraduate GPA's in the range of 3.0 to 3.3. It thus seems reasonable that students of "lower ability" may profit more from the TVI method of teaching, though this is to be expected to some degree because there is less room for improvement among the students of "high ability."

Student opinions of the TVI format were also collected at the end of each quarter and showed a generally enthusiastic response to the method. Some characteristic features of their responses are shown in Figure 4, from which some general effects of tutoring technique and group size can be determined. With respect to the effect of group size, it is clear from a comparison of Groups I and II (same tutor) that the smaller group was generally more enthusiastic about the TVI experience than the larger group. This same general result has been repeated in our industrial TVI groups, and a consideration of all of our present data on group size leads us to the tentative conclusion that the method works best when the group size is between 3 and 10.

Figure 4 also contains some specific information about the influence of tutoring styles that is consistent with our general observations. Specifically the students studying with the tutor who tended to answer questions directly (Group III) were less well pleased than students in a group of equal size studying with a tutor who tended to draw them into the discussion when the tape was stopped. Apparently, for on-campus TVI students, the opportunity to obtain direct answers from a tutor to more questions than could be asked of the in-class professor is not viewed as a major improvement, while the ability to discuss problems among themselves does represent a significant improvement.

The second set of experiments, performed during the Winter quarter of 1976, was conducted with the second half of an introductory graduate engineering economics systems course (EES201B) in which the regular course professor was away from campus. In the absence of a suitable replacement, videotapes of his course from the previous year were shown to the regular class in the presence of another instructor. However, for technical and scheduling reasons, the tapes shown to the large class could not be stopped for discussion.

Two small TVI groups were formed by random sampling from groups of students who had demonstrated high and low performance in the prior quarter, with each group having a separate tutor. A control group was also formed, consisting of 17 students who watched the videotape in the presence of the professor, but had no opportunity to ask questions or make remarks during the showing of the tape.

With respect to course grades, no statistically significant difference was found in the performance of the TVI and control groups, partly because of the small size of the sample groups, although again the data was consistent with the conclusion that the TVI students did at least as well as the regular class, and that the students of lower ability benefited more by the TVI educational method. In fact the comparison was frustrated by the fact that all low ability students in the control group dropped the course!

However, a pronounced difference was observed in student attitudes toward the use of a videotape with and without the combined tutor and tape stopping features. These results are shown in Figure 5, where the responses to several questions are recorded for the three groups of students ("low ability," "high ability" and control). Each question was answered on a preference scale which ran from +2 (strongly agree) to -2 (strongly disagree). Note that the "high ability" TVI group was highly enthusiastic on all counts, though their course performance was almost identical to what it had been during the previous quarter in the live lecture class. In fact the "high ability" TVI group stopped the tape on an average of every five minutes.

## IV. OBSERVATIONS

The tutored videotape instruction technique was invented in an effort to provide the benefits of both lectures and small group discussions to off-campus engineering students. Experience gained from three years of operation of the program suggests that the TVI technique is at least as effective as either classroom instruction or live TV with audio talkback capability, for both on-campus and off-campus students. However, our data is not yet sufficiently extensive to permit a rigorous statistical test of this conclusion to be made. We are also unable to generalize to subject areas other than engineering and science, though we believe the general principles of the TVI format will apply to a wide range of subjects and audiences.

To assist the reader in considering how the method might be applied to situations other than those described above, it will be helpful to enumerate the factors which we believe to be critical to the effectiveness of the TVI format and to provide some estimate of program costs based on our operating experience.

A. Factors that Contribute to the Effectiveness of TVI. Our experience suggests that the following factors are important for the educational effectiveness of TVI:

1. Tutor attitude, personality and instructional style are very important. The tutor should be willing and interested in helping the students

in his group. He should attend all or nearly all of the TVI sessions. Tutor competence is important, but it is better that he not be so over-qualified that he becomes bored or impatient with a lack of understanding in his students. Compensation for tutor effort is important for a continuing program.

2. Group size is also very important. Fewer than two or three students does not lead to good interaction and tends to make the method expensive, while group size greater than 8-10 tends to inhibit discussion and reduce the frequency with which the tape is stopped. A group size of 3-8 seems optimum, although this can vary with student personalities and acquaintance with each other.

3. Depending on the maturity of the student, committment to a degree program or similar educational objective may be important in sustaining interest and motivation. Certainly for most students completion of graded problems and examinations results in a more productive educational experience.

4. Active classroom participation in the live class is desirable. For the subjects and audiences served to date, unrehearsed, unedited videotapes of classroom lectures may be used and, in fact, may have more "presence" and be more interesting to watch than tightly-scripted, professionally-produced lectures.

5. It is important that the instructor be well-organized, knowledgeable in his subject, and free of annoying mannerisms. The charisma of a good instructor is emphasized on the videotape.

6. For industrial students, management attitudes toward participation play a very important role in the success of a continuing program. Job pressures which create long hours and interfere with family life markedly increase the difficulty of pursuing an educational program.

7. Continued management and evaluation of a TVI program needs to be the concern and principal responsibility of a person designated to coordinate and provide liason between the academic institution and the TVI students. Many

details require timely attention that would otherwise not be given by either the instructor or the company.

None of these factors impose unmanageable requirements, but they are all important. With attention to group size, good tutoring, quality of recorded educational material, adequate handling of supplementary materials and grading of problems and examinations, the TVI methodology can provide an excellent educational experience and opportunities for needed education in otherwise difficult or impossible situations.

Use of the TVI format in a large scale application will, of course, bring special problems of its own, such as difficulties in recruiting and training tutors, organizing and supporting large numbers of local tutorial groups, reproducing and distributing the videotapes and homework, arranging for the grading of homework and tests, and so on. Clearly our experience cannot offer much insight into how these problems can best be solved. However, the need for a separate administrative structure is apparent, since the grading alone for a large program could not be readily integrated into the daily operation of an existing educational institution.

With regard to the large scale distribution problem it is, of course, natural to consider the use of a satellite communications system for the transmission of lecture material and homework, and for telephone-based conferences between tutors and faculty. For the delivery of lectures, videorecorders could be installed at the separate sites to tape the lectures as they are received. Use of non-prime time and slow scan techniques could reduce the cost of such transmission. It might also be advantageous for the on-site tutor to watch the lecture as it is being taped and to call the faculty member to discuss problems before he shows the tape to his TVI group.

There is one cautionary note that should be added here, however. Intriguing as the use of satellites might be, in the TVI program they are basically replacing either the mail service or a closed circuit TV broadcast system that is operated in precisely the same way as the satellite system would be. Hence, there is a question of what the most cost-effective method of delivering TVI might be. There is also a question concerning the area over which it is advisable to distribute TVI groups. In particular, if a course requires regular face-to-face contact between tutors, faculty members and coordinators, a maximum travel distance of perhaps 500 miles is possibly indicated. In these cases the use of a satellite, which offers coverage over much larger distances, may actually encourage the distribution of TVI groups over a larger area than is desirable.

B. Equipment and Operating Costs Obtained from the Experimental Program. We conclude with a brief summary of the equipment and operating costs that have been obtained from an analysis of the experimental program operated at Stanford. More extensive cost data on the Stanford ITFS System is available in Miller and Baldwin [6].

1. Capital Equipment. Expenses for capital equipment can be divided into those associated with the classroom and those associated with the off-campus viewing facility. The classroom modifications that are necessary have been described in detail by Pettit and Grace [4] and include the provision of an overhead TV camera above the lecture platform, a camera mounted at the rear of the studio classroom, and appropriate lighting and air conditioning. These classroom modifications cost approximately $25,000. Control equipment and two black-and-white half-inch reel-to-reel videorecorders (one for back up) cost an additional $20,000, for a total of $45,000.

At each remote installation, two videotape players (one for back up) and a 17" TV monitor are set up on a cart that can be rolled into any of a number of viewing rooms at the off-campus site. The complete cost of this installation is somewhat less than $2,000.

2. Operating Costs. The operating costs for the experimental program will be stated on a per lecture basis:

| ITEM | AMORTIZED COST/LECTURE |
|---|---|
| 1. 1/2" tape @ $16, played twice per lecture | $ 1.00 |
| 2. Videotape players and recorders (amortized over 10 years) | 3.40 |
| 3. Student operators | 3.50 |
| 4. Tape mailing (preparation and round trip postage) | 5.60 |
| 5. Tutor salaries (for on-campus teaching assistant) | 3.50 |
| 6. Homework grading expenses | 2.00 |
| 7. Engineering and administration | 1.50 |
| 8. Space amortization | .50 |
| | $ 22.00/lecture |

The lectures can therefore be provided to a group of 10 TVI students at a cost of $2.20 per student-lecture. For comparison, the operating cost of "real time" television using the Stanford ITFS system is $2.43/student-lecture.

It should be noted that both the live television and the TVI operating costs are marginal costs; i.e., the cost of operating the on-campus class itself is not included.

## V. CONCLUSIONS

In conclusion, it seems worthwhile to summarize the principal advantages which we believe TVI has over both in-class instruction and live television. These are as follows:

1. It is (or can be) educationally more effective than either classroom or televised instruction, especially for marginally qualified students. This is primarily because it permits students to ask more questions and, through

organized discussion, find more answers for themselves than they could in either of the other formats.

2. It is cheaper than either classroom or televised instruction from the point of view of marginal costs. This is because it requires neither new educational plant nor expensive broadcast facilities.

3. It makes good use of teaching resources by using faculty for course preparation and paraprofessional tutors for discussion of the lectures. For this latter function it draws on the substantial (if latent) interest in tutoring that exists in a large segment of the population.

4. It allows instruction to take place at the convenience of the students. It is not bound by either the academic calendar or a broadcast schedule.

These advantages are substantial, and while over-generalizing is dangerous we nonetheless feel confident that TVI can be successfully extended to larger-scale applications, at least for courses in science and engineering. We believe the method can also be successfully extended to other subject areas. Such extensions will undoubtedly bring special problems of their own, but the probability of success seems high enough to warrant the effort of trying.

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## APPENDIX

### USE OF THE GUIDELINES FOR AN ANALYSIS OF SESAME STREET AND THE CHICAGO TV COLLEGE

The purpose of this appendix is to elaborate briefly on the guidelines that were described in Section II. For this purpose we will use the guidelines to analyze two very different ventures, Sesame Street and the Chicago TV College. For Sesame Street [7,8,9]:

(1) Target Audience. The program was designed primarily for inner-city pre-school children from three to five years of age. It has of course found wide acceptance amongst a far more general audience; however, it seems likely that other specific audiences could be better served by a somewhat different program.

(2) Educational Objectives. Instructional goals (viz., symbolic representation, problem-solving and reasoning, and familiarity with the physical and social environments) were carefully defined at the outset and were clarified for program writers through the Writers Workbook, in which each curriculum objective is described and strategies for achieving it are offered.

(3) Range of Media Employed. The major technology employed is broadcast television, though non-broadcast materials (magazines, books, games) have been developed and the educational effectiveness of the program is increased markedly when they are used.

(4) Media-sensitive Educational Staff. From the outset educational psychologists, specialists in children's education and television writers and producers worked together in the development and production of programs.

(5) Personal Interaction. An attempt is made to structure personal interaction through the distribution of a Parent Teacher Guide to Sesame Street, to be used in homes, day care centers and kindergartens. However, this component of the overall strategy has been far less successful than

other aspects of Sesame Street.

(6) Evaluation and Feedback. Individual programs were produced and tested for educational effectiveness nearly one year before they were actually broadcast. When broadcasting began, children from the target audience were tested in major instructional areas at 3, 6, and 9 week intervals and the results were used to modify the remaining programs.

For the Chicago TV College [8, 10]:

(1) Target Audience. The program was designed primarily for a home-viewing, highly-motivated audience that could not attend courses offered on the college campus.

(2) Educational Objectives. The audience was primarily interested in degree-oriented course work that was identical to course work already being presented on the college campus.

(3) Range of Media Employed. Broadcast television is used for course delivery. Telephone communication with the instructor is available immediately after the telecast. Course texts and other printed materials are also used

(4) Media-sensitive Educational Staff. Faculty who volunteer to teach on television are screened for academic excellence, classroom competence and television presence. Faculty who pass the preliminary screening are then trained by a TV production staff.

(5) Personal Interaction. Personal interaction between the faculty and students has been an important factor in the success of the program. Regular telephone contact between faculty and students has increased student retention in some courses from 25% to 60%.

(6) Evaluation and Feedback. Evaluation is provided by (i) a continuing survey of audience needs and characteristics carried out by the college and (ii) grading of homework and tests. One result of this continuing evaluation was that the telephone contact described above was instituted. Intervals between repetition of courses are also established in this way.

It will be clear from this comparison that the individual guidelines are not equally important in different situations nor do they fully describe the educational programs from which they were derived. Nonetheless we believe they can help educational planners in a general way to improve the use of technology in education. In particular, they provide some means of assessing the time scale and cost required to make technologically-delivered education effective. For example, the Chicago TV College is organized to make efficient use of an established educational institution and established instructional techniques. It attracts an already-motivated audience with known educational objectives. In such a situation the effective use of technology can be developed quickly and at low cost: The College aired its first programs only 3 months after planning began. The total planning budget was approximately $300,000, and the average cost per course for enrolled students over the first 3 years of operation was only $75.

For comparison, the production of Sesame Street involved the development of new educational techniques and a new form of collaboration between educators and media experts. As a result, nearly 18 months were spent in the planning, pre-production and testing of programs. The budget during these 18 months alone was nearly $2 million.

Before concluding this appendix, we also wish to elaborate further on the importance of choosing the technology correctly. In this connection, it is useful to mention the experience of WHA (state-owned and university-operated broadcast station in Wisconsin) with its program LET'S DRAW [11]. This program was designed to provide art education for children by radio broadcast. The program, which had been highly successful on radio, was transferred to television when that medium became available. It was soon discovered that the program was much less successful on television than it had been on radio, largely because the students tended to copy the television artist. The program was then returned to radio and is still successful there. Here we have an excellent example of the importance of choosing the technology in terms of the material being presented.

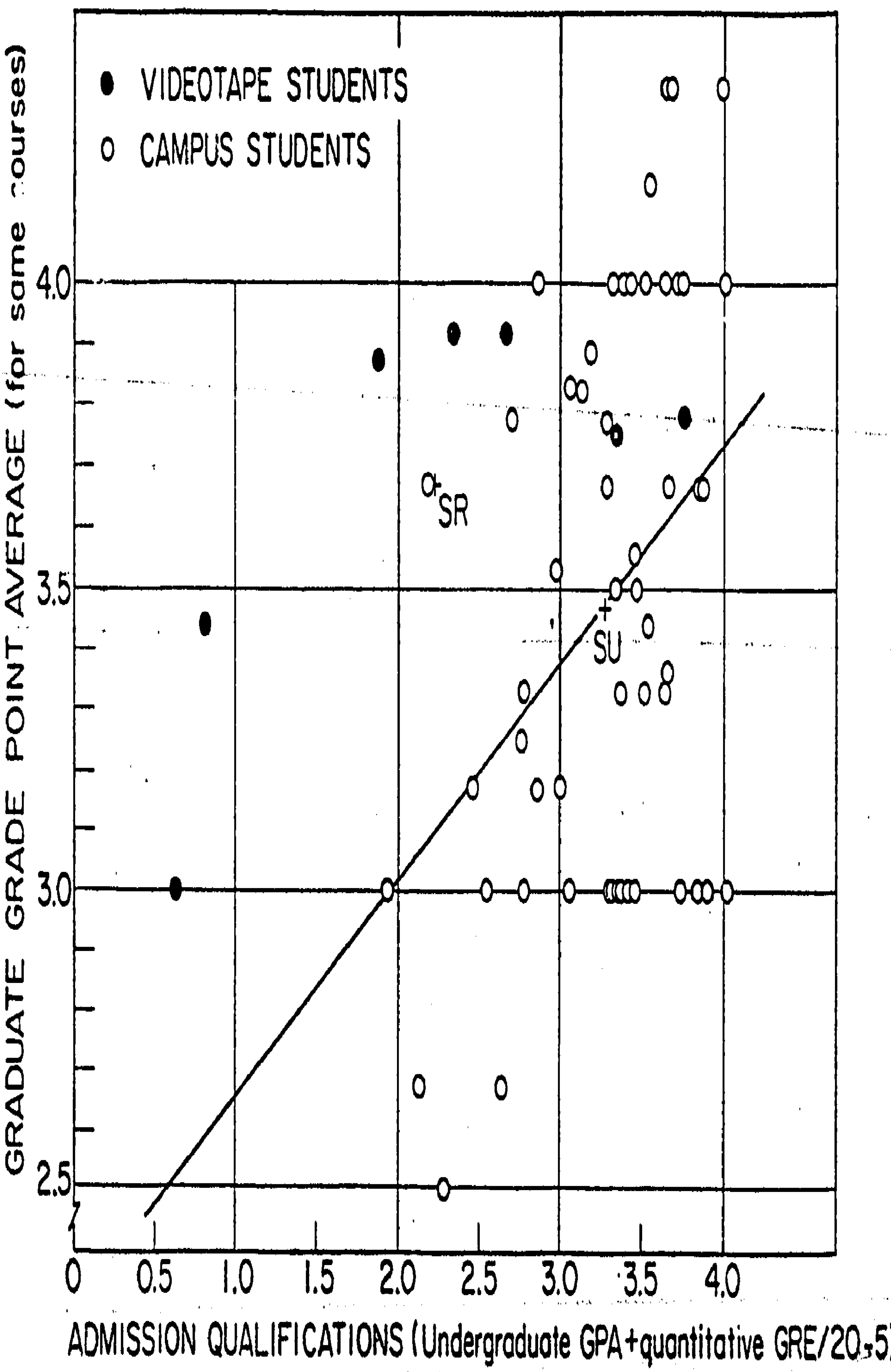




Fig. 1 - RESULTS OF TUTORED VIDEOTAPE INSTRUCTION EXPERIMENT (October 1973 - March 1974)

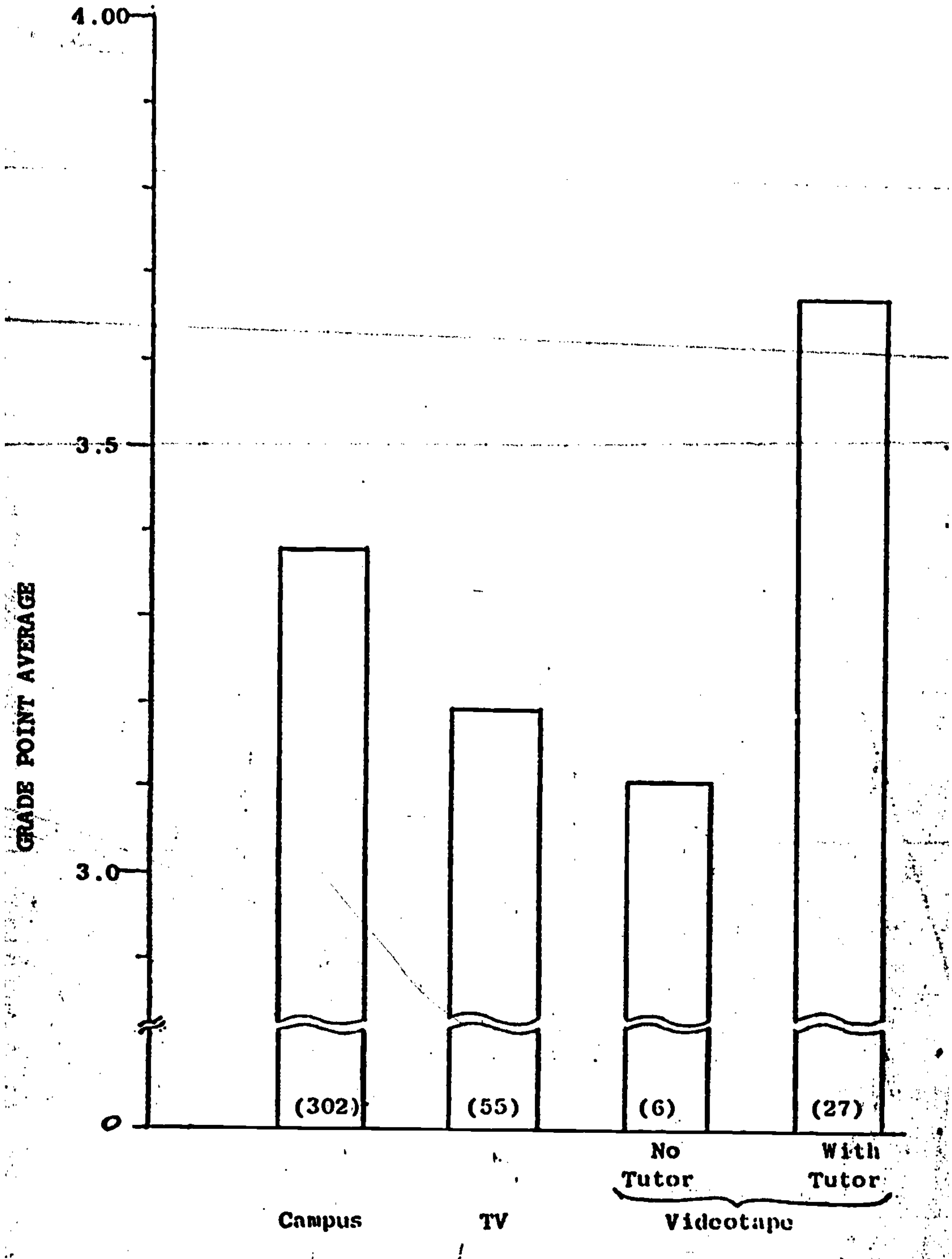


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FIG. 2 - RESULTS OF TUTORED VIDEOTAPE INSTRUCTION EXPERIMENT
(October 1973 - March 1974)

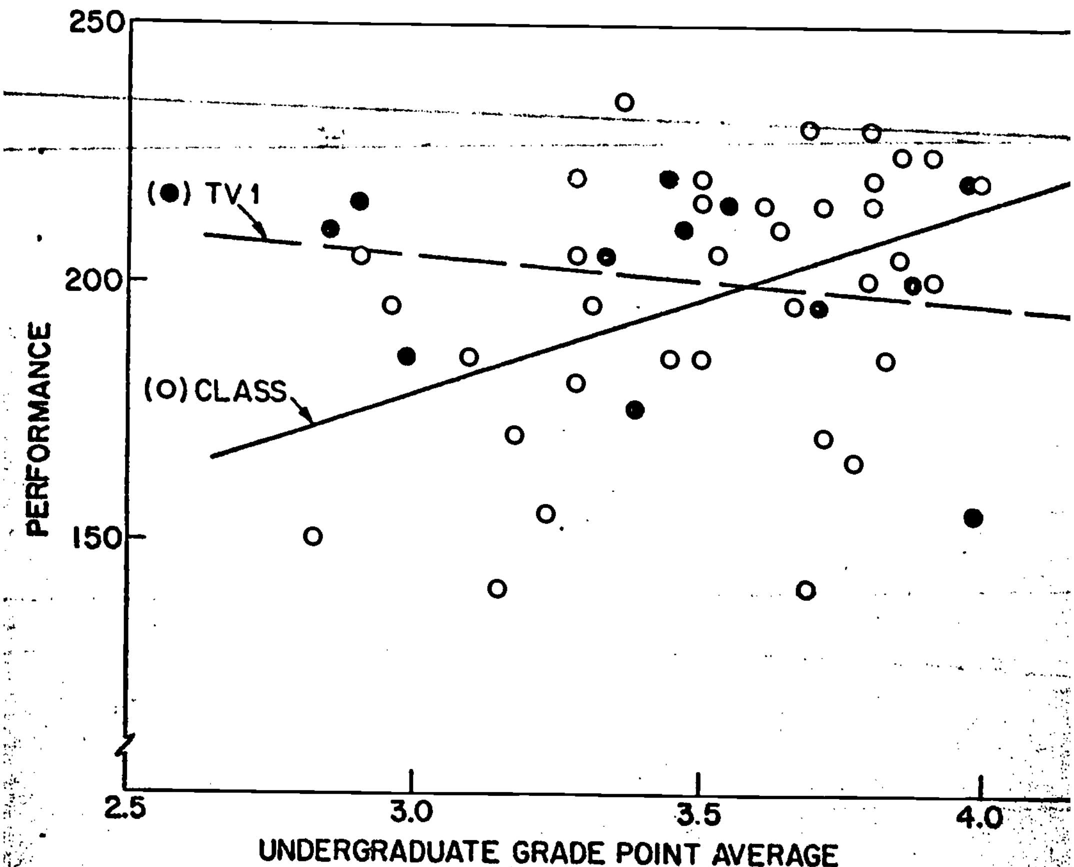
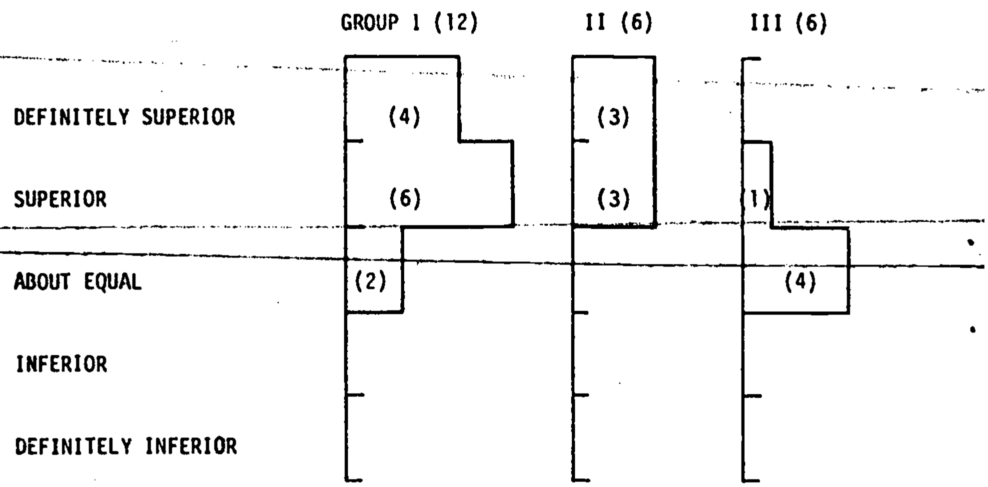
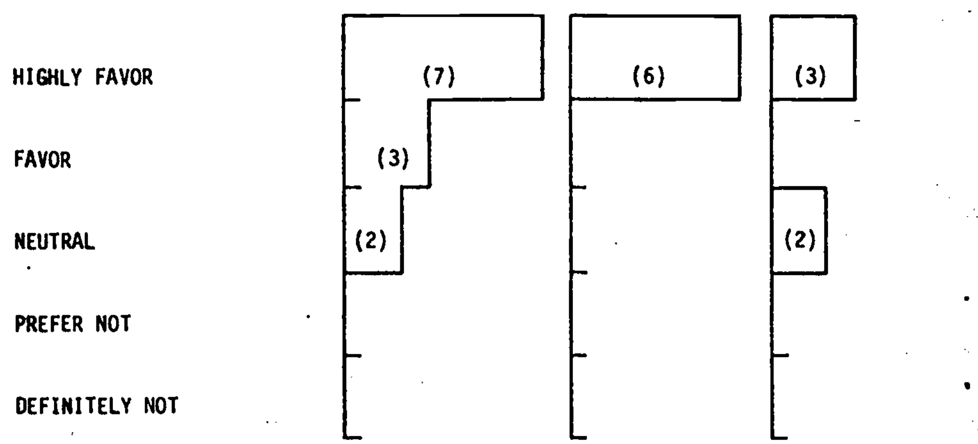



FIG. 3 - CLASSROOM AND TUTORED VIDEOTAPE INSTRUCTION STUDENT PERFORMANCE
(EE 221A - Winter 1975)




A. RATING OF TVI EDUCATIONAL EXPERIENCE COMPARED TO LARGE LIVE CLASS




B. FEELINGS ABOUT TAKING ANOTHER COURSE IN THIS MANNER

FIG. 4 - STUDENT REACTIONS TO TUTORED VIDEOTAPE INSTRUCTION ON CAMPUS
(EE 221A - Winter 1975)

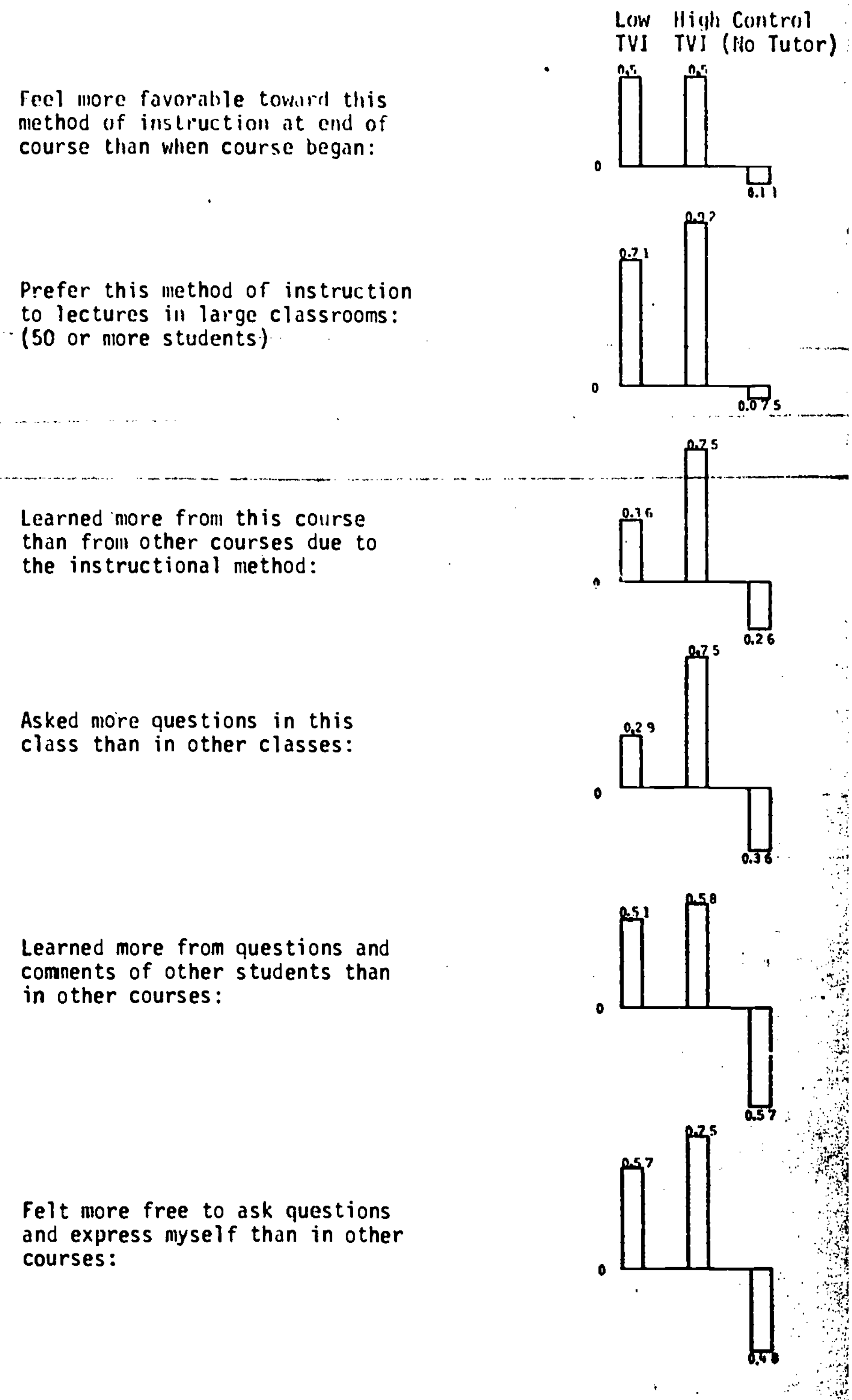



**FIG. 5 - CAMPUS STUDENT ATTITUDES TOWARD TUTORED VIDEOTAPE INSTRUCTION (EES 201B - Winter 1976)**