# INNOVATIVE, OFF-CAMPUS EDUCATIONAL PROGRAMS

# OF COLORADO STATE UNIVERSITY

by

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SUMMARY

For the past five years, Colorado State University has provided complete graduate study programs for engineers employed in Colorado's industrial and government facilities. Under the SURGE program, regular campus classes add part-time students who participate by seeing the classes on video tape on a two day delayed schedule at their place of employment. The faculty maintain consultation hours by telephone and visit the industrial sections twice a quarter. The video taping technique has been extended to provide educational programs for the students and teachers of community colleges and high schools, and also inmates of the state penitentiary. An average of 26 courses per quarter were offered in 1971-72 to 47 off-campus locations and 95 student groups. Over 400 video tapes were delivered by Colorado State University each week of the academic year.

Faculty productivity has been increased significantly. The operational costs and capital outlay for these programs are summarized herein. The average cost of instruction is shown to be appreciably lower than the cost for traditional instruction on campus.

UNIVERSITY-INDUSTRY COOPERATION: COLORADO SURGE*

Colorado has a concentration of technologically based industries and government facilities situated along the eastern slope of the Rocky Mountains in a narrow, 130-mile strip extending from Fort Collins to Pueblo (see Figure 1). In order to provide continuing educational opportunities for the professional employees of these industries, the College of Engineering of Colorado State University initiated Project Colorado SURGE in 1967. The principle aim of SURGE is to provide graduate-level course work to professional employees of Colorado industry and government

* Colorado State University Resources in Graduate Education

agencies regardless of geographical situation . Complete Master of Science degree programs are provided in Civil, Electrical, Mechanical and Industrial Engineering. Numerous courses are offered by the Departments of Mathematics, Statistics, Atmospheric Science, Watershed Science and the College of Business (ref. 1).

The course work is delivered to industries in the form of video taped class sessions with supporting written materials, produced for classes on the CSU campus. Every course in this program is a regularly scheduled offering on campus attended by full-time students. The SURGE classes are held in specially equipped studio-classrooms so that not only the lectures but also the student questions and discussions are recorded on video tape. After the tapes are made, they are packaged with class materials, assignments and examinations, and carried by a commercial delivery service to each of the industrial and government locations. The class sessions are viewed on a regularly scheduled basis by the off-campus students. The off-campus classes usually view class presentations two days following the on-campus class; over 80 per cent of these off-campus sessions are during regular working hours. Tapes, however, may be retained by the industry so that any person missing a class session may see the tape at some later time. After being viewed at the off-campus location, the tapes are returned to the campus, erased, then reused to record other class sessions.

The SURGE students are required to complete the same assignments, reports and examinations as the on-campus students. Laboratory work is frequently required in electrical engineering courses; the SURGE students use the laboratory facilities of their employer to perform these studies. The students of many courses need computer facilities to complete assignments. Here agin, the industrial computer facilities are utilized. To minimize the inconvenience of limited library facilities, the faculty frequently send a single Xerox copy of reference articles to each off-campus section.

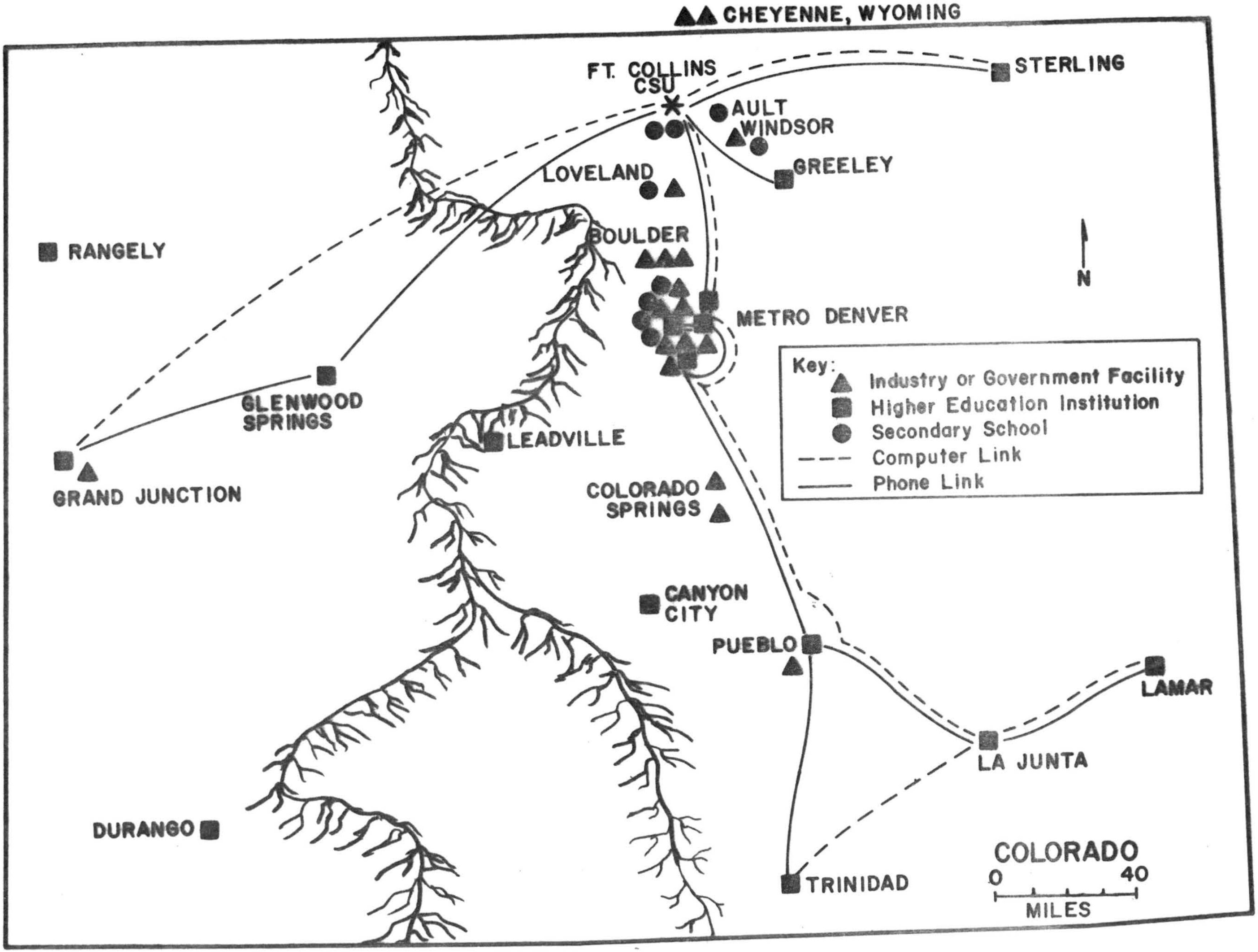


FIGURE 1:
LOCATIONS OF INNOVATIVE, OFF-CAMPUS EDUCATIONAL PROGRAMS OF COLORADO STATE UNIVERSITY.

In the spring of 1972, 23 industrial and government facilities are participating in the SURGE program. These are listed in Table I.

Table II is a summary of the number of courses and locations, and student enrollments, both on-campus and off-campus, for the history of the program. Appendix A lists the course titles and off-campus enrollments during this five-year period.

During the first three years of SURGE, the CSU Human Factors Research Laboratory conducted an educational evaluation of the program (ref. 2). These studies consistently indicated that the students in the remote classes were attaining levels of achievement equal to that of the on-campus students. Later surveys showed off-campus students' attitudes toward the video tape method of instruction were more favorable than to other options available to them. The faculty and on-campus students generally have favorable attitudes as well.

Students in the SURGE program are enrolled as graduate students of CSU and are charged the regular resident, part-time tuition rate which is currently $23 per quarter hour. The participating industries and government agencies provide playback equipment, classroom facilities and administrative support of the program. No other charge is made by the university. The SURGE students receive academic credit on official CSU transcripts. No notation is made to distinguish on-campus and off-campus students in the records.

While there is no prescribed pattern, each faculty member teaching on SURGE is encouraged to make at least two visits per quarter to each industrial location for direct contact with each of his students in a class. Additional live interaction between faculty and students occur in occasional telephone calls and more rarely, by student visits to the CSU campus.

In addition to courses being sent to the Colorado locations, CSU is currently offering courses to selected locations in California, New Mexico, Montana, South Dakota and Wyoming on an experimental basis.

TABLE I

INDUSTRIAL FIRMS AND AGENCIES

PARTICIPATING IN SURGE PROGRAM

Spring, 1972

| Company or Agency | City |
|---|---|
| Adolph Coors Brewery | Golden, Colorado |
| *Ball Brothers Corporation | Boulder, Colorado |
| Bell Telephone Laboratories | Denver, Colorado |
| C. F. & I. Steel Corporation | Pueblo, Colorado |
| Cobe Laboratories | Lakewood, Colorado |
| *Dow Chemical Company | Golden, Colorado |
| Eastman Kodak Company | Windsor, Colorado |
| Hewlett-Packard Company | Colorado Springs, Colorado |
| *Hewlett-Packard Company | Loveland, Colorado |
| *Honeywell, Inc., Test Instrument Division | Denver, Colorado |
| *I. B. M. Corporation | Boulder, Colorado |
| Marathon Oil Company | Littleton, Colorado |
| *Martin-Marietta Corporation | Denver, Colorado |
| Mesa College | Grand Junction, Colorado |
| *National Center for Atmospheric Research | Boulder, Colorado |
| Northeastern Junior College | Sterling, Colorado |
| U. S. Air Force Academy | Colorado Springs, Colorado |
| U. S. Bureau of Reclamation | Denver, Colorado |
| U. S. Bureau of Reclamation | Billings, Montana |
| U. S. Geological Survey | Denver, Colorado |
| U. S. Geological Survey | Cheyenne, Wyoming |
| White Sands Missile Range | White Sands Missile Range, New Mexico |
| Wyoming Highway Department | Cheyenne, Wyoming |

* Original locations for initiation of program, fall 1967.

TABLE II

COLORADO STATE UNIVERSITY

SURGE ENROLLMENT SUMMARY

1967 - 1972

| Quarter | | Number of Courses | Number of Locations | Number of Students On-campus | Number of Students Off-campus | Total/Yr. Off-campus |
|---|---|---|---|---|---|---|
| Fall, | 1967 | 4 | 7 | 105 | 189 | |
| Winter, | 1967 | 9 | 9 | 132 | 249 | |
| Spring, | 1968 | 8 | 9 | 100 | 206 | 644 |
| Fall, | 1968 | 12 | 13 | 283 | 341 | |
| Winter, | 1969 | 15 | 14 | 305 | 320 | |
| Spring, | 1969 | 13 | 15 | 314 | 288 | 949 |
| Fall, | 1969 | 15 | 14 | 209 | 336 | |
| Winter, | 1970 | 14 | 14 | 262 | 295 | |
| Spring, | 1970 | 14 | 14 | 162 | 165 | 796 |
| Fall, | 1970 | 17 | 15 | 232 | 403 | |
| Winter, | 1971 | 20 | 19 | 289 | 316 | |
| Spring, | 1971 | 18 | 16 | 235 | 202 | |
| Summer, | 1971 | 6 | 6 | 67 | 51 | 972 |
| Fall, | 1971 | 22 | 23 | 410 | 351 | |
| Winter, | 1972 | 24 | 22 | 353 | 284 | |
| Spring, | 1972 | 23 | 20 | 331 | 253 | 883 |

Advantages realized in the video taping of upper division and graduate courses for engineers and scientists in SURGE are:

1. Video tape allows complete freedom of scheduling of courses at each industrial location on a two-day, regular sequence.

2. Video tapes may be retained for those individuals who would otherwise miss a class because of illness or travel.

3. Students both off-campus as well as on-campus may use the tapes to review lectures.

4. Courses may be taught at locations beyond the bounds of a feasible live ITV system (there is no ITV system operating in Colorado at this time).

5. The capital cost of the video taping operation is significantly less than a live TV system capable of providing the same opportunities.

6. Faculty may review classroom presentations for self-evaluation.

During the first five years of the SURGE program, there have been 24 engineers of participating companies who have been awarded M.S. degrees completely through the video tape program. Over 12,000 quarter hours of university credit have been earned by other professionals without leaving their place of employment. The program operates at a reasonable marginal cost to regular campus offerings as will be discussed later.

UNIVERSITY-COMMUNITY COLLEGE AND COLLEGE COOPERATION: CO-TIE*

In the fall of 1968, Colorado State University and six other Colorado colleges, five two-year institutions and one four-year college, initiated a program which was originally aimed at enhancing the pre-professional course offerings at the six colleges. Project CO-TIE began with video taping sophomore level engineering courses at CSU and presenting them to students at the six participating colleges, thereby making it easier for the students

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* Cooperation Via Televised Instruction in Education

to transfer between these colleges and the engineering programs of universities (ref. 3 and 4). This cooperative program has now expanded to more colleges and into a variety of resource sharing activities which are summarized in Figure 2.

Much of the CO-TIE program activity utilizes the same equipment, studio classrooms, recording area and distribution methods as the SURGE program. In addition to the video taping equipment, CO-TIE employs a statewide audio network which interconnects the campuses and enables a continuing dialogue to occur between the faculty and students involved in the program. Using the audio network, CSU instructors provide real-time recitation periods to the students at the participating colleges. Instructors employ blackboard-by-wire equipment to illustrate subject matter for the off-campus students. Slow-scan television has also been used to transmit video frames over this network to the off-campus students during recitation periods.

By offering these college students courses identical to those taught at CSU, CO-TIE strives to overcome the age-old problem of subject matter deficiency which faces many students who transfer to the university. CO-TIE courses have saved many students at least a year in achieving their educational objectives.

The CO-TIE Project is a cooperative program among the participating colleges and does not usurp the role of any of the participating faculty. One of the significant aspects of CO-TIE is the involvement of the cooperating college faculty in the design of courses, laboratories and curricula. Among the significant activities included in the overall CO-TIE program are:

Avian Science -- Avian science became a part of the CO-TIE program in January, 1971, with the offering of a course related to poultry science and practice.

| | AVIAN SCIENCE | BIOCO-TIE | ENGINEERING | MATHEMATICS | COMPUTER NETWORK | AUDIO NETWORK |
|---|---|---|---|---|---|---|
| Aims Community College, Greeley | | ● | | ● | | ● |
| Arapahoe Community College, Littleton | | ● | ● | ● | ● | ● |
| Colorado Mountain College (East), Leadville | | ● | | | | |
| Colorado Mountain College (West), Glenwood Springs | | ● | | | | ● |
| Community College of Denver (Auraria) | | ● | | ● | ● | ● |
| Community College of Denver (North) | | ● | | ● | ● | ● |
| Community College of Denver (West) | | ● | | ● | ● | ● |
| El Paso Junior College, Colorado Springs | | | | ● | | |
| Fort Lewis College, Durango | | | ● | | | |
| Lamar Community College, Lamar | | ● | | | ● | ● |
| Mesa College, Grand Junction | | ● | ● | ● | ● | ● |
| Northeastern Junior College, Sterling | ● | ● | ● | ● | ● | ● |
| Otero Junior College, La Junta | ● | ● | ● | ● | ● | ● |
| Rangely College, Rangely | | ● | | ● | | |
| Trinidad State Junior College, Trinidad | | ● | ● | ● | ● | ● |

● Indicates program activity on campus



COLORADO STATE UNIVERSITY COOPERATION WITH HIGHER EDUCATIONAL INSTITUTIONS

FIGURE 2

By offering video taped lectures supplemented with other autotutorial materials, up-to-date scientific information about the poultry industry is presented to students who might otherwise not be able to obtain the information at the two-year college.

The avian science program for freshmen and sophomores provides video taped lectures, a coordinated textbook and a laboratory manual, audio tape-color slide packages supporting laboratory presentations, and permanently preserved specimens of laboratory materials.

This type of autotutorial course offering is useful to a community college which may not be able to offer a curricula as broad a desired.

BioCO-TIE -- In January, 1971, a new CO-TIE program came into being. BioCO-TIE (Biology Core Curriculum Cooperation via Televised Instruction in Education) is a cooperative program involving Colorado State University and thirteen two-year colleges in Colorado.

Colorado has a large reservoir of teaching talent among the biology faculties of community colleges. Through the use of video tape produced at CSU, project BioCO-TIE allows these faculties to employ effective audio-tutorial techniques in biology instruction.

Color video tapes 5 to 20 minutes in length are produced at CSU studios to provide visual support of classroom presentations at the colleges. A mobile television van is utilized to make recordings in the field, in laboratories and other locations. The color video tape recordings will be produced in CSU's television studios utilizing techniques specifically designed for illustrative and demonstrative materials. These visual materials assist the colleges in providing the second year of a core curriculum in biology for their sophomore students.

Community college faculty participate in all aspects of the BioCO-TIE program, including determining content of the tapes and participating in the making of tapes. In addition, the program draws from a resource of 450 biology-related faculty members and extensive laboratory and research facilities at CSU for preparation of the tapes.

BioCO-TIE provides an opportunity for the faculty of colleges to work together in developing effective methods of teaching basic undergraduate core courses in biology. In essence, BioCO-TIE is a teacher extending program, not a teacher replacement program. The program is supported in part by a grant from the Science Education Division of the National Science Foundation.

Computer Network -- The computer center at Colorado State University houses a large high-speed digital computer (CDC 6400). The on-line mass storage capacity is 170 million characters. This computer can perform scientific and business data processing as well as multiprogramming, multi-processing, time-sharing and date management tasks. Languages presently being supported are FORTRAN, BASIC, SNOBOL, COBOL, ALGOL, LISP, MIMIC, PERT, COMPASS, SIMSCRIPT and GASP. In addition, a program library of more than 1,000 fully documented programs and sub-routines has been developed, publicized and maintained.

Prior to 1971, the computer facilities available to serve the needs of Colorado's community colleges were nonexistent or severely limited. Consequently, students transferring to university programs or jobs which make significant use of computers, were at a great disadvantage.

Through a statewide computer network funded jointly by the National Science Foundation Office of Computing Activities and the state, nine of the participating CO-TIE colleges now have direct access to the complete capability of the digital computer on the CSU campus. A series of video tapes have been produced on such topics as Fortran IV and Cobol programming, file handling, and permanent files for use in the program. A series of summer institutes for teachers have helped introduce the new capability in an educationally sound manner.

Engineering -- Several basic courses taken by most engineering students in the sophomore year were not offered in Colorado community colleges prior to 1968. CO-TIE first focused on this deficiency. The program continues to offer three Electrical Engineering courses (Network Analysis) and one Civil Engineering (Fluid Mechanics) at the sophomore level. Regular campus classes are video taped and used by the participating colleges along with live tutorial sessions which twice each week make use of the audio network and its blackboard-by-wire equipment for each course. It should be emphasized that the community college students are registered at their institution for credit. Therefore, in each CO-TIE class, an instructor at the community college monitors student progress and administers examinations, several of which are coordinated with the CSU instructors.

Modern laboratories for the study of electronics have been developed at each of the CO-TIE colleges. These facilities though small, are important additions. A matching fund grant for scientific undergraduate instructional equipment from the National Science Foundation supported this cooperative effort.

Mathematics -- The CO-TIE program in mathematics began in 1969 with a grant from the College Science Improvement Program of the National Science Foundation. Each term a course is offered by CSU via video tape for the mathematics teachers of the community colleges. The purpose of the program is to improve the teachers' mathematical background so that they can become more effective instructors.

Most of the community colleges are not located near an institution which has a graduate program. Hence, CO-TIE allows teachers to remain on their regular jobs while they advance their education. The mathematics courses offered are at the graduate level; many participants apply the study toward advanced degrees.

Semi-annual meetings are held to discuss problems and identify curriculum suggestions. The purpose of the meetings is to reduce the problems which students have in transferring from a community college to a four-year institution. These meetings have encouraged mutual understanding and communication between the faculties. Summer institutes have been held at CSU to provide additional subject-matter training for the teachers in a coordinated manner.

UNIVERSITY-HIGH SCHOOL COOPERATION: HI-TIE

CSU has initiated a new project called HI-TIE which utilizes the same video taping facilities and studio-classrooms employed in the SURGE and CO-TIE projects. Through the HI-TIE project, CSU will offer courses for university credit to both students and teachers of Colorado's secondary schools. Through these video taped courses, secondary school teachers in a wide variety of areas will be able to complete in-service training and apply the credit earned to meet certification requirements. Students at the senior level will be able to embark on a university career prior to their high school graduation.

Two projects are already underway in HI-TIE: Freshman engineering and computing courses are offered to high school seniors and courses in mathematics leading to the M.A.T. degree are offered to junior and senior high school teachers in mathematics. These two programs are described briefly below.

Beginning in September, 1972, the CSU Department of Mathematics will offer video taped courses leading to the Master of Arts for Teachers (M.A.T.) degree. The courses will be taped in studio classrooms on the CSU campus then delivered to participating high schools. The HI-TIE program will, therefore, permit teachers to earn CSU graduate credit throughout the academic year which may be applied toward an advanced degree. These credits may also be used to satisfy certification requirements. This program will employ the techniques of the SURGE program which have been successful in offering mature, qualified professionals the opportunity of part-time graduate study at their place of employment.

The Department of Mathematics plans to offer two courses per quarter specifically for the HI-TIE program. Both courses will be at a level suitable for the M.A.T. degree program. Teachers in Colorado's schools are being surveyed by the Colorado BOCS (Board of Cooperative Services) to determine which courses in the above list are in highest initial demand.

Frequently, high school students simply overtake or outrun the course opportunities provided in their high school curricula. Having exhausted the advanced courses or study possibilities, a student in his senior year may find himself in a situation requiring less than full intellectual challenge. Currently, the geographical (and occasionally artificial) barrier which exists between high schools and universities almost precludes smooth transition between the senior year of high school and the first year of college.

Significant progress has been made in many areas of our country in recent years. For example, many high schools have designed flexible curricula which permit sophomores the opportunity to take junior and even senior courses. Freshman students in universities are routinely allowed to enroll in sophomore courses. Undergraduate students often earn graduate credit before receipt of their baccalaureate degree. One of the missing opportunities is the high school-university tie which would enable qualified students the chance to do college credit work on an elective basis.

A pilot program, presenting CSU's first ten-week freshman engineering course via video tape, was conducted with two Fort Collins high schools during the winter quarter, 1971. The pilot program was extended to five area high schools in the fall quarter, 1971. The response from the high school students who took the course, high school teachers and administrators, and CSU's own faculty was extremely encouraging. This enthusiasm has resulted in the proposed plans to implement this program with others on a statewide basis in the coming year. As a precursor to this expansion, CSU is now offering a Fortran IV course for teachers in eight high schools located primarily in the Denver metropolitan area. These teachers have agreed to serve as tutors for a freshman engineering class to be offered at these high schools by video tape during the fall quarter, 1972.

OTHER INNOVATIVE OFF-CAMPUS ACTIVITIES

In 1970 and 1971, much national publicity was focused on the unrest in the nation's prisons. Lack of educational opportunity was cited by prisoners and prison officials alike as being one of the contributing reasons for unrest. Educational programs are known to be useful in rehabilitation efforts of almost all penal institutions. In the past, most effort was put into vocational training; in fact, many prisons have extensive auto and electric shops wherein inmates may learn by on-the-job practice. In a few cases where prisons are located near college campuses, professors are offering evening academic classes to the prisoners in the classic mode used by extension programs.

From the experience in the SURGE and CO-TIE programs CSU faculty members believe that the offering of university level courses to mature persons is possible using modern communication capability. In the spring quarter, 1972, the Department of Mathematics is offering a 5 quarter-credit freshman mathematics course to inmates of the Colorado State Penitentiary at Canon City. The students are regularly enrolled CSU students and receive credit on a transcript upon successful completion of the course.

The instructor employs video tapes of a campus class together with blackboard-by-wire sessions to illustrate concepts for his students who are located 150 miles away.

CSU intends to expand the prison project by offering courses to the inmates in several different disciplines. Complete programs are being planned so that it may become possible that persons enrolled in the "university within walls" will be able to obtain a good start toward a college degree.

FACILITIES

The class sessions for the various outreach programs described herein are recorded in regular classrooms which have been specially equipped. A few graduate seminar sessions in management and all the recordings for the BioCO-TIE activity are produced in the university's color production studio. Only the studio classrooms and supporting facilities used for the great majority of the off-campus instruction are described below.

Studio Classrooms -- One of the four CSU studio classrooms is illustrated in Figure 3. Each classroom is equipped with at least three cameras. A camera over the instructor's desk allows him to display written or illustrative materials. The instructor controls the overhead camera for functions such as zooming, focusing and composing. A monitor at the instructor's desk displays the picture being generated by the overhead camera. Another camera at the back of the room is mounted on a pan-tilt head; this camera is controlled by a technician in the central record facility. The technician may remotely pan-tilt-zoom and focus the rear camera. If the instructor goes to the three-panel chalkboard or walks around the room, the technician follows his movements. A wide angle, fixed camera at the front of the room is located to pick up a segment of the student class. By means of switches at the instructor's desk, the instructor selects the camera which is to be recorded. Two rooms have split-screen capability which allows the instructor to show two pictures on a single screen. Two monitors are located at the front of the room to allow students in the class to see all material presented via the overhead camera. A button is located in front of each student to activate an overhead microphone, which picks up the questions and other dialogue between the professor and students. Because students sometimes fail to push the microphone button, a similar button is located at the instructor's desk and the console at the recording headquarters.

Two of the studio classrooms are identical to that shown in Figure 3. These rooms each seat 30 students. A third studio-classroom was tailored for the needs of the highly interactive instructional methods which are common in the College of Business. This seminar room accommodates 16 students around a large oval table. The TV camera arrangement is similar to that outlined above. A fourth studio-classroom seats 125 students in a small wedge-shaped auditorium.

<u>Control Console</u> -- Each classroom has an individual console at the recording facilities where a technician (frequently a work-study undergraduate student) is employed whenever an instructor is in the classroom. Figure 4 is a view of this area. The technician operates the back camera electronically from this location. He has telephone communications to the professor and can override the audio gain. Courses are not rehearsed, thus, the technician listens to the class presentation and takes verbal cues so as to display the best picture possible on video tape.

<u>Record Area</u> -- The record facility shown in Figure 5 consists of thirty-two video tape recorders and monitors on which tapes are made for the remote locations. An original video tape record is made as the class is conducted on-campus for each off-campus section. A switcher designed

STUDIO CLASSROOM INSTRUCTOR'S CONSOLE

FIGURE 3

by the television staff is used to program the needed number of recorders for any given course. The number of tapes needed for each classroom varies from hour to hour.

Tape Delivery -- Each video tape in the inventory is given a number. A card catalogue is maintained on all tapes recording the location of each video tape within the system. Tapes are packaged in fiber shipping cases and addressed for the proper destination. Each evening the tapes are picked up by commercial courier for delivery the next day at each remote location. Approximately 400 tapes are shipped to the remote locations weekly.

Audio Network -- Recitation and tutorial sessions are scheduled for CO-TIE, HI-TIE and the pententiary participants over a dedicated audio network (see Figure 1). Over 1,000 miles of full duplex voice-grade lines of the Mountain Bell Telephone network are devoted to audio use in these projects. In addition to two-way audio communication being available for dialogue an electromechanical writing system located at CSU (Figure 6) is used to transmit graphic information to TV monitors at the off-campus locations. Slow-scan television is also used on an experimental basis between CSU and Mesa College, Grand Junction. The blackboard-by-wire and slow-scan TV utilize the same lines as used for the audio. An additional 1,000 miles of full duplex voice-grade lines are used to interconnect CSU with nine campuses participating in the computer network. Most of the lines used for the computer network are part of the state-owned microwave system originally built for the Colorado State Highway Patrol now operated by the Colorado Department of Administration, Division of Communications.

PROGRAM COST

The institutional setting can greatly affect the costs of any program. In order to properly qualify the information to be presented

**CENTRAL RECORDING CONTROL CONSOLE**

FIGURE 4

CENTRAL RECORDING FACILITY

FIGURE 5


**CO-TIE COMMUNICATIONS FACILITY**

FIGURE 6

concerning costs of the off-campus programs, a brief statement concerning the Colorado State University setting is in order.

Colorado State University in 1967 did not have a history of either off-campus general extension or evening courses offered on-campus for part-time students. Consequently, the university had no administrative superstructure to manage general extension. Faculty were not accustomed to extra pay for off-campus or evening instruction. When the SURGE program was initiated by the College of Engineering, the Dean of Engineering chose to integrate the activity into the resident graduate programs of the departments. The Dean of the Graduate School obtained approval from the faculty committees and faculty government for the changes of traditional rules necessary to accomplish this integration. The faculty, therefore, added the part-time students to regular classes with the full expectation that traditional standards of graduate student attainment would be met. It was also possible to obtain the full impact of increased faculty productivity without the burden of a new administrative structure.

On the other hand, the University had taken steps in 1965 to organize media support within the Office of Educational Media as a central service organization. The function of this organization is to provide University-wide media support through its five operating units: Audio-visual, Graphics, Motion Picture, Photographic and Television Services. The total level of expenditure of the Office of Educational Media for staff and expenses in 1971-72 is approximately $500,000.

When television was implemented on campus at Colorado State University in 1965, a television policy was adopted by the governing board which placed the responsibility within the Office of Educational Media for: general supervision of all TV programs; purchase, inventory and maintenance of all equipment; all operating funds for the production and distribution of televised materials for resident instruction. Professional staff were employed for the television operation. Moreover, staff of the Office of Educational Media had demonstrated a strong willingness and ability to deliver. Thus, the replacement of this responsibility was not a function of authority but rather a means of obtaining a coordinated, well-managed program with an avoidance of splintering and duplication.

Projects such as SURGE, CO-TIE, HI-TIE and others have been smoothly integrated into an active campus program. There are several advantages to this procedure. Much test apparatus and other equipment needed for the on-campus program is available to be used for the new off-campus programs. One highly qualified television engineer is able to design the off-campus program components as well as the growing campus system of TV. Video tape, recorders and related items are bid in University-wide quantities, thus reducing cost. Technical standards and equipment compatibility is maintained and improved utilization of both facilities and staff is realized. As the off-campus programs at Colorado State University expand into many disciplines, the inclusion of such efforts under a single service organization continues to be advantageous. Of course, all academic decisions remain the responsibility of the academic departments and colleges involved.

The cost of instruction for the SURGE program which serves practicing engineers and professionals in industry can be estimated with precision, because the program has completed five years of operation and attained a relatively stable level of activity. The following discussion concentrates on this program although much of the information on the cost of operation is applicable generally to all regularly scheduled courses video taped for use off-campus.

Faculty productivity measured in terms of student-credit hours, increased significantly in SURGE courses. The five year average enrollment of students per course is 16.2 on-campus and 18.2 off-campus. There has been no adjustment in faculty teaching schedules due to this additional load. Rather, grading and graduate assistant help has been supplied to accommodate the increased enrollment.

The "direct cost of instruction" on-campus in the traditional mode is defined here as the instruction cost (faculty salaries) divided by the total number of student credit hours associated with that instruction. This index is frequently cited as a measure useful for comparing regional variations between similar schools and between various disciplines. Clearly, although a dominant cost in most instruction, this factor does not represent the total cost of instruction. The direct cost of instruction on-campus in the CSU College of Engineering averaged over all levels of instruction in 1971-72 is $40.20 per quarter student credit hour (qt. cr.). Comparable data gathered by Dr. F. E. Terman and averaged over seventy-one engineering colleges yields $46./qt. cr. (J. Engr. Ed., 59, pp 510-514, (1969); a six per cent annual increase was assumed to update these data). It is widely recognized that graduate level instruction is appreciably more costly than undergraduate and that wide variations in this index are usually found between the physical sciences and social sciences. For the M.S. level, SURGE courses which are predominantly in engineering and mathematics, the CSU direct cost of instruction on-campus has beem estimated to be $65./qt. cr. This figure is viewed as a conservative estimate for graduate instruction which averages 16 students per course. Any effective, non-traditional instructional system would generally be expected to compete with $65./qt. cr. if introduced on-campus. We apply such a comparison directly to the off-campus instruction of the SURGE program.

The cost of the SURGE program can be divided into three broad categories: (1) amortization of equipment, recording space and tape; (2) operating cost of production, delivery and program administration; (3) incremental direct instructional cost of adding off-campus students to existing classes. We discuss these cost categories in the following paragraphs in a manner which makes the scaling laws of the program clear. That is, we will focus on the cost of recording a class hour in a studio classroom plus the cost of making and delivering tape copies with instructional support.

Appendix B contains the details and supporting data for this analysis. Only the results are given below.

Equipment, Recording Space and Tape -- The cost per hour of recording is dominated by the amortization of the $25,000 for the remodeling and equipping of a studio classroom and control console. Assuming five year amortization with six per cent interest and 1000 hours per year of utilization, we calculate $6./hr. Note that only the cost of the TV facility is considered, because a regular on-campus class must be held in a classroom and we are interested only in the direct cost of adding off-campus students via video tape.

A video recorder and monitor ($800) was amortized over three years assuming 1,000 hours/year of use and six per cent interest. The resultant cost if $0.30/hr.

An hour reel of 1/2-inch video tape purchased in large lots costs $20. An average life of 100 uses yields $0.20/hr.

The video tape original copy which is costed above, is not distributed to off-campus students, but rather serves as a redundant or spare copy to insure system reliability.

The central recording facility space which houses the control console and a single recording unit is 300 sq. ft. This space was valued at $30/sq. ft. and amortized over 40 years with interest. This cost increment is $0.60/hr.

The total cost in this category for recording an hours' class time is the sum of the above or $7.10/hr.

Each additional tape copy requires $0.30/tape for recorders and monitors and $0.20/tape for the tape inventory. That is, the incremental cost in this category for each additional tape is $0.50/tape.

Operating Cost of Office of Educational Media -- The basic operating budget for production and program management at CSU for the current level of activity (80 courses/year) is $60,300. This budget includes fractional time of an administrator, a program coordinator and a TV engineer plus two full time TV technicians and a secretary. Other direct costs include student labor, supplies and spare parts, travel and telephone, and program correspondence. At the level of 80 courses per year or 2400 recording hours, this base operating budget is $25.15/ recording hour.

Each tape copy of an hour's length requires an additional $0.50 for tape handling and $2.50 for round-trip delivery by commercial courier. The incremental cost in this category for each delivered tape is $3.00/tape.

Operating Cost of Instruction -- The faculty does not receive any additional pay or work load allowance for teaching a regular campus class in the studio-classroom. So there is no instructional cost for the recording hour. Rather it is the instructional support of the off-campus students which must be estimated here. The marginal cost of adding 15 students to a 3 qt. cr. course is assumed to be 10 hours/week of graduate teaching assistance to help the professor with all aspects of the instruction. This allowance amounts to $1.00 for each off-campus student who views an hour length tape, or if we let S be the average off-campus enrollment in a SURGE location, $1.00 S /tape. To this incremental direct cost we add an allowance for secretarial support, supplies and telephone of $0.30 for each off-campus student who views a tape, or $0.30 S /tape. A travel allowance for the direct cost of faculty visits to the SURGE locations is $1.25/tape, independent of the number of students in a location but directionally proportional to the number of locations (or tape copies made each recording session).

The total cost of instructional operating expenses can be expressed in formula fashion as: (\$.75 + \$1.30S )/tape, where S is the average student enrollment in each off-campus section.

Total Cost of SURGE Instruction -- The factors outlined above are summarized in the following table in 1971-72 dollars.

| | Dollars per Recording Hour | Dollars per Delivered Tape |
|---|---|---|
| Equipment, Space and Tape | 7.10 | 0.50 |
| Office of Ed. Media Operating Expenses | 25.15* | 3.00 |
| Instructional Operating Expenses | -- | 1.25 + 1.30 S |
| Total | \$32.25 | \$4.75 + \$1.30 S |

* Based on ability to operate at current CSU level of 80 courses/year. This value becomes about \$18.35 for enlarged program of 160 courses/year.

The CSU unit costs of off-campus instruction for the 1971-72 SURGE programs can be computed from these cost factors. The following enrollment and program data are required:

Total Courses = 69

Total Sections* = 261

Total Off-campus enrollment = 883

Therefore, $N = \frac{261}{69} = 3.78 \left(\frac{\text{sections}}{\text{course}}\right)$ or $\left(\frac{\text{tapes}}{\text{recording hour}}\right)$

$$S = \frac{883}{261} = 3.40 \left(\frac{\text{students}}{\text{section}}\right)$$

and let C = qt. credits granted for 10 contact hours of course work.

$$F = \frac{\left(\frac{\text{recording hours}}{\text{course}}\right) \cdot \left(\frac{\text{dollars}}{\text{recording hour}}\right)}{\left(\frac{\text{ave. off-campus student credits}}{\text{course}}\right)}$$

where $\left(\frac{\text{dollars}}{\text{recording hour}}\right)$ is subdivided into fixed cost/course hour

plus variable costs/course hour.

$$F = \frac{(10C) \cdot \left(\$32.25 + [\,\$4.75 + \$1.30\ S\,]\ N\right)}{N \cdot S \cdot C}$$

$$F = \frac{322.5}{NS} + \frac{47.5}{S} + 13.$$

$$F = \frac{322.5}{(3.78)\ (3.40)} + \frac{47.5}{3.40} + 13.$$

$$F = \$51.97/\text{qt. cr.} \approx \$52./\text{qt. cr.}$$

---

* A section is a group of off-campus students meeting at a location and requiring a tape.

Recall that the on-campus instruction in these courses has a direct instructional cost of \$65./qt. cr. for an average course enrollment in 1971-72 of 15.6 students. The average cost of instruction for <u>both</u> on-campus and off-campus instruction is:

$$F_{ave} = \frac{15.6(65.) + 12.9(52.)}{15.6 + 13.0} = \$59/\text{qt. cr.}$$

Clearly, the program lowers the instructional cost from the point of view of the university and also increases faculty productivity. But it should be stressed that this is a very narrow view of the cost of this instruction. If the part-time student had commuted to campus during his regular work hours, the opportunity cost which is neglected here would have been large indeed -- perhaps, \$300./qt. cr.! Furthermore, the university may have been required to add campus classroom space and parking. Even more important, the cumulative cost of technical obsolescence to the national economy should be estimated because advanced engineering and management training frequently does not occur unless programs like SURGE are initiated.

The cost factors tabulated above are realistic and may be useful more generally than simply estimating the cost of a specific program in Colorado. For example, the decision whether to install a video tape system or an ITFS broadcast system, is a trade-off study between subtracting \$3.50 N (the cost of making and delivering tapes) and adding the amortized cost of the ITFS hardware on a course hour basis to the base value of \$7.10. For example, see "Technical and Economic Factors in University ITV Systems," by C. A. MartinVegue, Jr., A. J. Morris, J. M. Rosenberg, and S. E. Tallmadge, <u>Proceedings of the IEEE</u>, Vol. 59, No. 6, pp. 946-953, June, 1971. Appendix B includes two example calculations which show the gains of scaling economies which are possible through the expansion of existing CSU program.

DIFFUSION OF INNOVATION

Descriptions of the SURGE and CO-TIE programs have been widely distributed. During the past five years, nine journal papers describing various facets of these programs have been published (references 1-9) and presentations at eleven national conferences and meetings have been given (references 9-20).

CSU hosted a self-supporting symposia on SURGE and CO-TIE for three days in the summer of 1970 which was attended by 35 people. During the past three years, an average of twenty groups per month visit the campus to view the SURGE and CO-TIE activities. To date, there have been a total of approximately 7,000 visitors from every state and many foreign countries. Among these visitors have been many college presidents and vice-presidents, state and federal legislators, state and federal bureaucrats and state department of education officials.

Federal and foundation officials frequently bemoan the fact that effective, economical practices are not immediately and widely adopted in education. We believe that a major cause, though undoubtedly only one of many, is the total lack of consideration which is given to capital outlay amortization in budget preparation. In a growing system, physical plant construction may be financed over several years by bonds. But rarely do public officials make a decision from alternatives which recognize that most technically based options are capital intensive and will not survive a budget exercise which focuses on minimum expenditure <u>that year</u>. State officials strive increasingly to control annual expenditures, and rightfully so, but "tight budgets" are wedded to fixed labor costs and perpetuate the spiraling costs of a labor intensive system. At the local operating level, we have had essentially no capital outlay or remodeling money budgeted at CSU for the 1971-72 and upcoming 1972-73 academic years. Therefore, federal programs must recognize that innovational diffusion is greatly inhibited by our inability to plan capital expenditures properly.

ACKNOWLEDGEMENTS

The cooperative programs described herein have benefited from the active support of many faculty, administrators and students. We will limit specific thanks to our direct financial sponsors.

President A. R. Chamberlain has directed the introduction of instructional TV on the CSU campus since 1965 when he served as Executive Vice-President. Faculty commitment to specific goals has been a necessary prerequisite for CSU administrative support.

The National Science Foundation has supported a portion of the initial costs for several programs. The SURGE program in its first year was partially supported by the National Science Foundation, Division of Graduate Education in Science Grant GZ-753 (L. V. Baldwin, Principal Investigator). CO-TIE received partial funding from National Science Foundation, Division of Undergraduate Education in Science, Grant GY-5305 (Lee M. Maxwell, Project Director). Federal participation in the computer network and related teacher-training and curricula development came from National Science Foundation, Office of Computing Activities, Grant GJ-1086, (Lee M. Maxwell, Project Director). The CO-TIE computer project is also being partially funded by grants from Control Data Corporation. Partial support for the engineering laboratory development project was awarded by NSF Grant GY-8197 (L. M. Maxwell, Project Director). BioCO-TIE is partially supported by National Science Foundation, Division of Undergraduate Education in Science, Grant GY-9337 (John P. Jordan, Project Director). Ralph Niemann directs the in-service teacher training activities of the Department of Mathematics, College Science Improvement Program, GY-6599, and In-service Seminar Program, GY-5424.

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# APPENDIX A

## ENROLLMENT RECORDS

### Spring Quarter, 1972 Course Enrollments

(All courses SURGE unless otherwise noted)

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 570 | Air Pollution | 6 | 22 | 15 | |
| AT 620 | Climatology | 3 | 8 | 27 | |
| BG 476 | Operations Research II | 4 | 10 | 26 | |
| BG 720 | Management Seminar | 4 | 28 | 23 | |
| CE 550 | Foundation Design | 2 | 3 | 8 | |
| CE 568 | Advanced Structural Design | 1 | 5 | 9 | |
| CE 640 | Sanitary Engineering, Unit Processes | 3 | 10 | 10 | |
| CE 753 | Design of Earth Dams | 3 | 8 | 11 | |
| CE 761 | Theory of Elasticity | 2 | 6 | 10 | |
| ED 528 | Secondary School Reading Development | 1 | 8 | 30 | |
| EE 202 | Network Analysis II | 2 | 3 | 58 | CO-TIE |
| EE 413 | Control Systems III | 2 | 3 | 11 | |
| EE 421 | Communications Systems I (For Summer) | 3 est. | 25 est. | 21 | |
| EE 432 | Pulse Circuits II | 7 | 18 | 19 | |
| EE 503 | Active Network Synthesis III | 6 | 18 | 24 | |
| EE 583 | Digital Systems Design III | 3 | 5 | 9 | |
| EE 682 | Digital Signal Processing II | 7 | 20 | 5 | |
| M 121 | College Algebra | 1 | 11 | 15 | CO-TIE |
| M 433 | Applied Mathematics III | 6 | 11 | 21 | |
| ME 420 | Intermediate Mechanical Vibrations | 3 | 6 | 7 | |
| ME 432 | Quality Control | 7 | 14 | 14 | |
| ME 495 | Fortran Programming | 6 | 11 | 0 | HI-TIE |
| ME 586 | Topics in Bioengineering | 2 | 4 | 7 | |
| ME 788 | Operations Research Methods | 3 | 10 | 2 | |
| ME 824 | Applied Thermoelasticity | 2 | 5 | 6 | |
| PY 797a | Employment of Minority Personnel | 6 | 23 | 0 | |
| ST 525 | Time Series Analysis | 2 | 8 | 16 | |
| (27 courses) | | 97 | 303 | 404 | |

### Winter Quarter, 1972 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 750 | High Atmosphere Meteorology | 1 | 3 | 0 | |
| AT 788 | Survey & Meteorological Satellites | 4 | 18 | 7 | |
| AV 101 | Poultry Science | 2 | 39 est. | 38 est. | CO-TIE |
| BG 570 | Business Decision Making | 3 | 11 | 25 | |
| BL 560 | Research & Development in Industry | 5 | 17 | 5 | |
| CE 512 | Hydraulics of Open Channels | 3 | 17 | 15 | |
| CE 602 | Intermediate Fluid Mechanics | 3 | 4 | 21 | |
| CE 639 | Sanitary Engineering, Unit Operations | 3 | 14 | 11 | |
| CE 760 | Theory of Elasticity | 2 | 6 | 14 | |
| CE 795d | Studies in Mechanics | 1 | 6 | 2 | |
| ED 427 | Foundations of Reading | 1 | 9 | 30 | |
| EE 201 | Network Analysis I | 4 | 8 | 62 | CO-TIE |
| EE 202 | Network Analysis II | 1 | 1 | 69 | CO-TIE |
| EE 412 | Control Systems II | 4 | 7 | 13 | |
| EE 431 | Pulse Circuits I | 7 | 16 | 21 | |
| EE 472 | Solid State Theory | 1 | 2 | 6 | |
| EE 502 | Active Network Synthesis | 7 | 21 | 29 | |
| EE 582 | Digital System Design II | 5 | 11 | 24 | |
| EE 612 | Physical Systems II | 1 | 3 | 7 | |
| EE 681 | Digital Signal Processing I | 7 | 28 | 5 | |
| M 351 | Numerical Analysis II | 3 | 13 | 20 | |
| M 432 | Applied Mathematics II | 5 | 15 | 17 | |
| ME 532 | Reliability Engineering | 9 | 21 | 14 | |
| ME 561 | Applied Fracture Mechanics | 2 | 11 | 13 | |
| ME 585 | Cardiovascular Biomechanics II | 2 | 3 | 8 | |
| ST 309 | Engineering Statistics | 8 | 26 | 33 | |
| WS 682 | Remote Sensing of Natural Resources | 2 | 2 | 13 | |
| (27 courses) | | 96 | 332 | 522 | |

## Fall Quarter, 1971 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AE 528 | Groundwater Hydrology | 2 | 10 | 28 | |
| AT 300 | Weather & Climate | 1 | 6 | 65 | |
| AT 589 | Introduction to Atmospheric Science | 5 | 20 | 22 | |
| BG 475 | Introduction to Operations Research | 7 | 39 | 35 | |
| BL 400 | Production Planning & Control | 4 | 11 | 22 | |
| CE 560 | Advanced Mechanics of Materials | 3 | 9 | 16 | |
| CE 601 | Intermediate Fluid Mechanics | 4 | 6 | 25 | |
| CE 638 | Sanitary Engineering, Unit Operations | 4 | 23 | 7 | |
| CE 866 | Theory of Thin Shells | 1 | 9 | 9 | |
| ED 500 | Principles and Practice of Guidance | 1 | 9 | 30 | |
| EE 201 | Network Analysis I | 1 | 1 | 87 | CO-TIE |
| EE 411 | Control Systems I | 4 | 17 | 10 | |
| EE 471 | Solid State Theory | 1 | 4 | 8 | |
| EE 501 | Passive Network Synthesis | 7 | 35 | 31 | |
| EE 581 | Digital Systems Design I | 9 | 24 | 32 | |
| EE 611 | Physical Systems I | 3 | 6 | 10 | |
| EE 682 | Digital Signal Processing II | 2 | 7 | 5 | |
| EE 701 | Network Synthesis | 8 | 29 | 4 | |
| EG 101 | Engineering Principles I | 3 | 9 | 20 | HI-TIE |
| M 350 | Numerical Analysis I | 3 | 10 | 19 | |
| M 431 | Applied Mathematics I | 4 | 13 | 34 | |
| ME 410 | Engineering Economy | 10 | 39 | 28 | |
| ME 584 | Cardiovascular Biomechanics I | 2 | 10 | 8 | |
| PY 797a | Employment of Minority Personnel | 2 | 15 | 12 | |
| (24 courses) | | 91 | 361 | 517 | |

## Summer Quarter, 1971 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| EE 432 | Pulse Circuits II | 4 | 11 | 5 | |
| EE 681 | Digital Signal Processing I | 2 | 9 | 7 | |
| ME 697 | Seminar in Mechanical Engineering | 1 | 4 | 19 | |
| ME 795a | Heat Transfer Seminar | 1 | 12 | 12 | |
| ME 795b | Compressible Flow Seminar | 1 | 1 | 8 | |
| ME 795h | Solid Mechanics Seminar | 2 | 14 | 16 | |
| (6 courses) | | 11 | 51 | 67 | |

## Spring Quarter, 1971 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 630 | General Circulation of the Atmosphere | 2 | 5 | 20 | |
| AV 101 | Poultry Science | 1 | 17 | 40 | CO-TIE |
| BG 470 | Advanced Business Statistics | 2 | 3 | 20 | |
| BG 476 | Operations Research II | 4 | 6 | 19 | |
| CE 440 | Environmental Health Engineering | 5 | 24 | 31 | |
| CE 761 | Theory of Elasticity | 1 | 7 | 10 | |
| CE 768 | Statically Indeterminate Structures | 1 | 3 | 9 | |
| CE 867 | Theoretical Hydrology | 2 | 11 | 8 | |
| EE 201 | Network Analysis I | 1 | 1 | 0 | CO-TIE |
| EE 202 | Network Analysis II | 2 | 5 | 69 | CO-TIE |
| EE 203 | Network Analysis III | 1 | 17 | 40 est. | CO-TIE |
| EE 431 | Pulse Circuits I | 6 | 23 | 29 | |
| EE 503 | Active Network Synthesis III | 7 | 31 | 30 | |
| EE 603 | Logical Design III | 6 | 22 | 23 | |
| EE 613 | Physical Systems III | 2 | 2 | 7 | |
| EE 741 | Wave Propagation | 1 | 3 | 3 | |
| M 332 | Applied Mathematics III | 4 | 8 | 53 | |
| M 421 | Complex Variables II | 3 | 6 | 27 | |
| ME 420 | Intermediate Mechanical Vibrations | 3 | 9 | 13 | |
| ME 795x | Quality Planning | 8 | 29 | 6 | |
| ME 795qx | Topics in Bioengineering | 1 | 5 | 5 | |
| ST 522 | Stochastic Processes II | 1 | 5 | 39 | |
| (22 courses) | | 64 | 242 | 501 | |

Winter Quarter, 1971 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 610 | Energy Transfers | 2 | 11 | 33 | |
| AV 101 | Poultry Science | 1 | 15 | 35 est. | CO-TIE |
| BG 570 | Business Decision-Making | 9 | 33 | 9 | |
| BK 485 | Marketing Systems | 7 | 26 | 26 | |
| CE 544 | Water Resources Planning | 2 | 12 | 27 | |
| CE 622 | Statistics in Hydrology | 2 | 7 | 18 | |
| CE 760 | Theory of Elasticity | 4 | 8 | 12 | |
| CE 765 | Theory of Elastic Stability | 3 | 10 | 5 | |
| CE 767 | Statically Indeterminate Structures | 2 | 6 | 10 | |
| CE 795f | Numerical Computer Methods | 4 | 7 | 17 | |
| EE 201 | Network Analysis I | 2 | 5 | 81 | CO-TIE |
| EE 202 | Network Analysis II | 2 | 18 | 97 | CO-TIE |
| EE 472 | Solid State Devices | 1 | 7 | 8 | |
| EE 502 | Active Network Synthesis I | 8 | 44 | 39 | |
| EE 602 | Logical Design II | 8 | 34 | 34 | |
| EE 612 | Physical Systems II | 2 | 7 | 9 | |
| EE 702 | Network Synthesis II | 3 | 9 | 0 | |
| M 331 | Applied Mathematics II | 4 | 8 | 60 | |
| M 420 | Complex Variables I | 4 | 13 | 37 | |
| ME 697 | Cost Effectiveness Analysis | 7 | 55 | 42 | |
| ME 795hx | Cardiovascular Biomechanics | 1 | 5 | 5 | |
| ST 521 | Stochastic Processes I | 1 | 5 | 49 | |
| WS 680 | Remote Sensing of Natural Resources | 1 | 9 | 16 | |
| (23 courses) | | 80 | 354 | 669 | |

Fall Quarter, 1970 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| BG 475 | Operations Research I | 4 | 15 | 21 | |
| BL 540 | Automation | 7 | 52 | 5 | |
| CE 200 | Elementary Mechanics of Fluids | 1 | 4 | 39 | CO-TIE |
| CE 766 | Statically Indeterminate Structures | 3 | 12 | 11 | |
| CE 795fx | Finite Element Method | 3 | 19 | 2 | |
| CE 795hx | Water Resources Engineering | 3 | 17 | 7 | |
| EE 201 | Electrical Networks I | 3 | 19 | 126 | CO-TIE |
| EE 471 | Solid State Theory | 1 | 11 | 10 | |
| EE 501 | Passive Network Synthesis | 8 | 51 | 39 | |
| EE 601 | Logical Design I | 7 | 41 | 33 | |
| EE 611 | Physical Systems I | 4 | 20 | 6 | |
| EE 701 | Network Synthesis I | 3 | 13 | 3 | |
| M 330 | Applied Mathematics I | 4 | 11 | 17 | |
| ME 410 | Engineering Economy | 9 | 77 | 33 | |
| ME 424 | Advanced Dynamics | 3 | 18 | 9 | |
| ME 697 | Information Systems | 6 | 25 | 1 | |
| ME 795fx | Mathematical Optimization | 2 | 2 | 0 | |
| ME 795hx | Cardiovascular Biomechanics | 2 | 10 | 0 | |
| ST 410 | Probability Theory | 4 | 10 | 35 | |
| (19 courses) | | 77 | 427 | 397 | |

Spring Quarter, 1970 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 200 | Introduction to Weather & Climate | 2 | 6 | 17 | |
| BG 470 | Advanced Business Statistics | 5 | 20 | 24 | |
| CE 568 | Advanced Structural Design | 2 | 5 | 7 | |
| CE 714 | Hydraulic Structures | 3 | 4 | 12 | |
| CE 761 | Theory of Elasticity | 3 | 19 | 3 | |
| EE 202 | Electrical Networks II | 2 | 10 | 78 | CO-TIE |
| EE 203 | Electrical Networks III | 3 | 9 | 45 | CO-TIE |
| EE 643 | Electromagnetics III | 1 | 3 | 2 | |
| EE 795a | Network Theory | 7 | 23 | 3 | |
| M 430 | Vector Analysis | 5 | 24 | 30 | |
| ME 432 | Statistical Quality Control | 5 | 20 | 11 | |
| ME 451 | Compressible Fluids | 1 | 4 | 15 | |
| ME 727 | Continuum Mechanics | 2 | 7 | 9 | |
| ME 795f | Topics in Linear Programming | 6 | 25 | 1 | |
| ST 432 | Mathematical Statistics | 4 | 9 | 22 | |
| WS 697 | Seminar in Remote Sensing | 2 | 6 | 6 | |
| (16 courses) | | 53 | 194 | 285 | |

## Winter Quarter, 1970 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| BG 475 | Operations Research | 7 | 48 | 27 | |
| BG 570 | Business Decision Theory | 8 | 58 | 36 | |
| CE 400 | Applied Mechanics | 1 | 6 | 25 | |
| CE 544 | Water Resources Planning | 2 | 2 | 28 | |
| CE 562 | Fundamentals of Vibrations | 6 | 31 | 10 | |
| CE 712 | Hydraulic Structures | 1 | 3 | 23 | |
| CE 760 | Theory of Elasticity | 3 | 22 | 2 | |
| EE 201 | Electrical Networks I | 3 | 12 | 87 | CO-TIE |
| EE 202 | Electrical Networks II | 3 | 12 | 82 | CO-TIE |
| EE 402 | Passive Network Synthesis | 6 | 26 | 32 | |
| EE 472 | Solid State Devices | 2 | 3 | 11 | |
| EE 642 | Electromagnetics II | 1 | 4 | 3 | |
| EE 702 | Network Synthesis II | 2 | 6 | 5 | |
| M 435 | Engineering Mathematics II | 6 | 34 | 28 | |
| ST 431 | Mathematical Statistics | 6 | 20 | 22 | |
| WS 680 | Remote Sensing of Natural Resources | 5 | 32 | 10 | |
| (16 courses) | | 62 | 295 | 262 | |

## Fall Quarter, 1969 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| CE 200 | Elementary Mechanics of Fluids | 1 | 6 | 22 | CO-TIE |
| CE 513 | Computer Methods in Hydraulics | 1 | 9 | 7 | |
| CE 560 | Advanced Mechanics of Materials | 3 | 23 | 17 | |
| CE 812 | Erosion & Sedimentation | 2 | 5 | 23 | |
| EE 201 | Electrical Networks I | 3 | 13 | 105 | CO-TIE |
| EE 401 | Passive Network Synthesis | 5 | 27 | 5 | |
| EE 471 | Solid State Theory | 1 | 2 | 16 | |
| EE 651 | Ionized Gases | 1 | 4 | 4 | |
| EE 701 | Network Synthesis I | 3 | 12 | 6 | |
| EE 741 | Electromagnetic Theory | 2 | 6 | 4 | |
| M 420 | Complex Variables | 1 | 4 | 14 | |
| M 434 | Engineering Mathematics I | 9 | 38 | 24 | |
| ME 410 | Engineering Economy | 7 | 79 | 13 | |
| ME 444 | Heat Transfer | 1 | 2 | 32 | |
| ME 532 | Reliability Engineering | 6 | 31 | 3 | |
| PH 465 | Introduction to Qauntum Mechanics | 1 | 3 | 13 | |
| ST 410 | Probability Theory | 10 | 89 | 28 | |
| (17 courses) | | 57 | 353 | 336 | |

## Spring Quarter, 1969 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 630 | General Circulation of the Atmosphere | 3 | 9 | 23 | |
| BG 370 | Advanced Business Statistics | 4 | 17 | 20 | |
| CE 716 | Advanced Hydraulics of Open Channels | 3 | 11 | 5 | |
| CE 724 | Water Quality Hydrology | 1 | 4 | 11 | |
| CE 813 | Potamology | 2 | 4 | 23 | |
| EE 202 | Electrical Networks II | 4 | 12 | 98 | CO-TIE |
| EE 203 | Electrical Networks III | 2 | 4 | 38 | CO-TIE |
| EE 433 | Pulse Circuits | 3 | 5 | 23 | |
| EE 795a | Special Studies | 4 | 20 | 9 | |
| M 440 | Fourier Series, Boundary Problems | 5 | 18 | 46 | |
| ME 432 | Statistical Quality Control | 7 | 38 | 16 | |
| PH 727 | Electromagnetic Theory III | 1 | 1 | 6 | |
| PY 440 | Industrial Psychology | 8 | 88 | 25 | |
| PY 558 | Human Factors of Systems Design III | 2 | 23 | 3 | |
| ST 284 | Introduction to Numerical Methods | 9 | 50 | 104 | |
| (15 courses) | | 58 | 304 | 450 | |

## Winter Quarter, 1969 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 751 | Physics of the Upper Atmosphere | 2 | 5 | 15 | |
| BG 475 | Operations Research I | 11 | 100 | 14 | |
| BL 485 | Production Concepts | 3 | 56 | 29 | |
| CE 400 | Applied Mechanics | 1 | 10 | 14 | |
| CE 512 | Hydraulics of Open Channels | 5 | 6 | 15 | |
| CE 562 | Fundamentals of Vibration | 1 | 3 | 15 | |
| EE 201 | Electrical Networks I | 4 | 24 | 106 | CO-TIE |
| EE 202 | Electrical Networks II | 2 | 8 | 93 | CO-TIE |
| EE 402 | Active Network Synthesis | 4 | 28 | 62 | |
| EE 432 | Pulse Circuits | 2 | 9 | 33 | |
| EE 602 | Logical Design | 4 | 25 | 10 | |
| M 421 | Applications of Complex Variables | 3 | 11 | 42 | |
| M 430 | Vector Analysis | 1 | 5 | 42 | |
| ME 495 | Special Studies | 4 | 17 | 2 | |
| ME 532 | Reliability Engineering | 5 | 17 | 6 | |
| PH 726 | Electromagnetic Theory II | 1 | 1 | 5 | |
| PY 557 | Human Factors in Systems Design II | 3 | 27 | 1 | |
| (17 courses) | | 56 | 352 | 504 | |

## Fall Quarter, 1968 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 620 | Fundamentals of Climatology | 2 | 5 | 21 | |
| BL 540 | Automation | 6 | 64 | 12 | |
| CE 200 | Elementary Mechanics of Fluids | 1 | 4 | 25 | CO-TIE |
| CE 766 | Statically Indeterminate Structures | 1 | 7 | 16 | |
| CE 812 | Erosion and Sedimentation | 2 | 15 | 22 | |
| EE 201 | Electrical Networks I | 2 | 17 | 99 | CO-TIE |
| EE 401 | Passive Network Synthesis | 4 | 26 | 39 | |
| EE 431 | Pulse Circuits | 2 | 13 | 45 | |
| EE 601 | Logical Design | 4 | 52 | 11 | |
| M 365 | Matrices and Determinants | 1 | 7 | 46 | |
| M 420 | Complex Variables | 3 | 9 | 53 | |
| ME 410 | Engineering Economy | 7 | 79 | 7 | |
| PH 725 | Electromagnetic Theory I | 1 | 4 | 6 | |
| PY 556 | Human Factors in Systems Design I | 3 | 50 | 5 | |
| (14 courses) | | 39 | 352 | 407 | |

## Spring Quarter, 1968 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 742 | Tropical Atmosphere | 3 | 7 | 17 | |
| BL 490 | Manufacturing Concepts | 7 | 47 | 26 | |
| CE 795f | Vibration Fundamentals | 2 | 7 | 0 | |
| EE 424 | Network Synthesis | 4 | 24 | 12 | |
| EE 515 | Advanced Pulse & Digital Circuits | 4 | 16 | 14 | |
| M 435 | Engineering Mathematics II | 6 | 17 | 13 | |
| ME 432 | Statistical Quality Control | 8 | 81 | 14 | |
| ME 719 | Optimal Control Theory | 2 | 7 | 4 | |
| (8 courses) | | 36 | 206 | 100 | |

## Winter Quarter, 1968 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| AT 670 | Atmospheric Constituents | 2 | 9 | 15 | |
| BG 475 | Operations Research I | 7 | 82 | 23 | |
| BL 560 | Research & Development in Industry | 4 | 57 | 4 | |
| CE 400 | Applied Mechanics | 2 | 9 | 5 | |
| CE 562 | Fundamentals of Vibration | 3 | 16 | 14 | |
| EE 458 | Pulse Circuits | 5 | 24 | 30 | |
| EE 511 | Network Synthesis | 3 | 12 | 15 | |
| M 434 | Engineering Mathematics I | 5 | 18 | 17 | |
| ME 718 | Optimal Control Theory | 4 | 20 | 9 | |
| (9 courses) | | 35 | 247 | 132 | |

## Fall Quarter, 1967 Course Enrollments

| Course Number | Course Title | Off-Campus Locations | Off-Campus Students | On-Campus Students | Notes |
|---|---|---|---|---|---|
| EE 452 | Pulse Circuits | 4 | 34 | N.A. | |
| EE 510 | Network Synthesis | 2 | 15 | N.A. | |
| ME 410 | Engineering Economy | 6 | 127 | N.A. | |
| ME 417 | Automatic Controls | 3 | 13 | N.A. | |
| (4 courses) | | 15 | 189 | N.A. | |

## Recapitulation

| Quarter | Number of Courses | Off-Campus Students | On-Campus Students |
|---|---|---|---|
| Spring, 72 | 27 | 303 | 404 |
| Winter, 72 | 27 | 332 | 522 |
| Fall, 71 | 24 | 361 | 517 |
| Summer, 71 | 6 | 51 | 67 |
| Spring, 71 | 22 | 242 | 501 |
| Winter, 71 | 23 | 354 | 669 |
| Fall, 70 | 19 | 427 | 397 |
| Spring, 70 | 16 | 194 | 285 |
| Winter, 70 | 16 | 295 | 262 |
| Fall, 69 | 17 | 353 | 336 |
| Spring, 69 | 15 | 304 | 450 |
| Winter, 69 | 17 | 352 | 504 |
| Fall, 68 | 14 | 352 | 407 |
| Spring, 68 | 8 | 206 | 100 |
| Winter, 68 | 9 | 247 | 132 |
| Fall, 67 | 4 | 189 | N.A. |
| | 264 | 4562 | 5553+ |

## Key to Participating Departments

AE - Agricultural Engineering
AT - Atmospheric Science
AV - Avian Science
BG - Business, Management
BK - Business, Marketing
BL - Business, Administration
CE - Civil Engineering
ED - Education
EE - Electrical Engineering
M - Mathematics
ME - Mechanical Engineering
PH - Physics
PY - Psychology
ST - Statistics
WS - Watershed Sciences

## Course Numbering

100-299 Freshman & Sophomore courses
300-499 Junior & Senior courses
500-699 Graduate courses
700-899 Graduate courses

## Appendix B

## DETAILED COST DATA FOR OFF-CAMPUS PROGRAMS

Equipment, Space and Video Tape - Table B 1 gives the cost detail for remodeling and equipping a studio-classroom. The amortization calculations are given below for the studio-classroom with control panel, video-recording equipment and space.

Studio classroom with central control panel
\$25,000 amortized over 5 years with 6 percent interest
(\$25,000) (0.237) = \$6,000/yr
assume 1,000 hours/year utilization
\$6.00/hr

Video tape recorder (1/2 inch) and monitor
\$800 amortized over 3 years with 6 percent interest
(\$800) (0.374) = \$300/yr
assume 1,000 hrs/year utilization
\$0.30/hr

Video tape (one hour reel)
\$20.00 used 100 times to discard
\$0.20/hr

Recording facility space
300 sq. ft. at \$30/sq.ft.
Amortized over 40 years with 6 percent interest
and 1,000 hrs/yr utilization
(\$9,000) (0.066) ≈ \$600/yr
or \$0.60/hr

Category subtotal = \$6.00 + 0.30 + 0.20 + 0.60 = \$7.10/hr

The scaling factor for the capital cost of producing duplicate tapes for each off-campus section is simply:

| | |
|---|---|
| Recorder and monitor | \$ 0.30 / tape |
| Tape | 0.20 / tape |
| | \$ 0.50 / tape |

Operating Cost of Production Facility and Program Coordination - Table B-2 lists the annual operating cost for two levels of program activity. The first level of 80 courses per year represents the current CSU program and 160 courses per year is an estimate of expanding the program. There are 30 recording hours / course, so these cost columns represent 2,400 and 4,800 hours of recording a single master tape.

TABLE B1

STUDIO CLASSROOM AND MASTER CONTROL STATION

Capital Outlay

(For Black and White TV Equipment)

| | |
|---|---|
| 3 TV Cameras @ 1,000 | $ 3,000 |
| 1 Sync generator | 1,000 |
| 1 Pan tilt control unit | 1,100 |
| 5 TV monitors @ 160 | 800 |
| 2 Zoom lenses @ 1,100 | 2,200 |
| Instruction desk with control unit, split screen generator, and back pack play back recorder | 4,000 |
| Electronic control, amplifiers, cables, special room wiring | 2,300 |
| Master Control panel with TV monitors, switching unit | 5,600 |
| Studio classroom air conditioning and necessary remodeling | 5,000 |
| Total Cost | $ 25,000 |

TABLE B-2

BASE OPERATING COSTS

| | | | Present Level | Expanded Level |
|---|---|---|---|---|
| Administrator, | $24,000, | 1/10 time | $ 2,400. | |
| | | 1/10 time | | $ 2,400. |
| Coordinator, | $16,000, | 1/2 time | $ 8,000. | |
| | | 3/4 time | | 12,000. |
| TV Engineer, | $15,000, | 1/5 time | $ 3,000. | |
| | | 1/5 time | | 3,000. |
| TV Technicians, | $10,800, | 2 full time | 21,600. | |
| | | 3 full time | | 32,200. |
| Secretary, | $ 5,300 | 1 full time | 5,300. | |
| | | 1 1/2 full time | | 8,000. |
| Student Labor, @ $2/hr, | | 3000 hrs. | 6,000. | |
| | | 6000 hrs. | | 12,000. |
| Travel and Telephcne | | | 3,000. | |
| | | | | 3,000. |
| Supplies and Spare Parts | | | 8,000. | |
| | | | | 11,700. |
| Printing and Mailing Announcements | | | 3,000. | |
| | | | | 3,800. |
| | | | $60,300. | $89,100. |

Allocated to each master recording on an hourly basis, these cost factors are:

$$\frac{60,300}{2,400} = \$25.15/\text{hr.}$$

or

$$\frac{89,100}{4,800} = \$18.35/\text{hr.}$$

The additional operating cost of producing a duplicate tape and delivering it by courier are:

| | |
|---|---|
| Tape delivery (round trip) | \$ 2.50/tape |
| Tape handling (student labor for loading VTR, unloading VTR, packaging and erasing) | \$ 0.50/tape |
| | \$ 3.00/tape |

Operating Cost of Instructional Program -- Recall that the basic direct cost of instruction is already assigned to the on-campus class. We seek the cost of adding off-campus students to an on-going instructional program.

For each 30 off-campus students in a SURGE course, assign a graduate teaching assistant. This amounts to 20 hours/week of a GTA for 3 hours of class time each week when there are 30 off-campus students. The cost of the GTA is \$900/quarter, or

$$\frac{\$900}{30 \times 3 \text{ student qt. cr.}} \times \frac{S \text{ student qt. cr.}}{10 \text{ tapes}} = \$1.00\ S\ /\text{tape}$$

A 30 per cent allowance is made for departmental expenses associated with the added students. This cost factor covers extra secretarial assistance, Xeroxing, supplies and telephone charges. \$0.30S /tape

Faculty visits to each off-campus student group is encouraged twice each quarter. For two 188 mile round trips or 375 miles at \$0.10/mile, the allowance is \$37.50/section; since each section receives 30 tapes during the quarter: \$1.25/tape

Total instructional costs on a per tape basis are the sum of the three factors.

$$\left(\$1.25 + \$1.30S\right) / \text{tape}$$

Unit Cost Estimates for Expanded Program -- The principle cost advantage of growth in a program such as this is the gain possible in scaling the operating and production staff. Consider two examples which should illustrate how: (a) doubling of course offerings with the same average number of sections per course (N) and students per section (S ) would effect unit costs; (b) distribution of the same number of courses to many more sections but smaller student populations per section would also effect unit costs.

| | | | |
|---|---|---|---|
| (a) | Assume: | Total courses | = 160 |
| | | Total sections | = 605 |
| | | Total off-campus enrollment | = 2040 |

The doubling assumption has held,

$$N = 3.78 \left(\frac{\text{sections}}{\text{course}}\right)$$

and

$$S = 3.40 \left(\frac{\text{students}}{\text{section}}\right)$$

at the level of the current SURGE operation. The cost of instruction calculation will use \$18.35/hr. for the operating expenses of the Office of Educational Media.

$$F = \frac{(10C) \cdot \left(\$25.45 + [\$4.75 + \$1.30S] \quad N\right)}{N \cdot S \cdot C}$$

$$F = \frac{254.5}{NS} + \frac{47.5}{S} + 13.$$

$$F = \frac{254.5}{12.9} + \frac{47.5}{3.4} + 13. = \$47./\text{qt. cr.}$$

Unfortunately, this projection is not likely to be realized at CSU until new markets are found for existing campus offerings. It will pay to search for these markets.

| | | | |
|---|---|---|---|
| (b) Assume: | Total courses | = | 80 |
| | Total sections | = | 460 |
| | Total off-campus enrollment | = | 1288 |

These data are estimates of adding an extreme version of HI-TIE to the existing SURGE program. That is, 200 off-campus sections averaging two students (say mathematics teachers) each have been added while holding essentially to the existing level of course offerings.

Therefore, $$N = \frac{460}{80} = 5.75 \left(\frac{\text{sections}}{\text{course}}\right)$$

$$S = \frac{1288}{460} = 2.80 \left(\frac{\text{students}}{\text{section}}\right)$$

$$F = \frac{(10C) \cdot \left(\$32.25 + [\$4.75 + \$1.30\ S]\ N\right)}{N \cdot S \cdot C}$$

$$F = \frac{322.5}{NS} + \frac{47.5}{S} + 13.$$

$$F = \frac{322.5}{16.1} + \frac{47.5}{2.8} + 13 = 49.99 \approx \$50/\text{qt. cr.}$$

It appears that there are gains to be had in unit costs even as the off-campus sections approach the limiting case of a study "group" at a location.