A Systems Approach To Teaching

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Abstract

The systems approach described here evolved over a ten year period in response to changes in an experimental teaching program. The experimental program began in 1966 with use of audio-tutorial (AT) units in introductory soil science. The AT program required learning objectives, and the objectives were given to the students. Additional experimentation produced a successful mastery learning program in winter 1972. When enrollment increased from 162 in winter 1972 to cover 600 in winter 1976, emphasis in course development shifted to increase the efficiency of offering the course to larger enrollments. The result was a systems approach to teaching the course. This paper describes the learning center designed to accommodate the systems approach to teaching and the organization that evolved to increase teaching efficiency.

The first requirement of a systematic approach to teaching and learning is development of learning objectives. After objectives have been established, teaching strategies can be designed for efficient student learning and minimization of costs.

Integral to a systems approach to teaching is physical facilities. Some teachers have few options for altering physical facilities. More options, however, may be present than are commonly recognized. Many colleges have audio-visual learning centers; conventional labs can be modified without great expense to accommodate audio-tutorial programs: partition of time into various activities (lab, lecture, recitation, tutorial, etc.) can be changed to make most effective use of physical facilities; and facilities may be used on a more open, nonscheduled basis. Organization of any course will reflect both the educational objectives of the teacher and the availability of physical facilities. Experimentation with several different formats for the introductory course showed that we need one large auditorium for a lecture section that meets three times a week and a nonscheduled audio-tutorial program in a learning center.

A single large lecture class is efficient for providing motivation, evaluation, and some content. A nonscheduled learning center program available many hours each week and operated largely by undergraduate students provides for individualized learning and opportunities for one-to-one interaction (including tutoring) in a minimum amount of space with low labor cost. Attempts to offer small recitation sections on a scheduled basis were abandoned due to the work required to maintain a crop of continuously changing teaching assistants, large expense, and poor timing of the activity. Students were encouraged to use the learning center for discussion of course content and exams. I believe that giving students responsibility to initiate discussion and ask questions whenever they wish in a learning center, promotes effective and efficient learning. I hope the system teaches students to be more responsible for their learning and to become more independent learners.

Michigan Agr. Exp. Sta. Journal Article No. 8018. Dr. Foth is a professor in the Dept. of Crop and Soil Science at Michigan State University.

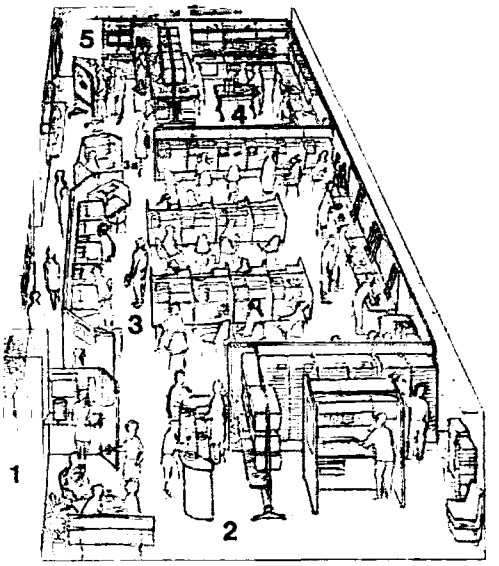

Figure 1. Activity Areas of Learning Center:

(1) Entrance and coffee bar lounge,
(2) Resource store and storage,
(3) Audio-tutorial, including tutor station (3a) and display table,
(4) Wet-lab, and
(5) Multipurpose area for independent study, A-T expansion, etc.

A Center Designed for Systematic Teaching

In 1974 a learning center facility was designed and built to satisfy the physical needs of a systems approach to teaching (4). The center has five major activity areas as shown in Figure 1: 1) entrance and coffee-bar lounge; 2) resource store with counter for dispensing and checking in materials, storage and retrieval lockers, and some work space for making displays; 3) audio-tutorial learning center with tutor station (3a), and a display area (along the right hand side); 4) wet lab: and 5) multi-purpose wet lab for special projects, informal meetings, and expansion space for audio-tutorial activities.

The counter of the resource store is the hub for activities (Fig. 2). A wide variety of materials including tapes, slide sets, reserve reading materials, etc. are checked out and in. Students can sign up at the counter for noncredit activities such as field trips or plant propagation mini-courses. The attendant is available for tutoring, and phone calls are accepted. Two undergraduates are scheduled during the busy hours to handle the full range of activities (tutoring, refilling reagent bottles, replacing broken equipment, providing supplies and equipment to special problems students, etc.).

Figure 2. The counter of the resource store is the hub for using the center's services. Storage shelves line rear wall and coffee-bar lounge is at right.

The storage and retrieval system is a unique feature of the resource store area. Mobile storage lockers hang on a wall rail and can be moved about to dispense or collect materials (Fig. 3). Only lockers needed for courses currently taught need to be stored in the resource store area. A small storage area therefore can serve a large number of courses during a year. Variable shelf spacing and a wide variety of storage containers promote efficient use of storage space. Materials for a course are stored in chronological order of use to facilitate retrieval and storage. Shelves and lockers are labeled to effect accurate replacement of any shelf at any time.

Figure 3. The wall storage lockers are moved about on cart at right. Note variety of shelf types and storage containers.

Locker shelves are used to store both supplies and displays. For example, a tray fitted with a colored cardboard forms the background of a display showing granite and the common minerals in granite (Fig. 3). The display is stored and used as constructed. Standard laboratory supplies and large equipment are stored in the wet lab storage cabinets where they are used and shared by several courses.

A notebook has been developed, with written comments and colored photographs, giving instructions on how to set up the center each week. A color code system identifies all materials associated with any given learning center unit. This organization reduces the labor needed to set up and take down the center each week and reduces loss of materials. An undergraduate assumes this responsibility.

The audio-tutorial area is shown in Figure 4. Low carrel height provides a feeling of openness, and the tutors can observe all activities. Plants and pictures make the learning environment attractive. Beauty of the center is also enhanced by the use of yellow, brown, orange and blue panels, shelves, and storage cabinets. Figure 5 shows the modular display table of the AT area.

The wet lab area (area 4 of Fig. 1) is also equipped with modular-mobile components. Lab bench surface height is alterable, and the modular concept permits rapid arrangement of lab work surfaces, shelves, tackboards, etc., to accommodate changing needs (Fig. 6). Upper level storage shelves have flipper doors for easy access. Shelf surfaces are easy to clean, and plastic shelf covers protect work surfaces where acids are dispensed. The oven on the right is on a mobile lab cart that serves a variety of uses. Shelf height and types of drawers used on the cart are variable. The cart and a mobile table are used to create work space in the center area of the wet lab.

Flexibility for using space is an outstanding feature of the center because wall panels and partitions are movable. Perimeter plumbing, gas and electrical service, along with electrical service from the ceiling with power poles (see Fig. 4), leaves all the interior space "open" for rapid rearrangement of partitions, etc. The sinks in the wet labs can be disconnected and removed. On the other hand, there is stubbed-in plumbing for three sinks along the display table wall. The center's space could be quickly concerted to a research lab or office space for faculty or secretarial services. The center is frequently rearranged to respond to changing needs. Some of the wall panels have one side that is a cloth-covered tack board, useful for posting exam results, notices, pictures, instructions, etc.

Mastery Learning System

The mastery or competency based learning system is designed to maximize learning of the objectives. Its essential features consist of 1) communication of objectives to students; 2) varied opportunities to master the objectives, including reading assignments, audio-tutorial modules, assigned problems, tutoring service, etc.; 3)

Figure 4. Audio-tutorial area.

Figure 5. Display table in AT area has cloth covered tack boards to aid display of pictures, etc. Panels and shelves are modular and easily rearranged.

feedback in terms of two self tests for each audio-tutorial module; 4) opportunities for remedial learning which include virtually unlimited access to materials both in the learning center and the audio library of the main university library; and 5) summative tests to establish degree of mastery or grades.

Summative tests are given twice — once on Friday and on the following Monday. The higher score of the two tests is used to determine course grades. The program is a **modified** mastery program in that there are only two opportunities to take summative tests for each unit, and students are not required to master current units before proceeding further. Grades are given according to a straight scale. Normally 50 to 60 percent of the students earn a 4.0 or an A (based on 88 percent), and about 70 to 80 percent earn a grade of 3.0 (based on 78 percent) or better. Failures are only one or two percent. Detailed results of achievement, organization, and student response have been reported (2) (3).

The Testing System

A large amount of time can be required to construct exams for a five-credit course in a mastery format with a large enrollment. This results from the need to construct 10 or more exams per term and the desire to have exams without errors. (Making corrections is difficult when there are several sections taking the exam simultaneously and when a significant number of students arrive for the exam five to ten minutes late). The Savin 900 Word Master has been used to reduce the time needed to compose an exam and the time and effort needed to type stencils that are error free.

The bank of multiple-choice exam questions has been typed onto magnetic tape with a Selectric typewriter connected to the Savin 900. The magnetic tapes are divided into 250 records that store 10 to 12 typewritten pages or 500 records that store 20 to 24 pages. Each question is given a record number to identify its location on the tape. After all the questions for a unit have been typed onto the tape, the typewriter is put on automatic and the questions are automatically typed at 150 words per minute. This copy is proof read, and appropriate corrections are made on the tape to provide an error-free copy of the questions.

A printout copy of questions with their record numbers is stored in a 3-ring notebook for composing exams. A standard form is filled out indicating unit title, objective number, and record number for each exam question. The typist uses the standard form to select the proper tape and location of each question. The typewriter stops after a question is automatically typed on the stencil. The tape is advanced to the next appropriate record and the process is repeated. For the typist, less time and effort is needed to type exams. For the instructor, less time is needed to compose exams, stencils need not be proof read, and exams are error free.

The content covered on each exam has been standardized for the past several years. This has produced a large number of "old" exams that can be randomly selected when students are sick, etc. Make-up exams are given, graded, and recorded by the tutors in the learning center.

Record Keeping System

Machine graded exams are given during lecture periods. The machine graded score sheets are coded by exam number before exams are given. Upon completion

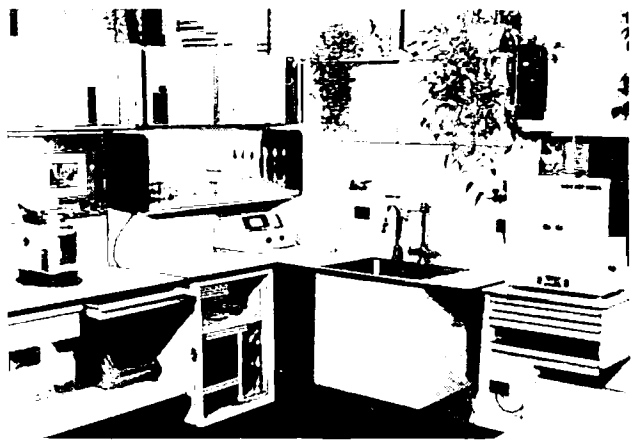

Figure 6. Corner of wet-lab showing modular nature of shelves, work surfaces, etc. The lab cart on right is used for support of equipment, storage, work surface, etc.

of the exam, the scoring sheet is turned in, and the test questions are retained by the students. Answers to the questions are provided in the lobby immediately after exams so students can score their papers and determine their grades. If they want to improve their scores, they sign up to take a different version on the following Monday. The higher test score is used in determining the course grade.

For each exam paper, the scoring office provides a computer card that contains the student number, student name, test number, and number of correct answers. A computer provides a printout of the student number, highest and lowest test scores, and cumulative total of the higher scores. The printout also provides a grade distribution of the class. The printout showing the cumulative test scores or grade is posted in the center after each exam. Most questions about test scores are caused by students' errors in grading their own papers. Placing the machine graded sheets in an accessible place in the center enables students to check answers and virtually eliminates all questions about whether or not the test scores recorded are accurate. At the conclusion of the term, a printout lists students' names alphabetically with all exam scores for the term, the total number of correct answers for the term, and the computed course grade. This past year a soil science senior operated the computer record keeping system.

Cost Considerations

The original introductory soil science course had four lectures and a 2-hour lab each week. Graduate teaching assistants taught the labs. An enrollment of 500 would require about 5 teaching assistants. Now one TA is used for managerial functions, and the remainder of the labor is by undergraduates. Since the salary of one TA can provide 40 to 50 hours of undergraduate labor, labor costs have been greatly reduced. In addition, 80 percent of the course content is now taught in the AT center as compared to 20 percent that was taught in the lab program. The total labor cost (including salary of lead teacher) is about ¼ of student tuition.

Labor costs can be reduced further by offering several courses in the AT center at the same time. For example, in the winter term 100 agricultural technology (2-year) students taking soils ride "piggy-back" on the 4-year introductory soil science course. For 7 of 9 weeks topics are similar, and the agricultural technology students use the same displays and wet lab equipment and supplies as the 4-year students. This arrangement has saved the cost of one TA for the winter term. Further, the agricultural technology students are from 3 areas, each with its own AT tract (turf, floriculture, and landscape nursery). (1). The separate tract option has created more student interest. The tracts were not feasible with the 2-hour lab format because the soil science TA's generally lacked experience in these areas.

An AT center can be created for the same cost or less than a typical chemistry lab. AT centers can reduce the number of scientific instruments needed because students work individually. High-quality AT equipment should be used to keep repair costs reasonable and enable the AT center to operate at maximum capacity at all times.

Student Teaching Opportunities

The opportunity for TA's to reach a lab section is no longer available. One TA, however, gains exposure to and experience with all phases of operating an AT center. Graduate students and undergraduates are given opportunity to engage in optional teaching activities such as field trips and nonscheduled mini courses on any subject they desire.

The limited teaching opportunity for graduate students has been offset in part by creating a small section of the introductory course for all interested graduate students. They have access to all facilities and materials (AT center program, exam file, lecture materials). Handling the lectures is not unduly taxing as they visit the lead teacher's lectures, and there are only 1½ content lectures per week in the current format. The system permits a beginning teacher to concentrate on classroom management and student interaction vs. program development, setting up labs, etc. Three graduate students have made use of the opportunity. They receive no pay but the experience satisfies the teaching requirement for advanced degrees.

While fewer graduate students are actively involved in teaching the introductory course, about 6 undergraduate students are involved. They greatly expand their knowledge of the subject, have opportunity to develop communication skills, and gain a valuable perspective of the teaching profession. On balance, the current format provides greater opportunity for students to receive meaningful teaching experience.

Summary and Concluding Comments

The major organizational changes resulting from ten years of experimentation in a large enrollment course have been described. Originally the goal of experimentation was greater student learning. Later, the goal was more efficient operation of the course to accommodate an increasing enrollment. Both of these goals tended to produce an organized mode of teaching.

Student response to the changes has been favorable. Teaching cost per student credit hours has declined due largely to substitution of undergraduates for graduate teaching assistants. More satisfactory opportunities for student teaching are now available.

The role of the lead teacher has changed so that there is less lecturing and more program development and management. Perhaps the major disadvantage has been the great amount of time necessary to make the changes. During the past ten years I have given up field research and serving as major advisor for graduate students (except for a few involved in teaching problems) and have devoted nearly all my time to teaching and development of 2 courses. Once established, the program requires less time to operate even though enrollment is much greater than originally. Some released time is used

to visit with students in the learning center and office. The learning center is an inviting and informal environment where meaningful interchange between students and workers is nearly always possible for any slack time or needed diversion. In a sense, the learning center is also a social center.

Changes in course organization are continuing. Currently, the colored slides used in most of the AT modules are being eliminated due to the high cost of colored slide-carousel tray management, and maintenance and repair of equipment. The equipment is also noisy and provides unwanted heat. This change is expected to create certain educational advantages as well as reduce costs. Some of the colored slides of the AT program will appear as black and white photographs in the study guide. This results in a permanent record for future study and reference since the photographs will always be available to the students. Some of the colored slides will be shown in lectures, and more use will be made of colored photographs at the display table and in the wet lab. There should be little loss of visual material. It will be possible, however, for students to listen to tapes at more locations on campus because facilities for viewing slides will not be needed. Now tapes and slides are available only at the audio-visual room of the main library. This change in handling the visuals has also made me realize that a large part of the AT tapes were used in association with the slides, and the new tapes will be able to cover the content in less time.

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Resources for Teaching and Learning

Wesley J.F. Grabow, Editor

Jargon and "Term" Dropping!

A barrier to understanding exists in our use of the short cut terminology called jargon that developes and builds around a particular field of study. This language of its own that is used in publications and other presentations may facilitate or expedite the flow of information and the understanding of those in the particular field, but it really turns off all those outside this fraternal framework. Just as many of us can be accused of "name dropping," we also can be accused of "term dropping." We often communicate for effect rather than for understanding. I'm reminded of the joke writers who numbered all their jokes. When they came together at periodical conferences, they would simply toss numbers back and forth, and laughter would break out among those that heard the joke and thought it funny. Those passing the conference room thought they had stumbled by the "funny farm." This may be carrying the point to an extreme, but how many times have you heard a colleague state, "its Greek to me" after attempting to decifer a new coded language in a journal article. Our communications are usually not meant to be top secret, but we certainly code them as such.

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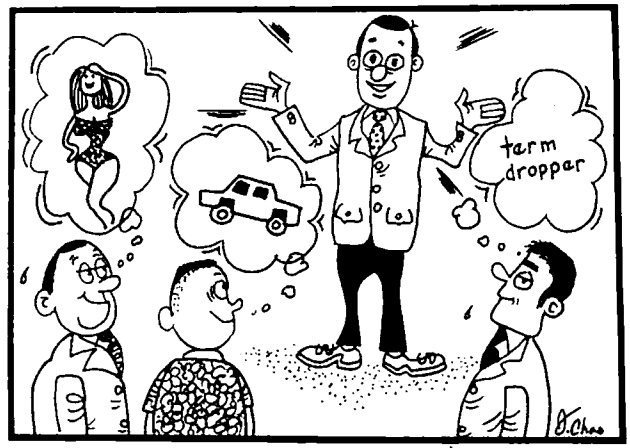
So many times we fail to communicate because we assume that a base of understanding exists in the language we use. Effective use of words in reading, writing, speaking, and listening is a major job of any educational system.

Congratulations to the editors of NN&Q, the newsletter of Phi Delta Kappa, the professional education fraternity. Their special research issue, Volume 21, Number 5, May-June 1977, should be read by all concerned with education. According to a survey they conducted a year ago most practicing teachers would say "No!" to the question, "Does research provide help for the teacher or practicing educator?" Of course this is not true, for research does provide help; but most of it needs to be translated. Education, as many other fields of study, suffers from jargon. Researchers develop a technical language and phraseology that helps them communicate quickly and accurately. Other educators have not mastered that technical language; to them it is confusing speech or gibberish devoid of meaning.



"Modeling effects student learning..."