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LAWRENCE LIVERMORE LABORATORY
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ANATOMY OF A CONTINUING EDUCATION PROGRAM

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June 22, 1973

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ANATOMY OF A CONTINUING EDUCATION PROGRAM*

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This paper is a description of one department's experience with in-house continuing education. At the Lawrence Livermore Laboratory in California, the Mechanical Engineering Department responded to its unique problems of obsolescence. Continuing education is not a solution for every organization's search for maintaining competence. Each organization has its own particular circumstances and needs. LLL has achieved at least a qualified success with continuing education as a tool for maintaining the competence of engineers.

Background to a Problem

The Lawrence Livermore Laboratory is located 50 miles east of San Francisco at Livermore, California. The Laboratory is operated for the Atomic Energy Commission by the University of California, and its primary mission has been the conception and development of nuclear weapons. The Laboratory has 5300 employees

***This work was performed under the auspices of the United States Atomic Energy Commission.**

of which about 1800 are professional engineers and scientists. One unique feature which had an impact on the development of in-house education, is our modified matrix organization wherein large numbers of professionals are in discipline departments from which they are assigned to research and development project teams. Without the collection of professionals into discipline departments, it is doubtful that early identification of obsolescence and a springboard for attacking the problem would have resulted.

The Changing Role of the Engineers at Livermore

When the Laboratory undertook nuclear weapons research and development in 1952, the engineering work required was not sophisticated. A set of college notes and a handy edition of Mark's Handbook provided nearly all the expertise needed to design the necessary hardware. Although the preceding is an understatement, the stress was on speed, sturdiness and reliability. Numerous Ph.D. physicists were nearby if something very complex needed analysis.

We made great strides in the 1950s in nuclear weapons development. In doing so, we also gradually disposed of all the easy engineering work. If further developments were to occur, more sophisticated engineering was necessary. New and different technology was in increasing demand. New materials

had to be developed. Weight savings had to be made. Dynamic loads had to be fully accounted for. Heat had to be disposed of to an exact degree and precision manufacture needed to become routine. An additional influence was occurring by the turn of the decade when LLL began moving into non-weapons nuclear research.

It was resolved in the early 1960s to change the complexion of the Mechanical Engineering Department by hiring advanced degree engineers and highly trained specialists with needed skills. Although a demand for older style engineering continued, there were many engineers who were inadequately trained for the changing program needs. The Laboratory had no wish to discard loyal employees; and it was often not clear who had obsolesced and to what degree. University regulations and social responsibility dictated against a wholesale change of staff, even had the Laboratory been so inclined.

Our situation was not unique. Most of the U.S. technology was changing rapidly and many companies and laboratories found themselves lacking current skills in their engineering staffs. At the same time, humanistic and legalistic considerations precluded radical reactions to the situation.

Early Continuing Education Efforts at LLL

While we were hiring new and up-to-date skills in whatever openings existed, we began studying, in concert with many universities and technical organizations, the need for continuing education as a means for overcoming the lack of current technology and for preventing obsolescence.

I recall many conferences in the early 1960s where everyone agreed that:

1. Continuing education was needed.
2. Something must be done to motivate engineers to seek continuing education.
3. The universities must accommodate this new student body.
4. Someone must pay for continuing education; either the engineer, the employer, or the government.

If you attend a continuing education conference today, you may well find these same questions being debated. A dozen years of work on this problem has not provided a universal set of answers for engineers and employers. Where progress has been made, the employer had to find the set of answers that suited his situation, and proceeded much on his own.

LLL had the usual array of educational opportunities available to it. The University of California as an employer provided time off from work and reduced tuition. There was a fee reimbursement program for a wide variety of college courses. Conferences and short training courses were available in areas directly applicable to current assignments. Part-time employment was sometimes arranged. Occasional after-hours courses were provided nearby, and a very few advanced degree scholarships were awarded. Despite an educational fringe benefit program as generous as most in the research and development field, an examination of participation revealed that its effect was extremely limited. Figure 1 shows an age profile of the Mechanical Engineering Department at Livermore with an estimate of the participation pattern in the mid-1960s. The young, eager pace setters were the primary users of the educational benefits, and the majority of older, middle performing engineers were simply not being reached. One suspects that these young pace setters would have continued their education and kept up with their fields whether they got help or not. What was needed was a program to reach the older, established engineers.

Several programs were designed to provide concentrated re-education and new technology training over periods ranging from two months to a year. None got off the ground because

too much effort would have been drained away from the ongoing technical work at a single time if a large fraction of the staff were engaged in education.

After-hours programs were provided but never appealed to enough employees to become an effective force to stem the growing obsolescence.

Meanwhile the first organized in-house program at LLL started in the Electronics Engineering Department in 1964 when 20 senior engineers were enrolled in a sequence of courses to attempt to update them in a one year period. Classes were held three hours a week during working hours. It provided a foundation group of revitalized engineers who began to take state-of-the-art courses which were taught at the rate of several a year. The program was well liked by those it reached. While technology has moved faster in electronics than in the mechanical field, the E.E. Department did not have a large body of older engineers for whom the need for updating and continuing education was so acute. After the initial program designed for senior engineers, the E.E. Department has maintained a steady, but modest, program which emphasizes new electronics technology.

The Mechanical Engineering Program

In the Mechanical Engineering Department, a viable continuing education program was finally launched when we in the Department stopped treating continuing education as a fringe benefit and instead made it an integral part of the engineer's job. As shown earlier in Figure 1, too often educational support programs appeal only to 25% of the work force. Yet, the remaining 75%, the majority of the continuing work force, had to be reached if the objective of preventing obsolescence was to be achieved.

Certain operational problems had to be overcome before a continuing education program could succeed. For example, previous attempts to present courses during working hours resulted in high dropout rates; often only 50% of the engineers enrolled in a course would complete it. A study of the dropouts revealed that the high dropout rate was related more to the nature of the engineer's work assignment than to course content or presentation. At Lawrence Livermore Laboratory, for example, an engineer might be required to travel frequently or work an erratic schedule. As a consequence, it was difficult for him to attend regularly scheduled classes or seminars. After missing a number of class sessions, he would fall behind in class work to such an extent that he would drop out, hoping perhaps that the next time he took the course his work assignment would be more predictable.

A way had to be found to make continuing education more flexible -- to fit the engineer's schedule rather than trying to make the engineer fit the class schedule.

In 1968, the Mechanical Engineering Department instituted a program for its 350 professionals to make continuing education for engineers a reality, regardless of work schedule or travel. The key to the program was videotape which made it possible to fit the program to the engineer's schedule. Each class, though presented "live", was videotaped. If an engineer missed a class, he could make it up at his convenience by replaying the tape. The dropout rate immediately decreased to 10%, and the number of engineers participating in the continuing education program increased by a factor of 5.

The program as it now is structured consists of selected courses in fundamental and advanced engineering theory. Each course is designed to reflect current university-level engineering material with emphasis placed on the material most useful to engineers at LLL. Many of the courses that are taught are combinations of more than one university course. The homework and examples draw heavily on LLL work. Homework does not exceed six hours per week. Specifically, the program runs for two semesters a year, and eight to twelve different courses are offered each semester. (Current plans are to convert to a three-quarter system starting in the fall of 1973 to mesh better with television

courses received from nearby universities which complement the in-house program.) Senior engineers not only have the opportunity to review basic engineering subjects, but their technical exposure can become equal to that of a recent engineering graduate. Although classes are scheduled at specific times in department classrooms, the engineers can easily make up a class by merely calling the television studio and arranging a playback at the individual TV carrels. Figure 2 shows the use of a TV carrel for a makeup class. In addition to videotape, lecture notes, homework problem sets, textbooks, and final examinations are integral parts of each course.

Instructors in the program are nearly always members of the department, selected on the basis of course knowledge and teaching ability. Some are Ph.D. engineers, and instructing in the continuing education program satisfies their desire to teach -- a satisfaction they might have sought elsewhere if the program had not been instituted. No instructor has had more than an initial hesitation about presenting his course in front of television cameras.

The Mechanical Engineering program is administered by a Curriculum Committee composed of all the instructors and the departmental training staff. The Chairman of the Committee

is the Head of the Mechanical Engineering Department. The Committee selects the courses, the instructors, course level, and sequence of course presentation.

An initial presentation of a class is "live" in a fully equipped television studio within the Laboratory. The studio, shown in Figure 3, accommodates 30 students and is equipped with several remote television cameras to eliminate distractions from cameramen in the studio. Courses run from 10 to 13 weeks in length and meet twice a week for an hour.

The videotape of each class is intended for those students on travel who could not attend the original class. Upon completion of the class, students are asked to complete a questionnaire concerning the technical information presented, the method of presentation, and additional courses which they feel would be helpful. The second presentation of a course is again videotaped. These tapes, assuming their quality is acceptable to all concerned, become the permanent class tapes. The third and succeeding offerings of a course are entirely by videotape. An instructor is assigned to each videotape class to counsel students and to grade the homework and tests.

Of the 342 mechanical engineers currently in the Department, 239 had completed one or more courses by the spring of 1973. These engineers had been out of college from one to forty years, and they range from B.S. to Ph.D.

The very fact that the courses have appealed to a broad audience of this type indicates accomplishment of the primary intent to reach all levels of engineers. Figure 4 demonstrates graphically how the program has appealed to the entire age spectrum of engineers in the department. There are engineers who still have not been reached, but the involvement so far has been very gratifying.

There is no question that charging class time to the program accounts has served to convince the engineers of management's dedication to making the continuing education program succeed. The rationale was that all courses were relevant -- if not currently, then in the near future. The training acted as "preventive medicine" by shortening the time and distance to useful solutions to work problems. We observed no drop in output when two hours a week were diverted to class time. The employees are expected to do homework on their own time, however. A small dose of education provides a stimulation and a tightening of personal discipline that seems to prevent a drop in output. It was also reasoned that when performing their work, engineers traditionally charged the program with their library time, reference book time, consultation time and tutoring time as an accepted cost of getting the job done. Perhaps continuing education lessened

the time required for other boning up and refreshing such that the weekly work output was not decreased. Deciding to charge student class time as a program cost instead of as overhead suddenly brought the whole program into reasonable perspective.

Changes in the Character of the Program

The Mechanical Engineering program has accomplished its initial purpose of involving the majority of the staff, irrespective of age. Many older B.S. level engineers now take courses with modern content at the graduate level in comfortable competition with their younger colleagues. The program has not been a success for everyone but the staff now accepts that continued course participation is the "in" thing to do. A large fraction of the department is now able to stay current with the technology of their discipline. Restored confidence became the trademark of many 40+ year-old engineers. Several reported how they had drifted into a conservative stance, designing more empirically and intuitively than with adequate analysis. Such a stance did not encourage risk-taking which is a necessary ingredient for the new ideas needed in R&D.

The TV Link with U.C. Davis

In the midst of this program, a television link with the Davis campus of the University of California was completed. This linkage provides an opportunity for interested engineers

to pursue a formal degree program during working hours in their own engineering building. The program complements the in-house program of both Electronics and Mechanical Engineering.* A number of students have been sufficiently motivated under the continuing education program to enroll in the degree program. Both the Master's and Doctoral programs are offered, and the required thesis is frequently a Laboratory research topic which fits into the student's work assignment.

The Future Character of the Program

Only a small fraction of the engineers have indicated they plan to undertake a degree program. Of the remainder, many already have an advanced degree, and many Bachelor level engineers foresee no financial incentive for another degree. A Certificate of Competence from the numerous state-of-the-art courses available often satisfies his need for evidence that he is combating obsolescence. He also does not feel the need to endure the rigor and thoroughness of a degree program to fulfill his educational goals.

It is planned that increasing use of regular university courses over the TV link for auditing only by continuing education students will complement and enlarge the in-house program.

*University of California, Davis, "Instruction by Television (Davis-Livermore)", College of Engineering, May 1972.

It is becoming apparent that the ideal continuing education program at LLL will be a mixture of in-house courses and non-credit university courses. Because of excellent cooperation and support from our academic colleagues, we should have no trouble developing an adequate program of wide appeal that will serve to keep our engineers at the cutting edge of technology.

Expansion to Scientific Disciplines

In the past year, our scientific colleagues in the physics and chemistry disciplines at Livermore have conducted their first in-house courses. It is likely that there will be a stronger reliance on audit courses brought in from the universities by television than in the engineering program. In contrast, the Computations Department of LLL is likely to remain nearly 100% in-house. Their program, in existence for two years, draws on one of the largest and most advanced computer centers in the world.

The involvement of all disciplines at the Lawrence Livermore Laboratory in a continuing education program is consistent with the Director's resolve to make this tool the major thrust toward maintaining the highest skill levels with a technologically current staff. The experience at LLL to date convinces the management that continuing education is a basic element in its attempt to maintain staff vitality.

Table 1 shows the projected participation in the professional in-house programs. Of the 1800 professionals at LLL, about 700 currently take some kind of course each year. As an investment, this represents less than 1% of our total manpower budget. Even if it grows to 2% or 3% of our total effort, all agree that it will be worthwhile.

Has There Been a Layoff?

An unexpectedly significant result has been the effect on our in-house instructors who have polished their expertise enough to become very competent specialists. Our evaluations of the students have been primarily subjective in nature, but they have been frequent and in depth. We cannot demonstrate that in research and development work our continuing education program is cost effective. Objective evaluation of education programs has always been difficult because of a lack of comparison criteria. An obsession to evaluate continuing education has rung a death knell for some company programs. A quantitative evaluation of education has not developed for our public school system so it is hardly logical to require it for a company program. Yet management innocently, but understandably, will try to measure cost effectiveness in the same manner it evaluates its technical missions. While adequate cost-benefit measures should continue to be sought, the lack of them should not be allowed to forestall continuing education efforts.

To embark on a viable continuing education program, management cannot get hung up on "how valuable" it is but can only accept the position that it is valuable and then try to operate an efficient teaching program that directly addresses the needs of its professional staff.

From management's perspective, we do not assess success in terms of enrollments but by the job performance of each individual. Our experience convinces us that, for most professionals, maintenance of skills and avoidance of obsolescence can be achieved by once-a-year participation in technical courses. We leave it to the professional's initiative, however, to chart his own course in continuing education, as well as to decide whether to participate at all.

We rely most heavily on students' evaluation. We regularly ask the students such questions as, "How does the continuing education program contribute, in a significant way, to your job effectiveness?" The answers so far show that they believe that tangible improvements in job skills and new technology have resulted. If, at any time, the surveys failed to reveal these positive, although largely subjective, results, we would be warned that our program needs redirection. We hope to remain sufficiently responsive so that the program is kept at its current level of success.

LAWRENCE LIVERMORE LABORATORY
JUNE 1973

TABLE 1

IN-HOUSE CONTINUING EDUCATION COURSE PARTICIPATION BY PROFESSIONALS
ESTIMATED ENROLLMENT PER QUARTER THRU 1976*

<u>DEPARTMENT SPONSOR OF COURSE</u>	<u>LOW</u>	<u>HIGH</u>	<u>PROBABLE</u>
COMPUTATIONS	80	110	85
ELECTRONICS ENGINEERING	25	50	30
MECHANICAL ENGINEERING	65	80	65
SCIENCE	<u>65</u>	<u>110</u>	<u>70</u>
	235/QTR	350	250

*LLL HAS ABOUT 1800 PROFESSIONALS - ENGINEERING & SCIENTIFIC

PARTICIPATION IN CONTINUING EDUCATION COURSES
FOR FIVE YEARS BEFORE IN-HOUSE PROGRAM

(ESTIMATED)

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 3

PARTICIPATION IN CONTINUING EDUCATION COURSES
AFTER FIVE YEARS OF IN-HOUSE PROGRAM

FIGURE 4

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