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POST UNIVERSITY ON-THE-JOB TRAINING FOR ENGINEERS

By

EUGENE J. MANGANIELLO

and

VINCENT F. HLAVIN

Lewis Research Center
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Cleveland, Ohio

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POST UNIVERSITY ON-THE-JOB TRAINING FOR ENGINEERS

Our national need for qualified scientists and engineers is greater now than at any other time in our history. Fortunately, we can point with pride to this need as a measure of the impact of science and technology on our way of life. In effect, we have made such rapid strides in advancing established sciences and in opening new technological fields that we have proved the value of the scientist and engineer to society, and, as a result, have created an expanding demand for their services which we must now attempt to satisfy.

This demand we face is also due to the changing skills and high degree of specialization required to perform in these new technological fields. The colleges and universities are doing their part to provide current graduates with a modern technical foundation, but we cannot afford to ignore the thousands of experienced engineers and scientists already employed by private industry and government. As employers, we have an obligation to these men and women to see that they are provided with an understanding of the latest advances that modern technology has to offer; that we develop them in particular specialty areas characteristic of a given field of work; and, equally important, that we assist them in the transition from one field to another as the technological emphasis shifts.

Practically all technological industries have experienced and continue to experience rapid changes in their activities. The aerospace business, in particular, has been characterized by extremely rapid, in fact revolutionary, changes during the relatively short period of its existence. At the National Aeronautics and Space Administration, successor to the National Advisory Committee for Aeronautics, for example, we have encountered the full impact of a changing science and technology. Indeed, as a research organization, we have undoubtedly contributed, in some measure, to this change.

Within the NASA's Lewis Research Center, we have approximately 800 research scientists and engineers who have matured professionally in an environment which is essentially one of continuous learning - an experience which comes close to being a form of post graduate training in itself. This environment, in addition to providing continuous evolutionary changes, has also provided two major revolutions which have made this development picture more complex. We will describe these environmental changes which have occurred at the Lewis Research Center and discuss the various techniques and programs we have employed to provide for the professional development of our staff.

The Lewis Research Center has had an interesting and exciting 18-year history of aerospace propulsion research and development. It began during the early years of World War II as an expansion of the Power Plant Division of the NACA Langley Center with the mission of conducting research required for the development of improved reciprocating engines and to study the associated problems of subsonic propulsion aerodynamics. It was only a few years later, however, that turbojet and ramjet propulsion and supersonic flight research became our main concern. This transition to jet type engines and higher speeds was our first major technological change. The aerodynamics of propellers became the aerodynamics of high speed turbine and compressor blades; the fuel ignition and carbon deposition problems were transferred from a cyclical or intermittent high compression combustion chamber to a continuous combustion zone within a thin-walled metal shell; aerodynamics problems were thrust into the supersonic range; and high temperature materials began to play an increasingly critical role. Although this transition still required the same basic knowledge and principles as before, the new engine types did involve a different emphasis and variety of consideration not generally familiar to our scientists and engineers.

Again, in the last few years, our research activities changed radically. While space flight might in one sense be considered an extension of flight within the atmosphere, the approaches to the problem required entirely new techniques and considerations. New propulsion concepts such as the chemical and nuclear rocket and electromagnetic systems replaced the more traditional, but still recent turbo-jet engine research. Our major concern, throughout the existence of the Lewis Research Center, was not as much one of knowing where we were going or by what means we were to achieve our objectives as it was the reorientation of our staff in the new scientific specialities they would need to meet these challenges.

The problem was a critical one, as it is with any organization whose principal area of interest has been completely reoriented. We always point with pride to our outstanding physical research facilities - the tools of our trade - but even more so to our staff which we recognize as an even more important asset. Indeed, the facilities are the product of the staff's ingenuity. Over the years we have assembled a team of highly competent research scientists. Their competency results from a number of factors including creative ability, experience, and education. We feel that we not only have an investment in these people, but a responsibility to them as well. Just as we provide them with the required research facilities to do their job, we also try to provide them with a continual updating of the specialized educational background required in their particular fields of activity.

We had always encouraged our staff to improve their educational backgrounds through on-the-job seminars, brief specialized lecture courses, and attendance at graduate evening courses provided by local colleges and universities. Throughout the first decade of our existence, however, we were unable to provide any financial support to supplement and extend these educational activities to a full-fledged post-university on-the-job training program.

An appreciation for our problem was recognized by the Congress in April 1950, with the passage of the NACA-Graduate Study Leave Act. This was our entrance into the field of financial support for education purposes. The Act authorized us to allocate a limited number of dollars to compensate the salary losses incurred by members of our research staff taking advanced courses at colleges and universities. Because of the rigidity of our training budget, we were able to provide only partial salary support for those selected to attend, with no provisions at that time to compensate for additional educational expenses such as tuition. In spite of this financial limitation, the program grew steadily from seven participants in the 1950-51 school year, when our training budget was just under \$10,000, to a total of 51 participants eight years later at a budgeted cost of \$31,000. During the same period, a number of our scientists and engineers continued to take graduate courses at their own expense.

While this Graduate Study Act enabled us to provide financial benefits, it was still fairly restrictive in terms of the participation we felt was necessary. To furnish wider training opportunities for our entire research staff, we expanded the informal seminars and lectures conducted at Lewis into a series of formal graduate level courses which were developed around our own particular fields of activity and taught by members of our research staff. In most instances, parallel courses of this nature could not be found in the colleges and universities. The initial response was excellent. In the first year of operation, 1953, there were 150 participants. Since that time, the enrollment has steadily increased to a point where last year 400 employees, approximately half of our professional research staff, were enrolled in the program.

Courses offered in this program served the needs of those who were interested in supplementing their education without enrolling in formal graduate programs or for those who were financially unable to attend graduate school under our limited support program. Courses taught at the Lewis Center also offered an excellent means of communicating advanced concepts developed by one particular research group to others whose research activities were in broadly related fields.

As a side of graduate training, we developed an arrangement with Case Institute of Technology, after World War II, to supplement their faculty in the aeronautical engineering field. Our Center supplied part-time faculty members for approximately 5 years to teach a number of courses related to aircraft propulsion. Subsequently, we provided Case with the outlines and lecture notes of some of these courses and of some of our internal courses which they then taught with their own faculty. This is an example where the schools, partially because of the national security restrictions, were unable to keep pace with a rapidly advancing technology. Our efforts in this regard were designed to assist the college until such time as it was able to incorporate this advanced material into its own curriculum.

For about 10 years we continued to follow the previously outlined development program of attendance at colleges and universities, internally taught courses, and close working relationships with local schools to assist them in updating their curricula.

On the other hand, there are in many of our schools scientists who for years have been conducting theoretical and experimental research in unexplored fields of interest. Almost without exception, whenever we at Lewis have moved into new areas of research these university scientists have been able to provide us with fundamental knowledge upon which our new programs can be based. Our regulations permit us to hire these men as consultants and lecturers to indoctrinate our staff in new concepts and problems.

In the past, a few other Federal agencies, for example, the Department of Defense, enjoyed special legislation to cover the expenses of training for their technical staffs. These individual training legislative provisions, however, furnished different benefits for different agencies, and did not extend to all Federal agencies who had a need for them. In July of 1958, all Federal training legislation was incorporated into a more uniform government-wide training program. The Government Employees Training Act, as this law is called, was much more liberal and permitted us to improve and expand the Lewis program. It authorized the payment of all expenses incurred as a result of training including salary, tuition, travel and per diem, books and supplies. We were now able to train members of our research staff, and to finance the cost of this training, to the extent we felt it practical and desirable to do so.

The program that has evolved has been well received and, we feel, is proving highly successful. For example, in the 1959-60 school year we sent 9 employees to graduate school for one entire school year; 158 on a part-time basis to local colleges and universities, and 34 to short technical courses, institutes, and conferences held throughout the country. The expenses involved, however, were considerable. The cost for tuition and related fees was \$50,000. Of greater consequence - our total research time lost through training of 201 scientists and engineers was about 33,000 man-hours. This is roughly 2% of our total research and engineering staff time.

This is a real cost to any organization and it raises the question as to the value received for our expenditure - in other words, the return on investment. Education expenses and lost productivity are real, measurable and immediate. Research and development results are of a long range nature and difficult to attribute to a particular educational pursuit. How then can we measure the return on investment? We can't in specific terms. Yet, we feel strongly that the intangible benefits more than outweigh the cost. Let us review our reasons for this belief.

We have previously mentioned the rapidly changing technology and increasing specialization which impose trained manpower demands that the industry must meet if it is to do an effective and competitive job. As one technical recruiting manager wrote facetiously not so long ago: "The technical manager would like his young engineers to have a basic four-year engineering course, topped off by graduate work in a specific field, plus the physics or math of a doctorate, superimposed on a liberal arts background, with a survey of economics added." Lacking a ready supply of graduates with such qualifications, we have little choice but to help provide the necessary additional training. Furthermore, the additional education may well be more meaningful and better focused if it is provided while or after the graduate has been on the job.

As a parallel, the cooperative education system for undergraduates has existed since the turn of the century on the precept that a combined work-study program is more meaningful to the student. Is this philosophy not equally true for the graduate student? We hire recent college graduates with the knowledge that their real education has only begun. By assisting the better members of this group to pursue programs which we know to be directly related to our work, we not only provide for their development but insure that this effort is of direct value to us.

We attempt to maximize this potential research benefit through our selection of participants. We have established a committee of operating officials to weigh and evaluate the qualifications of each applicant in the light of our research emphasis. The major criteria used by them in their selection are the relatedness of the education to the applicant's present or future assignments; the applicant's relative degree of ability as a student and as a significant contributor in the field of research; and his demonstrated willingness to pursue further study, independent of our support.

An additional benefit of our education support program is its aid in recruiting the type of college graduate we desire. We have found that today's superior student, who possesses a strong desire to enter the research field, usually possesses an equally strong desire to continue his educational program. Since educational costs have risen to a point where it is becoming economically prohibitive for many qualified students to pursue graduate study without financial assistance, college seniors have placed graduate study opportunities high on their list of requirements in selecting a future employer.

Let us point out that we do not encourage graduate study support to be viewed as a special fringe benefit for new recruits. Applicants for research positions are informed that they are subject to the same evaluation and selection procedure that we employ for our more experienced employees and that their eligibility is entirely a result of their demonstrated characteristics and performance.

This, in effect, serves as an incentive to our new employees as well as to our senior staff. We are sure that each of them realizes the value of advanced study in terms of future assignments, broader responsibilities, and advancement opportunities. The enthusiasm and response that have been shown, thus far, point up the fact that in our advanced study program we embody many of the incentives that are considered important to the effective operation of a research organization.

We also know that many outstanding contributions in our research fields are being made in the colleges and universities. It benefits our own research effort if key members of our staff who are responsible for research planning are aware of, and understand, the significance of these contributions. By sending them to attend special, up-to-date, courses we minimize the possibility of spending time and talent duplicating what others have already accomplished and provides assurance that our contributions are significant and that we are truly building in our field.

Our statements regarding these benefits would be meaningless, though, if an employee were to leave our organization immediately after satisfying his educational desires. Although we have experienced a few such losses, fortunately they have been the exceptions rather than the rule. We do have some measure of insurance in our program to provide for such occurrences. Each employee who is selected to receive our support is required to complete a specified term of service. The contract which we employ specifies that, upon completion of the training, an employee must return to the NASA for a period of three times the length of the training program or reimburse us for the expenses incurred, excluding salary. For part-time students, the program's length is interpreted as the total time spent in class or with an instructor; for full-time students, it is the total length of the program based upon a forty-hour week.

We do not consider this to be an excessive demand nor a real deterrent in the event that someone does wish to leave our employ. Instead we believe it develops in the participants a sense of obligation to the NASA without their feeling that they have been cast in the role of "bonded servants". We want to encourage our better employees to further their education, not discourage them with too excessive a time or financial commitment. We prefer to believe that we retain them because they enjoy the challenge, opportunity, and environment which the Lewis Research Center provides.

Earlier, I discussed our program in terms of both full-time and part-time study without considering the pros and cons of either method. We have found that, from the standpoint of an equivalent number of subjects taken, the economic and time factors are approximately equal. For part-time studies, it can be argued that the student can apply his education as he is learning it. On the other hand, a full-time student covers a greater number of subjects in a shorter period of time. He, therefore, can apply his talents to higher level problems in the time period that his part-time counterpart is striving to attain the same educational level. Although it is thus six of one and half a dozen of the other, we personally prefer the part-time study.

We have briefly reviewed the major considerations of an educational support program - elements in favor of the program, and some of the difficulties. Again, let us emphasize that our greatest asset is our manpower. It is our men and women who must accomplish the job. If they fail then our research effort fails.

Education is only one part of the over-all picture. In our particular business it is an extremely important one. Indeed in any technological industry, it is significant. If science and technology are to continue as a major aspect of our way of life; if manpower shortages persist in critical skill areas; if we are to retain our present competitive position; then as employers we must take steps to insure that the immediate educational needs of our technical staffs are met and we must continue to make provisions for meeting the future needs.