Maintenance Training Research

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•THE Louisiana Department of Highways is conducting research to develop effective methods for training maintenance personnel. The training research is based on findings of a more extensive research undertaking directed toward the development and implementation of a modern maintenance management system. The principal elements of the management system—and bases for maintenance personnel training—are performance standards defining optimum service levels, quantities of work, and work methods and procedures.

This paper reports on that phase of the research directed to the testing and evaluation of different training methods. The following subject areas are covered:

Work Force Characteristics—A description of the characteristics of the maintenance supervisory personnel who are to be trained. These characteristics influence decisions on the selection and development of training methods.

Subject Matter Content—A general outline of the subject matter—developed from performance standards—used to conduct the research and a discussion of some management actions required before end-behavior can be altered.

Training Methodology—A description of the different training methods selected for testing.

Evaluation of Effectiveness—The plan for evaluating the effectiveness of training and some preliminary conclusions reached at this stage of testing the methods.

WORK FORCE CHARACTERISTICS

Maintenance supervisors in Louisiana are very similar in terms of age, education and experience to those found in other states and Canadian provinces with whom the consultant has been associated.

Typically, they are extremely dedicated men who have spent the greater part of their lives as public servants of the highest order. Still, they present some difficult problems from the standpoint of their capacity to absorb training material.

Their age places them many years away from the formal learning processes of school and they are generally lacking in education. Their experience often represents many years of doing things the same way, which means some nonefficient work habits and methods are quite ingrained.

Age

The range in age of maintenance supervisors to be trained was from less than 25 to more than 65 years. Equipment operators, from whom future supervisors will be drawn, had roughly the same distribution in age. The distribution of both groups is shown in Figure 1. As can be noted, the mode of the distribution of both groups is in the 55 to 64-year range. The average age of the present supervisors is 51 years; the average age of potential supervisors is 49 years. These data indicate a potentially high turnover from retirement and the promotion of new men will not shift the age distribution to any appreciable extent. Therefore, training materials and methods must be designed to accommodate both the young and old supervisor.

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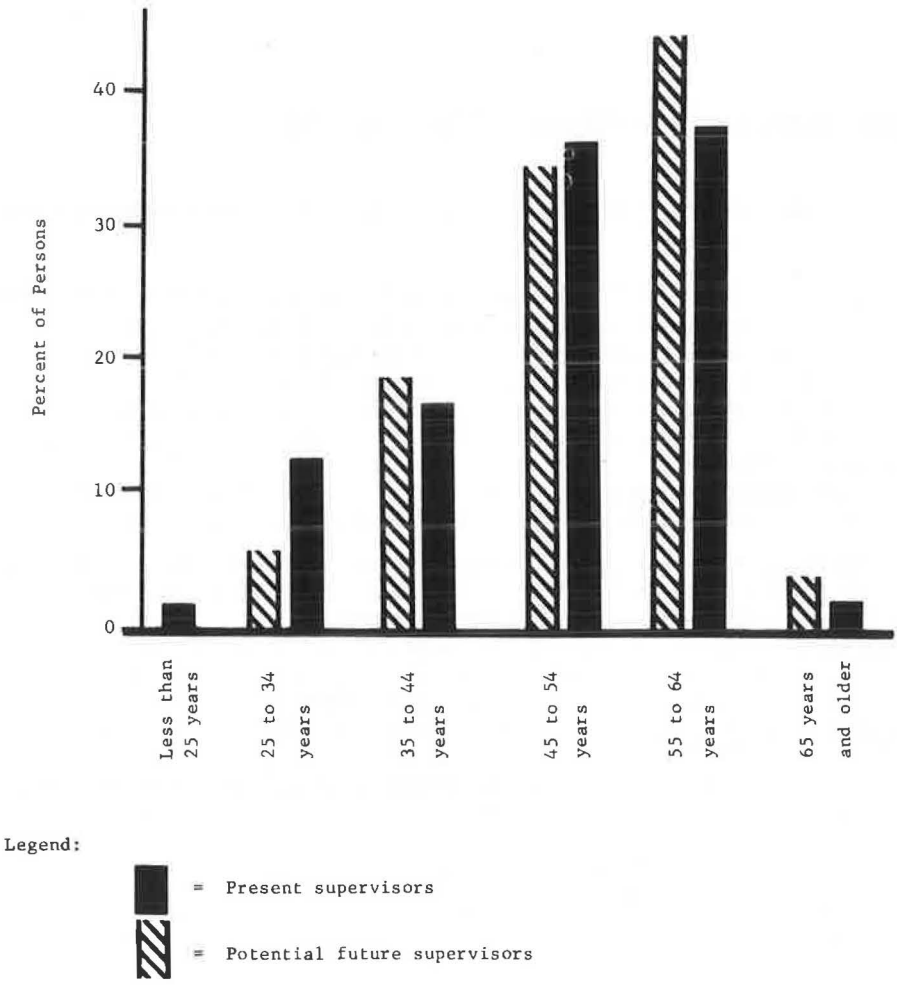

Figure 1. Age distribution of maintenance supervisors.

Education

The education distribution of maintenance supervisors is shown in Figure 2. The average number of school years completed was 8.9 for current supervisory personnel and 6.7 years for potential supervisors. The number of years of education ranged from less than 4 to 16 years. The educational level is a significant factor in any training program because verbal or reading skills have a large effect on trainability. Training must be designed to cope with the person who can barely read and write as well as the high school or college graduate.

To complement the inventory of education data, a Wonderlic Personnel Test was given to a sample of supervisors. This widely accepted test indicates the relative capacities of individuals to learn from training. A summary of the results of this test is given in Table 1.

In a similar test of the potential supervisors, only 9 percent showed a general ability to be trained. These test results mean that new techniques must be developed if personnel with low capacities for learning are to be trained successfully.

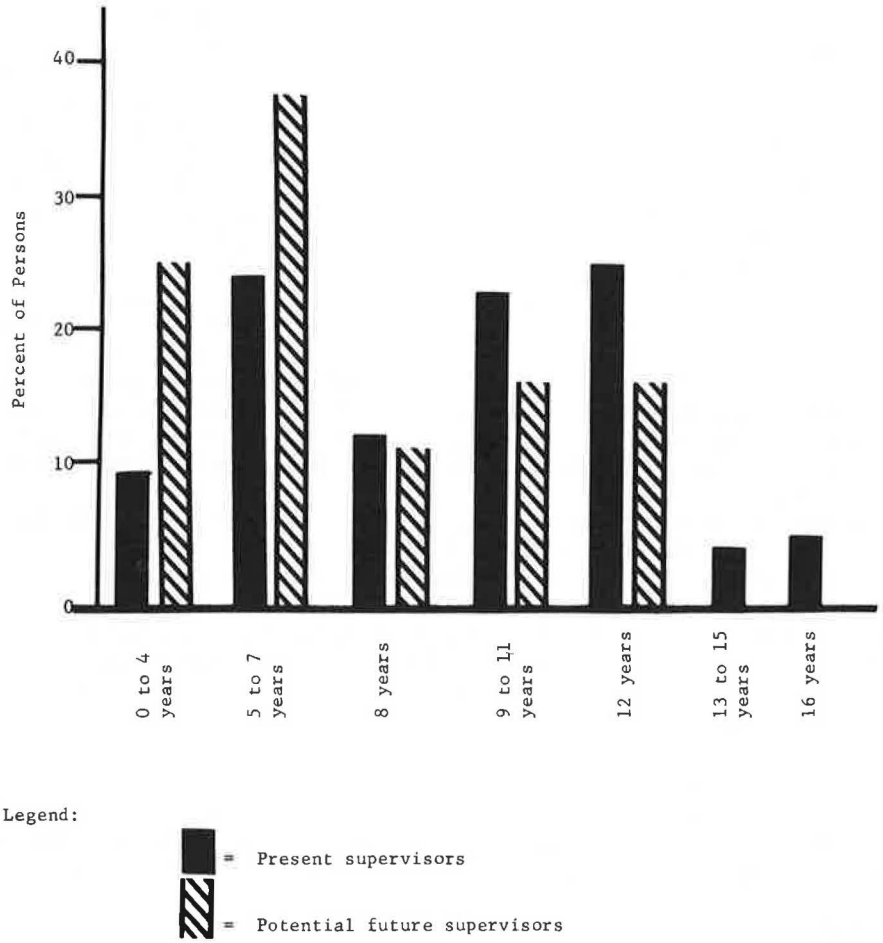

Figure 2. Education distribution of maintenance supervisors.

Experience

Both current and potential supervisors are generally well experienced. More than 79 percent of the current supervisors have more than 10 years experience—and 20 percent of them have more than 20 years. The potential supervisors generally have less experience with only 41 percent having more than 10 years.

The experienced supervisor has a good general familiarity with maintenance equipment, materials and needs. However, supervisors with long experience will be reluctant to take training with less-experienced personnel. They also will have more difficulty in accepting new concepts.

SUBJECT MATTER CONTENT

The content of maintenance training is recognized as one of the chief problems in training. As compared to the fields of construction or materials testing, the procedures of maintenance are very poorly defined. Furthermore, the knowledge of maintenance operations possessed by maintenance engineers is often lacking in sufficient detail for use as subject matter data for training.

TABLE 1

WONDERLIC TEST RESULTS

Wonderlic Test Scores	Ease of Training	Percent of Present Supervisors
0 to 11	Difficult—inability to read or grasp numerical relationships and abstract concepts.	66
12 to 15	Marginal—can be trained in repetitive tasks.	13
16 to 50	Readily trainable—by using carefully developed materials.	21

As a result of other research efforts to improve management practices in Louisiana, virtually all maintenance work methods and procedures are being modified. This meant that the collection of training data by observing crews in action was not possible because no crew was doing the job according to the revised methods.

Therefore, the approved performance standards were used as the basis for developing training material. Basically, these standards indicate when work should be undertaken, how much work should be done, and what methods and procedures are the most productive. The performance standards were expanded into training material through discussions with persons thoroughly familiar with the rationale behind the new practices.

To evaluate the training methods, the maintenance category of "bituminous surface care" was selected as the subject matter for development. The most salient feature of the new bituminous surface care program is the planned seal coat of a road every 5 years. A number of bituminous surface work functions must be performed. Each has a distinct purpose and is directed toward obtaining a specific quality or service level. For each, the amount of work to do, labor/equipment staffing pattern, work procedures and standard unit cost have been spelled out. The aspects of the surface care job in Louisiana are set forth in the following sections.

Surface Treatment Patching

Surface treatment patching is a spot seal coat operation consisting of an application of liquid asphalt and cover aggregate. Its purpose is to prevent deterioration of a pavement beyond the stage of light pattern cracking or oxidation in-between seal coats.

Premix Patching

Premix patching is repair of traffic hazards—potholes and severe depressions—by bringing the area of failure back to the original surface height. The Department's desire is to keep emergency work separate from planned, major programs and to hold the amount done by these methods to a minimum.

Patching Base

Base repair consists of the removal of unsuitable base and its replacement with good material. All base repairs are subject to specific approval by an engineer from the district.

Seal Coat

A seal coat is a full-width treatment consisting of a single application of liquid asphalt and cover material. The seal program is intended to have an average frequency of 5 years.

Premix Leveling

Premix leveling is a general leveling course applied in the same season as a road is sealed. It is intended to restore all cross section deviations greater than top-size premix aggregate. This work is authorized along with the seals on a road-by-road basis by the district.

Spot Surface Replacement

Spot surface replacement consists of removing necrotic surface material that has cracked all the way through and re-paving the area with hot mix.

Training must communicate to maintenance field supervisors the way a job should be done. In this sense, training is one part of the implementation process required for new practices. In addition to the training of supervisors, there are significant changes in the action patterns of other managers required to accomplish the desired end behavior. The actions required of persons other than the supervisors being trained include:

1. The development of an objective maintenance program for the districts involved in the research. (The program is built up from performance standards and represents an objective in terms of good performance. This is contrasted with a program based on past performance, which would be essentially predictive.)
2. A formal inspection jointly conducted by the supervisor and an engineer from the district office to designate roads for major maintenance effort and to agree mutually on approaches to specific problems.
3. The installation of a scheduling process in each parish to facilitate scheduling of work as called for by performance standards.
4. Minor reorganization within the operating forces to allow greater flexibility of operations on the part of the field supervisor.

TRAINING METHODOLOGY

Through a review of training methods now in use, those tested in other maintenance research, and those utilizing the new techniques of programmed instruction, the decision was made to investigate 5 basic methods. These are as follows:

1. Written programmed instruction—self-instructional materials in a printed book format, prepared according to the generally accepted programmed learning technique.
2. Audio-visual programmed instruction—self-instructional materials that minimize the need for reading by use of a "teaching machine." For this research, a slide projector and tape recorder were used.
3. Programmed workshop—a carefully led small group that uses written materials highlighted by both classroom models and field observations of road conditions and proper corrective procedures.
4. Group discussion—a leaderless small group that uses written materials. The job of temporary discussion leader is rotated among the trainees.
5. Conventional lecture—presentation of training material through the standard lecture technique using a knowledgeable instructor.

Each training method was selected because of certain characteristics that are spelled out in the following sections.

Written Programmed Instruction

The usual written programmed instruction materials have a number of advantages not found in other training methods. Their effectiveness in industry has been conclusively demonstrated and, as a result, they formed the basis for this training research. Their characteristics are as follows:

1. They are self-pacing. The student is paced entirely according to his own abilities. It has been found that differences in test results of other training methods are merely the result of differences in speed of learning; so, the results do not accurately reflect the total amount of information a person can learn.
2. The student is unlikely to be embarassed—an important factor in training adults.
3. The materials are always conveniently available and can be effectively used in slack time.
4. Retention generally is superior to other forms of training.

5. The disadvantage of these materials is that they depend on reading ability. For this research, the subject matter material was prepared for fourth grade reading level. However, only time will tell whether or not this will be satisfactory.

Audio-Visual Programmed Instruction

The same characteristics of learning—discovery of the facts by the student and immediate confirmation of correct answers—that make programmed instruction so effective are also inherent in an audio-visual format.

A series of slides, designed to illustrate concepts and to create mental interruptions at the appropriate time, will be used for this method. As the slides are being viewed, spoken supporting information will be furnished to the student by means of a prerecorded tape program. The student is asked questions on the material and his answers are verified by the tape.

It is anticipated that most learning problems associated purely with reading can be eliminated. Comparison of test results with conventionally programmed material should provide needed insights into the significance of reading ability. There are available a number of self-instructional reading improvement programs that may well be an alternative for the Department should this be noted as a significant factor.

Programmed Workshop

For training to be effective, the student not only must gain knowledge but also must act on that knowledge in the field. The principal characteristic of this method is the immediate reinforcement in the field of the information learned during a group discussion.

The method planned is to use a series of classroom models augmented with demonstrations in the field to support the written material. The student will be asked to evaluate some existing road conditions and to indicate the proper corrective actions. The student also will be shown approved procedures for performing each function of surface care job.

Group Discussion

It is recognized that many motivational factors affect the behavior of men trained, and that these factors cannot adequately be separated from other training considerations.

One of the primary motivators, theoretically, is group acceptance of a concept. Conceivably, an individual could agree completely with what he was taught, but not be moved to act for fear of being the only person around who would be doing the job in a new way. This training method will be tested so that the combination of programmed preparation and group dynamics can be evaluated.

Conventional Lecture

The material on bituminous surface care will also be presented in a conventional lecture format. A blackboard will be used as the major visual aid to stress major points and to avoid extraneous material. In effect, the lecture is being used as a "control" method to determine the extent of improved training through the programmed methods.

EVALUATION OF EFFECTIVENESS

The basic procedure for testing each of the training methods is as follows:

1. A comprehension test—The purpose of this test, which consists of 97 basic questions on language and mathematics, is to determine the learning ability of the trainees so they can be divided into comparable sub-samples.
2. A pre-test—This is used to determine the amount of subject knowledge prior to training.
3. One of the 5 "bituminous surface care" training methods.

4. A post-test—The purpose of this test is to determine the amount of subject knowledge immediately after training.
5. Retention tests—These tests will be administered at one-month and three-month intervals after the training to measure trainees' retention levels.

The training methods will be evaluated in two stages. These are as follows:

1. Immediate or short-term—An evaluation directed to the comparative communication ability of the various methods as determined from pre- and post-testing.
2. Long-range—An evaulation in terms of specific retention levels and also one coming automatically from the Louisiana Maintenance Reporting System, which will show performance change and dollar savings.

The training will be administered by the line organization. Representatives of each district have been instrumental in developing the standards, which have the approval of the maintenance engineer. Obtaining standard results or better is the objective of the Department. If this objective is to be fulfilled, managers in both the central office and the districts must give full notice to their people that that is what they want done. In essence, this is a regular part of the management and supervision of the maintenance function. Such an outlook is essential to the success of a training effort. No one is likely to change his methods of doing work unless he is convinced this is the way his organization wants him to do it.

Short-Term Plan

The primary evaluation will consider the following factors:

1. The test results obtained compared with an evaluation of the man's learning potential.
2. The reaction of people as evidenced by their attitude toward training and their desire to take more training.
3. The changes in work behavior.
4. The organizational convenience of each training method.
5. The amount of follow-up required by district-level supervisors.

The research team will assist Department and district managers in evaluating research results, but the decision as to what methods should be adopted for use will lie with them.

Preliminary Results

Based on the limited sample tested to date, the following preliminary conclusions were drawn:

1. Above-average trainees (in terms of age; education, experience, and learning ability) gained more from the audio-visual and workshop methods than from any other method.
2. Average and below-average trainees gained more from the audio-visual and group discussion methods than from any other.
3. The amount of information gained does not seem to be dependent on the age, experience, or educational level of most trainees. Insignificant correlations were found among these variables.
4. The comprehension test seems to be a good predictor of the capacity to learn. Trainees who scored high on the test gained more knowledge than those with low test scores. Therefore, the test can serve as an aid in the selection and the screening of good potential supervisors.
5. The first retention tests indicate that the average trainees retained about 90 percent of the information learned.
6. The attitudes during the pre-test ranged from the noncommittal to an "I don't need training" remark. Trainees definitely became more interested as they progressed through the course and all but 5 of the 90 sampled to date felt that further training in other areas was essential.

TABLE 2

TRAINING METHOD RESULTS

Method	Approximate Time to Administer (hr)	Average Comprehension Test Score[a] (¢)	Average Gain Rate[b]
Written programmed instruction	7	45	0.60
Audio-visual programmed instruction	6	45	0.73
Programmed workshop	20	46	0.68
Group discussion	13	46	0.68
Conventional lecture	3	46	0.46

[a] Perfect score = 97.0

[b] Gain rate $= \frac{\text{Post-test score less pre-test score}}{\text{Perfect score less pre-test score}}$

7. About one-half of the trainees indicated that they planned to conform to maintenance procedures learned during the course. The remaining trainees accepted only parts of the training, indicating the need for follow-up by supervisors.

The relationship among the various methods is given in Table 2.

Long-Range Plan

Tests for retention of information will be conducted at regular intervals after conclusion of the training; but the final evaluation will occur several months later when the data feedback from the Louisiana Maintenance Reporting System shows the change in the quality of the work, in the amount of work required when done properly, and the unit costs. This will be looked at as the final test of the different methods.