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Transportation Research Record 1101

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Contents

Abridgment

Undergraduate Transportation Engineering Education

C. J. KHISTY

A survey of transportation professionals was conducted to determine their views on the contents of a required transportation course in the bachelor of science in civil engineering (BSCE) program. The results are compared with a similar survey of transportation educators. Substantial congruence exists in the views expressed by practitioners and educators. Additional observations and suggestions offered by practitioners to enrich a required course are also presented. It is recommened that topics in transportation engineering receiving a high score from both practitioners and educators be included in a required course in transportation engineering for undergraduates.

A recent nationwide survey of undergraduate civil engineering (CE) programs in this country has revealed that about 86 percent of CE departments teach a required transportation engineering course, representing an average of about 3.5 credit hours *(1)*. Over the years there has been a running debate about what to include in this required course (or courses), because "no two teachers have identical views as to what transportation engineering topics should be taught to aspiring civil engineers" *(2)*.

Most courses in civil engineering are taught using standard textbooks, and transportation is no exception. Although there appears to be a general dissatisfaction with introductory textbooks on transportation, most instructors follow one or more of these texts, supplementing parts of the course with relevant notes. Recently, the author of a transportation textbook conducted a survey of professors teaching transportation to determine the content of the course(s) that should be included as a requirement in a CE curriculum *(2)*.

Although the collective views of transportation educators obtained through this survey have been useful in developing courses, it was believed that similar input from qualified transportation practitioners would further enhance the information available. A telephone survey of 50 transportation professions was, therefore, conducted, and the views of educators and practitioners are compared in this paper followed by a discussion of the survey results.

THE PROBLEM

The multidisciplinary nature of transportation has created several problems in teaching a required course in transportation in the undergraduate CE program. Some of these problems are: lack of suitable, moderately priced, relatively self-contained, introductory textbooks; general deficiency among students in areas such as microeconomics and statistics, which are needed to comprehend transportation problems; lack of understanding of the systems necessary to address socioeconomic issues connected with transportation; lack of appreciation of the multivariable, open-ended, conflict-ridden, value-laden nature of real-world problems; and presentation of the principles of transportation from a modally oriented point of view *(3–5)*.

The questions stemming from these problems are: What constitutes transportation engineering education for an undergraduate CE curriculum? What do employers expect from a CE undergraduate? How should the course be developed so that it addresses the needs of a relatively large number of CE students who in all probability do not foresee the possibility of pursuing further studies in transportation, and at the same time stimulates a relatively small number of students who may develop an active interest in transportation? *(2,3,6)*

BACKGROUND

Although the master's degree is considered by most educators and practitioners as the degree of specialization in transportation, only a small percentage of undergraduates elect to pursue the master of science in civil engineering (MSCE). This is not surprising. When industry pays an individual with a BSCE a starting salary comparable to a Ph.D., it deprives the young engineer of any significant motivation to acquire an advanced degree *(4,6)*.

Proper grounding in the principles of transportation is essential because the entry-level BSCE in federal, state, and local government, as well as in construction, design, and consulting firms may have had only one required course in transportation engineering. The Committee for the Study on Transportation Professional Needs had similar views:

> Some hiring at levels above the entry-level is undoubtedly occurring, but is probably small. The normal practice in most states is to hire relatively inexperienced entry-level engineers, train them in varied activities of the agency and promote them after several years to fill higher staff positions. This not only provides an adequate supply of professionals versed in the methods employed by the agency, but also establishes a career path that encourages loyalty *(7)*.

SURVEY OF PRACTITIONERS

To identify the views of the transportation practitioners, the author selected, at random, 50 professionals in the United States, working for departments of transportation, counties,

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cities, and private firms. The mode-distribution of these professionals was as follows: highways 30; general transport 6; public transport 8; airways, railroads, and seaports 2 each. This distribution matched the ITE membership mode distribution *(8)*. All the practitioners interviewed had acquired an MSCE in transportation after receiving their BSCE. The practitioners were asked to evaluate the importance of 30 topics that could possibly be included in a required course in transportation for CE students. They were also asked to express their views regarding their choice of topics, including general observations and suggestions for improving the quality of CE students.

Each of the topics presented was ranked by the practitioners on a 5-point scale as follows: 1, definitely do not include; 2, probably not include; 3, no opinion; 4, probably include; and 5, definitely include.

Table 1 gives the 30 topics by rank. It also includes as a comparison, the 10 topics that received the highest scores awarded by transportation instructors in Wright's survey *(2)*. Figure 1 is a plot combining the scores given to topics common to practitioners and educators.

DISCUSSION OF SURVEY RESULTS

The 45 degree line shown in Figure 1 represents equal valuing by practitioners and educators. Common topics plotted above the line represent educators assigning a higher score than practitioners for these topics and vice versa. The pattern that appears to emerge is that geometric design of highways, vehicle operating characteristics, highway capacity studies, intersection design, and transportation planning have greater relevance to practitioners versus educators. On the other hand, description of transport systems, traffic flow characteristics, and traffic safety are scored higher by educators versus practitioners. Considering the scale of Figure 1, it is evident that we are essentially dealing with scores of 4.0 and above indicating that these topics are considered essential for inclusion in a required course and that ranking per se has little significance. Also, the fact that the 10 topics receiving the highest scores awarded by educators are common with 13 topics receiving the highest score awarded by practitioners reinforces the belief that there is a high congruence in the expectations of educators and practitioners.

SUMMARY OF VIEWS EXPRESSED BY PRACTITIONERS

Conversations with practitioners interviewed in the telephone survey resulted in the following general observations, views, and suggestions with respect to enriching a required course in transportation.

- Students should be given the opportunity to tackle open-ended problems, defending their solutions or conclusions with short narratives.

TABLE 1 TRANSPORTATION TOPICS

Topic	Practitioners (N = 50)			Educators (N = 51)		
	Score	SD	Rank	Score	SD	Rank
Geometric Design of Highways	4.80	0.63	1	4.62	–	2
Vehicle Operating Characteristics	4.72	0.72	2	4.34	0.77	5
Highway Capacity Studies	4.69	0.68	3	4.28	0.99	6
Intersection Design	4.58	0.90	4	4.00	–	8
Transportation Planning	4.44	1.33	5	3.96	–	9
Traffic Control Devices	4.32	1.20	6	4.38	0.96	4
Economics of Transportation	4.20	1.35	7	–	–	
Land Use/Transportation Interaction	4.18	1.45	8	–	–	
Evaluation Techniques	4.13	1.02	9	3.90	–	10
Transportation System Management	4.06	1.40	10	–	1.36	
Description of Transport Systems	4.04	0.80	11	4.72	0.57	1
Traffic Flow Characteristics	4.04	0.94	12	4.54	0.79	3
Traffic Safety	4.00	0.73	13	4.22	0.89	7
Contracting Procedures	3.92	1.20	14	2.30	–	–
Specifications	3.80	1.31	15	–	–	–
Operational Characteristics of Modes	3.80	1.37	16	–	–	–
Mass Transit	3.79	1.35	17	–	–	–
Airport Planning	3.63	1.50	18	–	–	–
Human Powered Transport	3.50	1.41	19	–	–	–
History and Development of Transportation	3.41	1.11	20	–	–	–
Earthwork Operations	3.40	1.39	21	2.28	1.49	–
Transportation Materials	3.27	1.15	22	–	1.46	–
Pavement Management	2.90	1.15	23	–	1.37	–
Construction Procedures	2.68	1.04	24	–	1.37	–
Transportation Legislation	2.54	1.98	25	–	0.73	–
Pipelines	2.42	1.29	26	–	–	–
Statistics Applied to Transportation	2.40	1.10	27	–	–	–
Maintenance of Facilities	2.31	1.37	28	–	1.34	–
Belt Conveyors	2.30	1.40	29	2.08	–	–
Ports and Harbors	2.28	1.39	30	2.12	1.46	–

Note: SD indicates standard deviation.

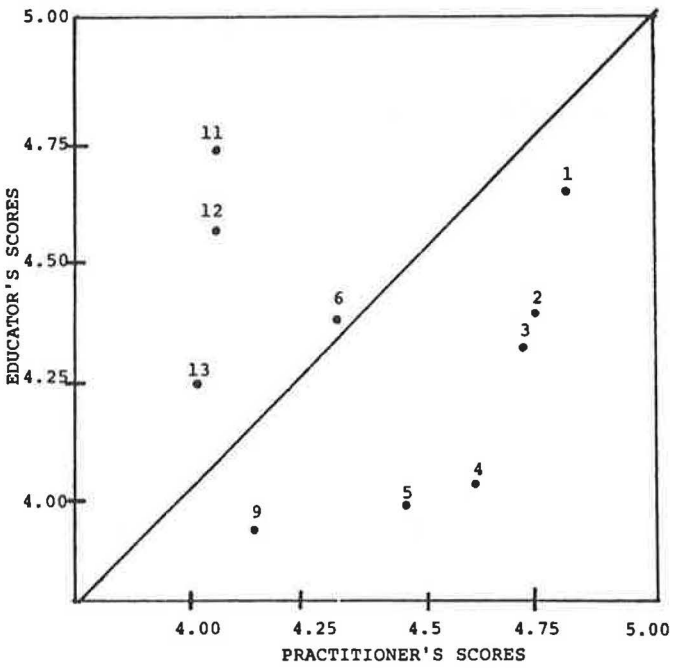

FIGURE 1 Comparison of scores.

- Students should be given every opportunity to tackle real-life problems. This could be in the form of one or more projects done individually or in a group. The group project idea should be encouraged because it provides students with a realistic experience in team dynamics. Assessing individual effort from team performance should not prove a menacing problem if proper peer assessment techniques are used *(9)*. If possible, a practitioner should be asked to help in the assessment.
- The ability to solve problems with incomplete or redundant data should be impressed on students through appropriate examples and class assignments.
- The fundamental principles underlying transportation should be emphasized.
- To do justice to such topics as pavement design, construction methods, maintenance of facilities, and so forth, it would be best to address these topics in courses other than the required course.
- Where possible, between 10 to 15 percent of the course should be taught by instructors actively collaborating with practitioners.

RECOMMENDATIONS AND CONCLUSIONS

On the basis of the data presented, it is recommended that

1. A required course(s) in transportation engineering in the BSCE program cover all or most of the topics receiving a score of 4.0 or more as given in Table 1.
2. The proportion of time devoted to each topic and the sequence in which these topics are addressed be left to the discretion of individual instructors.
3. Cognizance be given to the suggestions made by practitioners.
4. The basic principles of transportation be emphasized, if necessary, through one mode of transportation.

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An Institute for Chief Administrative Officers of State Departments of Transportation

LESTER A. HOEL AND GARY T. JOHNSON

Described in this paper are the design and implementation of a transportation executive institute for chief administrative officers of state departments of transportation (DOTs). Although education and training programs for state DOT staff are widely available, there has been little transportation education for chief administrators. The objectives of the Transportation Executive Institute are to contribute to the understanding of political, technological, social, legal, and economic forces affecting transportation management; increase the understanding of current issues in transportation; and provide a forum for the exchange of ideas and concepts related to transportation. The institute curriculum was developed on the basis of needs assessment surveys of the states. The results provided a priority ranking of organizational and policy issues of concern to chief administrators. The key elements of the success of the program have been (a) assuring that those who attended participated in program development, (b) recruiting outstanding program faculty, and (c) providing a comfortable and attractive learning environment.

The character of state transportation agencies has changed considerably during the past two decades in terms of mission and outlook. Most agencies functioned primarily as highway departments in the 1950s and 1960s, but with changes occurring at all levels of government in the 1970s, most of these agencies were reorganized as departments of transportation. In the 1980s state transportation organizations have been dealing with a broad spectrum of modes and issues, and have also been faced with problems resulting from reductions in work forces as the highway construction program has begun to wind down.

The management of state transportation agencies has also changed during this period. With the transformation to departments of transportation (DOTs) came administrators with backgrounds other than those common to the highway field. Many of these newcomers have been political appointees of governors rather than career professionals in transportation, and are generalists, as compared with the highway engineer-administrators of the past. Most have a short tenure and must deal with a wide spectrum of multimodal concerns. Usually, they are in the public spotlight as they deal with rapidly changing issues, and many do not have the background needed to identify and evaluate options and advise political leaders on a variety of technical issues. Today's chief administrative officers, while effective in the leadership role within a state DOT, still need to be quickly "brought up to speed" in key policy and organizational areas so that they can effectively deal with evolving issues.

In response to the special needs of administrative officers of state DOTs, the Transportation Executive Institute (TEI) was organized at the University of Virginia in 1984. The TEI is a 1-week program tailored for top managers of departments of highways and transportation to provide them a sound understanding of their organizations and of the forces of change that affect their operations. The think tank environment, and the extended time away from the office made possible within a university setting, is intended to provide a mechanism whereby current policy and managerial issues facing state DOTs can be fully developed, discussed, and debated. The purpose of this paper is to describe the design, organization, and implementation of the program and to discuss the response to it. Although education and training programs for state DOT staff are usually available, there has been little in the way of transportation education for top administrators and policymakers.

INSTITUTE CHARACTERISTICS AND OBJECTIVES

Several ground rules were established for the institute. First, the program is restricted solely to chief administrative officers (CAO) of state DOTs and officials of the U.S. Department of Transportation. This limitation assures that the program will be designed to meet the needs of CAOs and will address their common concerns from a state perspective. Thus, curriculum design can be tailored to and focused on problems faced by transportation agencies in states throughout the nation.

Second, the institute is not a management seminar in the general sense, but is intended to focus specifically on the issues that affect the top management of state transportation agencies. Thus, the TEI is not intended to duplicate other management programs, such as the Mississippi Highway and Transportation Management Institute, which is of 3-weeks' duration and intended primarily for middle management engineers. Furthermore, the TEI is not an executive management program such as is offered by schools of business administration. These programs attract middle and upper management personnel from private industry, and usually run for 6 to 9 weeks. Schools such as Harvard, Massachusetts Institute of Technology, Stanford, Virginia, and Northwestern have offered executive management programs of this type for many years.

The objectives of the Transportation Executive Institute are to (a) contribute to the understanding of the political, technological, social, legal, and economic forces affecting transportation and transportation management; (b) increase the under-

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standing of current issues in transportation; and (c) provide a forum for the exchange of ideas and concepts related to transportation.

PROGRAM DESIGN AND CONTENT

The institute curriculum was developed on the basis of needs assessment surveys of the states. Those respondents who indicated an interest in attending the institute, either the CAOs or deputy administrators, were asked to rate a series of topics on a scale of 1 to 5, with 5 representing "very important" and 1 representing "of little importance." The results from two surveys, the first conducted in 1984 and the second in 1985, are given in Tables 1 and 2. Each table gives the general subject areas and the means of the individual ratings for subtopics within the areas. For example, the general topic "information systems" was subdivided and rated as follows: computer-aided design (4.23), computer-aided financial management (4.27), and communications technology and state options (3.91). The overall rating given in Table 1 is 4.14.

TABLE 1 MAJOR TOPICS IN TRANSPORTATION AS DEFINED BY STATE DOT ADMINISTRATORS IN 1984

Topic	Rating
Information Systems	4.14
A Look Ahead in Transportation	4.11
Changing Emphasis in DOTs From New Construction to Maintenance	3.96
Dealing with the Public	3.93
Funding and Manpower	3.88
Coping with DBE/WBE Requirements	3.57
Impacts of Changing Levels of Service	3.54
Trucks	3.44
The Transportation Manager and the Law	3.28
Synthesis	2.94
Transit and Rail Issues	2.89

Notes: Rating scale 1 to 5 (lowest to highest) with 22 states responding. DBE—disadvantaged business enterprises; WBE—women-owned business enterprises.

An examination of Table 1 indicates that the subjects of greatest interest to chief administrators in 1984 could be considered in two categories. The first dealt with their organizations and events that directly affected highway and transportation organizations in terms of goals, mission, priorities, sources of funding, and technology. The second area of concern was how their organizations had to deal with the outside world in terms of public perception, the law, and changes that would be occurring in the future.

The general subject areas that were rated high (3.8 or better) in 1984 were information systems, a look ahead in transportation, the changing emphasis in DOTs from new construction to maintenance, dealing with the public, and funding and manpower. Although the general subject dealing with the law was not rated as highly (3.28), one subtopic, tort liability, received a rating of 4.05.

In the 1985 survey, the chief administrators also expressed interest in both organizational and global issues, and although the priorities had changed somewhat, each of the five topics that received a rating of 3.8 or higher in the 1984 survey were also rated high in 1985. This result confirms the observation that chief administrative officers today are most interested in understanding what the future holds in transportation, funding sources and trends, dealing with human resources and employee productivity, effects of the changing emphasis within DOTs from new construction to maintenance, and dealing with the public.

TABLE 2 MAJOR TOPICS IN TRANSPORTATION AS DEFINED BY STATE DOT ADMINISTRATORS IN 1985

Topic	Rating
A Look Ahead in Transportation	4.40
Funding for Transportation	4.12
Manpower and Productivity	4.10
Coping with DBE/WBE Requirements	4.07
Impacts of Changing Levels of Service	3.95
Changing Emphasis in DOTs from New Construction to Maintenance	3.90
Information Systems	3.82
Inter- and Intragovernmental Relations	3.80
Dealing with the Public	3.80
Trucks	3.67
Maximizing Research Investments	3.40
Case Studies of State Transportation Departments	3.20
Environment: Land Use, Esthetics, and Noise	3.13
The Transportation Manager and the Law	3.02
Transit and Rail Issues	2.80

Note: Rating scale 1 to 5 (lowest to highest) with 15 states responding.

In the 1985 survey, several topics were added, including inter- and intragovernmental relations, maximizing research investments, case studies of state DOT's, and the environment. Topics considered of lower priority were those dealing with transit and rail issues, law, environment, case studies of DOTs, and research. The topic of trucks was given a higher rating in 1985, particularly the subtopic effects of new regulations on road quality (3.9) and structural changes and their impact on highway finance and design (3.9). Coping with disadvantaged business enterprises (DBE) and women-owned business enterprises (WBE) requirements was also rated higher in the 1985 survey.

The preceding information was used to design a program that would be responsive to the transportation issues deemed most critical by state highway administrators. There was considerable discussion as to the length of the program, recognizing that top administrators have many demands on their time and find it difficult to be away from their offices for an extended period. However, it was also believed that the program would have little impact if it were too short and the topics were covered hurriedly. Accordingly, a program length of 1 week, Sunday evening to Friday noon, was selected. Furthermore, each topic was allotted a minimum of one-half day to ensure that the coverage would not be superficial and that there would be ample opportunity for discussion, debate, and clarification.

The topics selected for the institute are not neatly labeled and found in textbooks. Instead, they are contemporary, broad rang-

TABLE 3 PROGRAM TOPICS: TRANSPORTATION EXECUTIVE INSTITUTE

1984	1985
Changing Emphasis in DOTs from New Construction to Maintenance	The Influences and Impacts of Changing Levels of Service
Funding Issues in Transportation	Tools for Managing and Operating Highway Systems
Manpower and Productivity	Funding Transportation in the 1980s
Computer-Aided Financial Management for Transportation Agencies	Human Resources and Employee Productivity
Tort Liability and Transportation	Microcomputers and Computer-Aided Design
Dealing with the Media	Dealing with the Governor and State Legislature
A Look Ahead	Trucking Issues Impacting State DOTs
	A Look Ahead

ing, and unique to the problems of transportation organization and administration. Accordingly, the lectures are tailored to the audience and taught by the most qualified persons available. The instructors are individuals who know their subjects well, understand the audience and their needs, and are able to communicate effectively. The TEI faculty are speakers who are not only "doers" in the topic but "thinkers" as well; that is, they are people who have taught and written about the subject and are able not only to discuss what they and their organizations are doing, but can articulate the broad issues that the topic implies. They are also familiar with the spectrum of approaches to various issues, both successful and unsuccessful.

Transportation Executive Institute
University of Virginia

CHANGING EMPHASIS FROM NEW CONSTRUCTION TO MAINTENANCE

Outline of Presentation	Personal Notes

I. Background
  A. Trends
    1. Mechanization and Unionization
    2. Reduction in Manpower
  B. Funding
    1. Trends in Construction versus Maintenance
    2. Current Legislation
      a. Federal
      b. State
  C. Definitions
    1. Maintenance
    2. 4 R
    3. Construction

II. Maintenance Issues
  A. Limitation of Funds
    1. Inflation Effects
    2. Petroleum Product Costs
    3. Federal-Aid Limitations
    4. Inadequacy of Unit Tax
  B. Highway Loads
    1. Increasing Traffic Volumes
      a. Roadway Occupancy
      b. Routine Maintenance
    2. Increasing Axle Loads
      a. Pavement Damage Measurement
      b. Load-Damage Relationships
  C. Levels of Service
    1. Policy Decisions
    2. Implementation
      a. Methods of Measurement
      b. Data Handling and Analysis
      c. Management Controls

FIGURE 1 Illustration of lecture format.

The topics covered are those given the highest ranking in the survey of chief administrative officers, but the faculty is responsible for establishing the lecture content and format. Table 3 gives the program topics for the 1984 and 1985 sessions.

The material covered in each topic was given to the participants in a detailed outline form, with space sufficient for note taking. An illustration of the format used is shown in Figure 1. In addition, each participant received an extensive bibliography and a set of supplementary readings, including books, monographs, and papers.

To supplement the formal academic program, other activities were included for further enrichment of participants. These included two evening optional management seminars that dealt with understanding behavior and management styles and productivity in the public sector. Further, three formal dinners were held, one with speakers in the famed Dome Room of the University's Rotunda. A separate program for spouses was also held.

LECTURE TOPICS AND OUTLINES

The course material included detailed outlines, recommended readings, specially prepared lecture notes, and (where appropriate) extensive bibliographies. Listed next is a description of the subject matter included in each topic. (To provide a list of the recommended readings here would be impractical because of the number of publications involved.)

Changing Emphasis in DOTs From New Construction to Maintenance

Introduction: Trends, Funding, Definitions

Maintenance Issues:

- Limitation of funds
- Highway loads
- Levels of service
- 4-R design standards
- Deferred maintenance
- Work under traffic
- Personnel–staffing
- Contract maintenance

- Highway Network Maintenance and Operations
  - Management Systems
    - Introduction to management systems
    - Highway maintenance management systems
    - Pavement management systems
    - Bridge maintenance management systems
    - Equipment management systems
- Funding Issues in Transportation
  - Historic framework for transportation finance
  - Patterns of transportation use
  - Spending for transportation
  - Current revenue sources
  - Principles of highway finance
  - Results of transportation investment
  - Outlook
- Human Resources and Employee Productivity
  - Importance of human resources and productivity
  - Review of relevant literature
  - Results of TRB Professional Needs Study
  - Options to enhance organizational productivity
  - Developing a human resource plan
- Microcomputers and Computer-Aided Design
  - Definition of microcomputers
  - Microcomputer hardware
  - Microcomputer software
  - Comparison of microcomputers and other computers
  - Microcomputer use in state DOTs
  - Definition of computer-aided design and drafting (CADD)
  - Computer-aided drafting as a special form of CADD
  - Detailed description of elements of CADD
  - Status of CADD in transportation
  - Description of examples of CADD
  - Future of CADD
  - Management consideration of CADD
- Tort Liability and Transportation
  - Introduction: Legal Responsibility, Public Liability, Changing Legal Concepts
  - Reducing the risks of liability
  - Preparation for trial
  - Developing a loss mitigation program
  - Managing claims activities
  - Case studies and discussion
- Dealing With the Media
  - Why do many public officials fear the press?
  - Who are the media?
  - What polls show about conflict between media and public officials
  - How are the news media organized?
  - Rules of the conflict
  - What reporters expect
  - What public officials can do to help media relations
- Trucking Issues Impacting State DOTs
  - History, industry composition, DOT reorganization
  - Uniformity
  - Taxes
  - Size and weight
  - Safety
  - Other issues
- A Look Ahead in Transportation
  - Key role of DOTs in the future U.S. economy
  - Background and setting of DOT operations
  - Managing state systems in a changing world
  - Assessing the travel future
  - Outlook for freight
  - Expanding transport responsibilities: the demand side
  - Financing strategies for the future
  - DOT operations in a global context

PROGRAM RESULTS

The 1984 and 1985 programs have been attended by chief administrative officers or deputies from 17 states, the FHWA, and Canada. Figure 2 shows the distribution of states represented. Participant evaluations have been positive, as indicated in Table 4, and many favorable comments were offered. Similarly, faculty lectures were well received. Interestingly, the evaluations for the second program were slightly lower than the first, including items such as food and lodging, which were identical in both programs. One measure of the program's success is the decision by the American Association of State Highway and Transportation Officials to continue its support of the institute.

TABLE 4 TRANSPORTATION EXECUTIVE INSTITUTE OVERALL EVALUATION (1984–1985)

Attribute	Rating 1984	1985
Overall administration and organization	5.00	4.85
Variety of instructional methods	4.00	4.00
Quality of instruction	4.14	3.85
Mix of practitioner and academics	4.54	3.70
Institute content	4.33	4.00
Classrooms	4.40	4.23
Lodging facilities	4.67	4.30
Food	4.74	4.69
Overall evaluation	4.58	4.38

Note: Rating scale 1 to 5 (ponses.

The key ingredients in the success of the TEI have been (a) assuring that those who attended participated in the selection of curriculum topics, (b) recruiting outstanding program faculty, and (c) providing a comfortable and attractive learning environment. Based on the experience gained, however, it is noted that the demand for a program of this type is constrained and factors such as program cost, travel distance, time away from the office, conflicts with other meetings, legislative or other crises, and perceived benefits from the program all serve to limit attendance. Because the total potential audience is probably fewer than 200 people, this small, albeit important group is not likely to produce large numbers for a program such as this. Educational enrichment is a deferrable commodity and

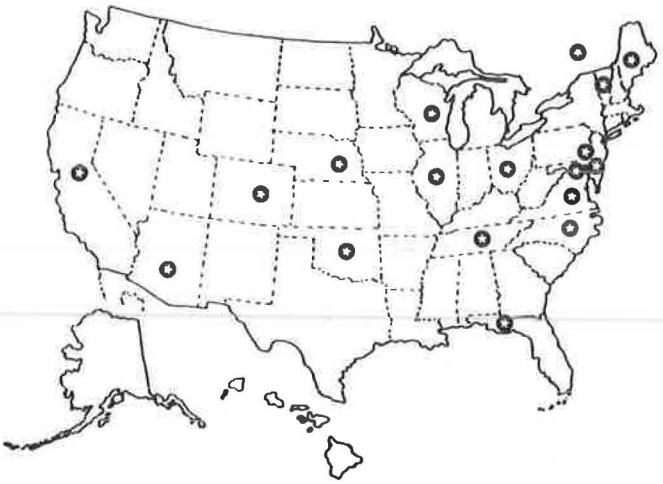

FIGURE 2 Origins of program participants.

the pressures of life tend to overtake the need and desire to stop now and then and "smell the roses." However, for those who do take the time, the rewards are many, both in expansion of horizons and in shared experiences.

CONCLUSIONS

What can be learned from this experience and what conclusions can be drawn that may be of assistance to transportation professionals or university groups in developing programs of this nature? Some key points are as follows:

- Transportation is a rapidly changing field and the environment in which top administration works is a moving target. Thus, any attempt to provide education or training must be constantly updated and revised.
- Educators are not accustomed to dealing with such rapid change. They often teach the same course year after year with textbooks that are out of date as soon as they are published. Perhaps a new form of education is required that assures greater relevance.
- Top administrators will spend a considerable portion of their most valuable resource—time—if they perceive that it will enable them to understand and do their jobs better. New administrators are a particularly fertile market for this type of training, but seasoned administrators with considerable experience can benefit as well.
- CAO's are concerned with why things happen and how things work in general. They do not want to get involved in specifics or details because they believe that this is the role for their technical staffs.
- A most important element of a program for top executives is their interaction with each other. Speakers cannot expect to deliver a 3-hour lecture, but must be able to handle give and take and draw on the experiences of such a group.
- To deliver a program of this type is a complex and challenging task. The student in the program is accustomed to running the show and expects to be treated in a first-class manner both in and out of the classroom.
- Finally, although there is a need to be innovative and creative, the program should "stay close to the customer." This is accomplished by having the participants involved in curriculum design and later in program evaluation.

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Cooperative Research Between State Highway Agencies and Universities

PAUL W. SHULDINER AND JOHN COLLURA

A study of cooperative research programs between highway agencies and universities in 10 states was conducted. A wide variety of cooperative arrangements was found. Major differences involved the degree of formality in the arrangement, the extent to which the university participated in the specification of the annual research program, funding provisions, and the role of the agency's research director. In all instances, the benefits of cooperative efforts were judged as being well worth the costs. The most successful programs were characterized by the following features: (a) joint participation by both the university and the highway agency in the initial development of the collaborative program; (b) a willing commitment by both parties to make the program work; (c) a truly collaborative, rather than an arms-length, relationship; and (d) lots of time, trust, and patience.

In the interest of developing a more productive research relationship with the universities in the Commonwealth, the Massachusetts Department of Public Works requested the University of Massachusetts Department of Civil Engineering to review cooperative activities in other states and to advise the department on alternative collaborative approaches that it might want to adopt. Discussions were held with highway agency and university personnel from 10 states whose cooperative research programs represent a broad range of approaches; survey materials collected by others were also used. [Note that the agencies and individuals contacted are listed in the acknowledgment at the end of this paper. The authors recognize that variations on the several approaches to research cooperation discussed here undoubtedly exist and would welcome information on which to supplement the findings of this study.] A summary of the major results of this research is provided.

MAJOR TYPES OF COOPERATIVE ARRANGEMENTS

The nature and extent of cooperation between state highway agencies and universities vary considerably among the 50 states. At one end of the spectrum are those state agencies that have vigorous, ongoing research programs, generally conducted in close collaboration with the principal public university in the state under the umbrella of a formal working agreement between the two agencies. At the other end of this spectrum are those state agencies that conduct little or no research and that maintain at best a sporadic relationship with the universities in the state. Although there is no inherent necessity that a strong highway agency research program be conducted in concert with a university, the two usually appear to go together. (The research program of the New York State Department of Transportation appears to be a notable exception to this general rule.) It is generally also the case that in those instances where a close, long-standing relationship exists between the state highway agency and a university, not only is the highway agency's research program strong, but also the university's highway education, research, and public service programs are strong. Often these activities are carried out by the university under the aegis of a clearly identified center or institute established specifically for those purposes.

The major organizational arrangements for highway agency–university collaboration may be categorized as follows:

- *University manages and conducts highway agency's research program.* The oldest and most impressive example of this type of arrangement is carried out between Purdue University and the Indiana Department of Highways under an organizational structure known as the Joint Highway Research Project (JHRP). The JHRP currently receives a sustaining allocation of about $300,000 a year in state funds to which Purdue University adds contributions in kind. In addition, approximately three-fourths of the state's HPR research money is expended by JHRP on projects selected by that program. Other states in which the highway agency's research program is essentially conducted at and by a university are Texas (with Texas A&M and the University of Texas, Austin) and Tennessee (with the University of Tennessee).
- *Highway agency locates its principal research facility and staff on a university campus.* The best established of such arrangements is found in Virginia, where the Virginia Department of Highways and Transportation Research Director and his staff are housed in a research facility built by the department on the campus of the University of Virginia, Charlottesville. The department's research program is developed and implemented by the Virginia Highway and Transportation Research Council, which is jointly sponsored by the department and the university. As far as is known, the only other state in which the highway agency's research staff is housed at a university is Arizona, on the campus of Arizona State University in Tempe.
- *Highway agency research director is an employee of both the highway agency and a university.* The only known example of this arrangement is in the state of Washington, where the Research Director of the Washington State Department of Transportation (WSDOT) is also a full-fledged member of the faculty of the University of Washington. The time of this individual is divided between the highway agency headquarters in Olympia and the university in Seattle. A substantial portion of the agency's research program is conducted by the Washington State Transportation Center (TRAC), a joint creation of the Washington State Department of Transportation, the Uni-

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versity of Washington, and Washington State University. The department's research director serves as the director of TRAC.

- *Highway agency and principal state university establish a general agreement under which research projects are conducted by the university.* This is the least elaborate and most common of the formal arrangements between highway agencies and universities. The Illinois Cooperative Highway and Transportation Research Program, established by written agreement between the Illinois Department of Transportation and the University of Illinois, typifies this type of arrangement. This general agreement provides the framework under which an annual program agreement is developed between the university and the department. The program agreement specifies the individual research projects to be conducted during the year by the university and the funds to be provided by the department for the work. The program director is appointed from the university staff with the department's approval. This individual and one or more additional university staff, along with key department personnel, sit on the Illinois Highway Research Council, which develops the state's annual research program.

A similar arrangement exists in Connecticut between the Connecticut Department of Transportation and the University of Connecticut. The Connecticut Joint Highway Research Council was created pursuant to state statute and funding authorization. Unlike the Illinois program, state funds (currently in the amount of $50,000/year) provide continuing base support for the council's program. The council, which consists of four members of the department of transportation and four members of the civil engineering department of the university at Storrs, develops the transportation department's annual research program. Funding for projects under this program are negotiated by the department with the university and others as appropriate.

Highway Agency–University Agreements

In states in which a formal cooperative research arrangement between the highway agency and one or more universities exists, a written agreement specifying the rights and responsibilities of each party is usually in effect. In several instances, the authority for the agreement is found in a specific legislative act. This is the case, for example, in Connecticut, where explicit statutory authorization exists both for the establishment of a ". . . . Continuing Cooperative Highway Research Program to be undertaken by the Connecticut Highway Department and the University of Connecticut . . ." and for the use of state funds to support this program on a continuing basis. In other instances, the highway agency–university agreement is entered into pursuant to general legislation authorizing such interagency agreements. Such is the case in Washington, where the agreement between the University of Washington, Washington State University, and WSDOT is authorized by the state's Interlocal Cooperation Act.

Reference to state enabling legislation is made in the context of cooperative agreements between a state highway agency and one or more state universities. In every state reviewed thus far, agency–university agreements were limited to public institutions. Where private universities and other nonpublic entities participated in state highway research programs, they did so under a contract limited to a specific project.

Funding Arrangements

As with most other aspects of highway agency–university cooperation, there is considerable variation in funding arrangements from state to state. However, one feature is constant among all states with productive cooperative programs—continuity of funding. This is not to say that large amounts of money are necessarily involved or even that a set amount is guaranteed from year to year. What does hold true is that by practice or written agreement a commitment has been made by the highway agency to sustain a level of support sufficient to elicit a commitment on the university's part to devote sufficient faculty and other resources to meet the highway agency's needs.

In other major respects—whether monies are provided via grants or contracts; whether state funds, as distinguished from HPR monies, are used; and whether reimbursement is limited to direct project expenses or also cover university administrative costs—state practices vary widely. Most states operate on a contract rather than a grant basis. The major exception is Indiana, where the base support for the Joint Highway Research Project is a grant ". . . for the use and benefit of Purdue University in carrying on programs of highway research . . .". In most states in this study a measure of state-funded support is provided to sustain the cooperative program, with the bulk of the research funding coming from the state's HPR program. This state-funded support ranges from less than $50,000 a year to about $300,000 a year (in Indiana). Indirect costs (overhead) are usually accepted as a legitimate contract cost, although often a reduced rate of overhead is applied. In those instances where both state and HPR funds are used, overhead is often allowed on the HPR funds only.

RESEARCH MANAGEMENT WITHIN THE HIGHWAY AGENCY

The effectiveness of highway research programs, in the view of those interviewed for this study, is related to the commitment to research by upper management in the highway agency. The most important expression of this commitment is the personal involvement of senior management in the research policy board or executive committee that reviews and approves the agency's annual research program. In Washington State, for example, the Research Executive Committee is chaired by the Deputy Secretary of the Department of Transportation; in Indiana, it is the Executive Director of the Department of Highways; and in North Carolina, it is the Assistant State Highway Administrator. Active participation by senior agency executives in the management of the research program not only provides a ready communication channel between the research function and the policy and budgeting echelons of the agency, it also makes it clear to middle managers and their staff that research is considered by top management to be an important activity in fulfilling

the agency's mission to provide safe, effective, and efficient highway transportation to the people of the state.

In addition to the active involvement of one or more senior department executives in the research policy board, participation by the directors of the agency's major functional units, including field directors, is a common feature of most of the programs. Usually one or more university representatives are also included on the policy board. In Connecticut and Indiana, for example, the highway agency and the university are represented in equal numbers.

Of equal importance is the status of the research director in the highway agency hierarchy. The most common placement for the research director is either within the planning or the materials division. In the latter instance, nonphysical research is often conducted through the planning division. Whether the research director is in the planning or the materials division, there are still several layers of authority between the research function and senior management. This being the case, the involvement of a senior department executive in the research policy board becomes even more important. The arrangement in Washington is instructive in this regard. In that state the research director reports to the assistant secretary for planning, research, and public transportation. However, the research director also has direct access to the deputy secretary of WSDOT by virtue of the latter's role as chairman of the research executive committee. The research director of the Virginia Department of Highways is even more favorably situated. He reports directly to the deputy commissioner and, as secretary of the administration board of the Virginia Highway and Transportation Research Council, works closely with the deputy commissioner, who is chairman of the council.

IDENTIFICATION AND SELECTION OF RESEARCH TOPICS

There are two major issues concerned with the identification and selection of research topics. The first issue centers on how research needs are identified within the highway agency and how a list of research topics is established in order of priority from whatever statements of needs are developed. As with almost every other aspect of research management, the range of procedures is large. Until recently, for example, the University of Tennessee Transportation Center, which manages the state's research program, conducted a mini-NCHRP process within the state involving solicitations of research problems from department of transportation staff and University of Tennessee faculty and a lengthy winnowing process that eventually led to the establishment of a priority list of research problem statements. Finding that elaborate process much too unwieldy, the center no longer formally solicits research problems from faculty and department staff, but develops a short list on the basis of informal discussions and its own knowledge and experience.

In Indiana, an advisory board composed of six Purdue University faculty and six Indiana Highway Department staff, including the executive director (or his deputy) as chairman, solicits problem ideas from department personnel at an annual 1-day meeting and then meets almost monthly to review written proposals and approve projects.

In Maryland problem statements are submitted by major unit heads in the Department of Highways and by university faculty to a Research Advisory Council each fall. These statements are distributed to appropriate staff in the department for review and are eventually developed into a draft research program by the chief of the bureau of research. The Research Advisory Committee establishes funding priorities from this tentative program at its spring meeting.

The procedures for the solicitation of and the assignment of priorities to research problems in Illinois follow much the same pattern as that in Maryland with one major difference being the more active role taken by the University of Illinois in this process. Perhaps the simplest procedure is that followed in Connecticut, where the director of the office of research initiates, prepares, and oversees all aspects of the agency's research program.

The second major consideration in the identification and selection of research topics is the position of a research advisory group in this process and the role of the participating university in that group. In every state reviewed, responsibility for the development of the annual program of joint research was vested in an advisory group composed of both university and highway agency personnel. In Tennessee, the University of Tennessee is actively involved in both the advisory group, which recommends the annual research program, and the executive committee, which approves the program.

BENEFITS OF COOPERATION

In every instance in which an active cooperative program exists between a highway agency and a university, both parties interviewed expressed satisfaction with most features of that program. True, concerns about one or another aspect of the relationship were often voiced by either one party or another, but the benefits were considered by most to far outweigh the costs. Although the exact nature and extent of the benefits accruing to the highway agency and the university varied with the type of cooperative arrangement between them, a number of common themes were expressed by all of those interviewed.

The major benefit to the highway agency in maintaining a collaborative research program with a university is the assured access that such collaboration provides to the specialized knowledge available at the university. Such knowledge is not limited to narrow discipline foci, such as engineering materials or geotechnical engineering; equally as important, if not more important, is the general knowledge and experience of faculty in developing and conducting research. Universities are, among other things, research institutions; highway agencies are not, and if the benefits of research are of interest to an agency, it is appropriate that they turn to universities in this regard.

Universities also provide the potential for benefits that go beyond their role as centers of knowledge and research experience. Under the proper circumstances, the university's flexibility in hiring highly qualified technical professionals on a temporary basis can serve to extend the highway agency's staff to meet rapidly changing needs for which research positions within the agency are not available or cannot be filled. In the view of many interviewed, universities are also considered to

be the most-cost effective means for conducting research; no doubt in part because of the availability of student research assistants. The willingness of a university to forego reimbursement for part or all of the administrative cost associated with a cooperative research program is often also a major factor in assuring the competitive position of the university. As an outgrowth of the active involvement of students in agency-funded research, the pool of trained junior engineers who are interested in and knowledgeable about the highway agency is significantly increased. In certain instances, highway agencies have also found that a close working relationship with a major university enhances their ability to attract and retain qualified professionals at all levels.

The benefits of cooperation do not all run in one direction. Cooperating universities benefit in equal degree, if not in identical terms. The most obvious and direct benefit is the financial support that cooperative programs provide to help sustain research activities at the university. The immediate beneficiaries are students, primarily graduate students, who are supported as research assistants. However, because qualified graduate students are the *sine qua non* of a viable program of advanced scholarship and research in a university, the institution gains as well. The institution, if it is a public university, also gains by virtue of the public service aspect of collaboration with another state agency.

Faculty benefit in several ways from programs of cooperative research with highway agencies. Most obvious, although not necessarily most significant, is the additional financial support that faculty and their programs enjoy. This support usually takes several forms: (a) equipment purchases; (b) travel in connection with specific research activities, as well as travel to technical and professional meetings; and (c) supplements to their base university salary. This last form of support is generally limited to the summer period, during which faculty usually are not paid by the university.

Of greater significance is the opportunity that collaboration with a highway agency provides to faculty and their students to work on problems of an immediate and practical nature. Indeed, intimate, sustained exposure of faculty to the day-to-day engineering problems faced by the highway agency was cited repeatedly by those interviewed as a fundamental condition for the existence of a program of collaborative research that is considered useful and worth the time and money invested by the highway agency. Whatever their formal structure, successful collaborative programs share many of the same characteristics that foster this depth of faculty involvement. Among these characteristics are

1. *Joint participation by both the university and the highway agency in the development of the collaborative program.* Both parties are involved from the beginning so that the interests, concerns, capabilities, and limitations of each party are understood by the other and factored into the collaborative arrangement. Participation by both parties at every step also engenders the sense of involvement vital to the development of a good working relationship.

2. *A commitment by both parties to doing whatever may be necessary to make the program work.* On the part of the university this involves a willingness of the faculty who will be involved in the program to spend substantial amounts of time talking with highway agency personnel, on their terms, about their problems. It also requires the willingness of university administrators—from the department head up—to support this type of activity and to reward it. On the part of the highway agency, such a commitment involves a willingness by highway personnel to devote their share of the time and effort necessary to establish a meaningful dialogue with their university counterparts.

3. *A collaborative rather than an arm's-length relationship.* Research is not a commodity or even an engineering service that can be specified, let out to bid, and awarded to the lowest qualified bidder. The most productive collaborative programs are just that—collaborative. In such programs, research problems are identified, refined, and assigned a priority through the joint efforts of highway agency and university staff, and university and agency staff collaborate in the preparation of research task descriptions and, often, in the conduct of the research when appropriate. It is only in the negotiations regarding the specifics of a given contract that an arm's-length position is taken.

4. *Time, trust, and patience.* Underlying all of the preceding characteristics of a successful collaboration are these three eternal verities of productive relationships. When those highway agency–university programs that work best are examined, it is amazing how little meaning there is in formal, written agreements in the absence of these unwritten commitments. At the outset there must be sufficient trust by all parties in the potential benefits in the undertaking and in the determination of all to work for those goals. Then there must be the patience to deal with the inevitable delays, frustrations, and setbacks that are part of any cooperative enterprise. Finally, provisions must be made to sustain the effort over a sufficiently long period of time so that what is sown and cultivated has an opportunity to reach harvest.

The story of the American tourist's admiration of a verdant lawn at Oxford College is worth considering here. When asked how he managed to get such a beautiful carpet of green, the college gardener replied that all it took was a little seed, a little water, and a little rolling. "Is that all?" asked the incredulous tourist. "Aye," said the gardener, "that and 300 years." Perhaps it will not take that long to reap the benefits of investment in a collaborative program of research, but some reasonable span of time must be allowed in which the investment may mature.

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A Workshop Format for Developing Technology Transfer Materials

H. RANDOLPH THOMAS, DEL SWEENEY, AND EDWARD D. JOHNSON

Value engineering, or value analysis, has been used by numerous state highway agencies since the early 1970s, but it has not been widely applied on a smaller scale by local agencies such as counties, municipalities, and townships. The purpose of this project, which was funded under the Rural Technical Assistance Program, is to develop training materials that will support the transfer of the value engineering technique to local highway agencies. In an attempt to ensure that the training materials produced in this project would be appropriate and responsive to local needs, they were developed in a series of four, 1 ½-day workshop sessions held over a 4-month period. The project team provided instruction in value engineering principles, and two value engineering studies were conducted by nine persons from nine different local highway agencies. The participants' comments and questions about the instructional techniques and training materials were used to develop a new 1 ½-day seminar for local highway agencies. Several months later, the participants and the researchers met again, in a day-long session, to review the revised materials, including a slide-tape presentation. The experience gained in the workshop proved to be valuable in clarifying for the researchers the needs of local highway personnel and in identifying the limited applicability of previously developed value engineering training materials.

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Earlier attempts at transferring technology to local transportation agencies have had mixed results. The principal problem appears to have been that the investigators have overestimated or underestimated the level of sophistication and understanding of the audience, primarily local administrators and roadmasters. The purpose of this paper is to describe the lessons learned from using a workshop-oriented approach for developing technology transfer training materials. The project, "Value Engineering for Local Highway Agencies," was sponsored by the Pennsylvania Department of Transportation in cooperation with the Federal Highway Administration, U.S. Department of Transportation, using Rural Technical Assistance Program funds. The objective of the project was to develop a 1 ½-day seminar that would support the transfer of value engineering techniques to local highway agencies.

The development of the 1 ½-day seminar entailed the preparation of an introductory slide-tape presentation, a participants' notebook, and an instructor's guide. The entire package was to be designed so that the course could be offered by instructors with a variety of backgrounds. In an attempt to ensure that the training materials for this project would be appropriate and responsive to local needs, a new approach was attempted. The training materials were developed in a workshop in which the participants came from local highway agencies. In the workshop sessions, the participants were instructed in the application of value engineering techniques; they undertook two value engineering studies related to local maintenance problems and evaluated the training aids prepared by the researchers.

VALUE ENGINEERING

Value Engineering (VE) is the systematic application of recognized techniques that identify the function of a product or service, establish a value for that function, and provide the necessary function reliability at the lowest overall cost. VE has been used by numerous state highway agencies since the early 1970s, but it has not been widely applied on a smaller scale by local highway agencies such as counties, municipalities, and townships. VE is more than cost cutting; it is a combination of techniques to reduce costs without loss of quality.

The first distinguishing characteristic of value engineering is its emphasis on function. A VE study defines the functions that must be performed and seeks less costly alternatives for performing those functions. The second characteristic of value engineering is its use of creativity. Value engineering makes a concerted effort to expand the number of choices by identifying as many alternatives as possible. The third characteristic of VE is the job plan, which is an organized plan of action for the accomplishment of VE studies. It consists of eight phases:

1. Selection: The specific object to be studied is chosen. Projects worth studying include costly or complex projects and routine procedures that need updating.
2. Investigation: The project functions and related costs are identified. Comparisons of present design costs versus minimum possible costs are made to identify the areas with the greatest potential for savings.
3. Speculation: A variety of speculative techniques, including brainstorming, are used to assemble a large number of alternatives for the necessary functions of the project or procedure.
4. Evaluation: The creative ideas generated are evaluated, and the best alternatives are selected for development.
5. Development: The best alternatives are refined by assembling supporting cost data, sketches, and life-cycle cost analyses.
6. Presentation: The refined alternatives are presented to management as recommended changes to the original design or procedure.
7. Implementation: The accepted ideas are put into practice.
8. Audit: A simple system is devised to track the savings and costs of VE efforts.

The VE study is conducted by a multidisciplinary team. A mix of talent is desirable to bring different points of view to the study. Through the VE approach local managers can free their thinking from the restraints imposed by precedent, standard practice, habit, and even past experience. VE supports and encourages innovation, and it produces a substantial return on investment.

SELECTION OF WORKSHOP PARTICIPANTS

The objective in selecting participants was to ensure a cross section of persons and levels of government responsible for local roads and bridges. Ten participants were selected from Pennsylvania and two from Maryland. To identify potential participants from Pennsylvania, the researchers contacted the Pennsylvania State Association of Township Supervisors, the Pennsylvania Boroughs Association, and the Pennsylvania League of Cities. It was agreed that the following breakdown of names would be supplied by these organizations: two names each would be suggested for cities (population greater than 50,000), boroughs, and townships of the first class. Four names would be supplied for townships of the second class, the most numerous category in Pennsylvania (1,459 of 2,572 municipalities). In addition, the names of two county road supervisors from the state of Maryland were to be provided in order to have representation from a state where the county has significant responsibility for roads and bridges.

Although two-person teams from six agencies were originally planned, representatives of the Pennsylvania municipal organizations stressed that taking two individuals from the same organization for 2 days would place sufficient hardship on some of the smaller organizations that they might decline to participate. As a result, the workshop plan was altered to provide for one individual from each agency.

Representatives of the Pennsylvania municipal organizations strongly urged that they be allowed to make the initial contact with potential participants. They were able to emphasize to the participants the importance to the study and to the municipal organization of their involvement. Another advantage of having these representatives select and contact the potential participants was their broad knowledge of individuals in their organizations. However, only 10 names were provided instead of the 12 originally requested. Those contacted were open-minded, experienced people (although not necessarily engineers) and were known to be forthright in offering criticism. In general, the selection process worked satisfactorily. When the researchers contacted the individuals regarding their interest in the study, only one person declined to participate.

The participants proved to be the type of individuals desired. Their educational backgrounds did not appear to be crucial. Of the nine persons who agreed to participate in the study, three had a bachelor's degree, two had a master's degree, and four had an engineering degree. In this project, experience in planning and managing resources and a positive attitude toward

making changes were the most important criteria for successful participation.

CONDUCT OF THE WORKSHOP

Communicating the Workshop Objectives

Before the first group session, each participant was sent a description of the project and a six-page introduction to value engineering. At the beginning of the workshop, the objectives of the project and the workshop sessions were explained. There appeared to be a widespread misunderstanding of the objectives of the workshop. The participants believed that they had been assembled to develop a manual on drainage and shoulder maintenance. In retrospect, it appears that the amount of explanation given, both before and during the first workshop session, was inadequate. The purpose of the participants' involvement, namely, to assist in the development of the training materials for the seminar, should have been more carefully explained both in the initial contact and in the follow-up material sent to them.

Size of the Group

The initial plan was to divide the participants into two subgroups consisting of five persons each. Of the 10 persons originally suggested by the representatives of local municipal organizations, one declined to participate. A second person, although agreeing to participate, did not attend any of the sessions. The eight remaining participants attended the first session, but that number declined to five at each of the subsequent sessions.

Attendance declined for several reasons, including illness, increased workloads, and previous commitments. Although the reasons were varied, lack of interest is perceived by the researchers to have been a significant cause. The time frame for the sessions was also a factor in the decline in attendance. Because of the project schedule, the four sessions had to be held between January and April. On more than one occasion participants were absent because they were on snow alert. It appears reasonable in such efforts to plan for an attrition rate of about one-third.

Length of Sessions and Timing

The length of the sessions was a function of the objectives and scope of the study. For this project, four, 1 ½-day sessions were held at 1-month intervals. Each session began after lunch on the first day and concluded at about 3 p.m. on the second day. This schedule was selected to reduce the need for lodging to one night and to allow participants to travel during daylight hours. The available time appeared to be adequate.

The 1-month interval between sessions was also satisfactory. The level of interest remained high among individuals who continued to attend. Participants were asked to assemble information and cost records in the time between sessions, and several individuals regularly did so. A time interval longer than 1 month, it is believed, would have resulted in declining interest.

VE Studies

In the workshop sessions, the researchers provided instruction in value engineering principles, making use of previously developed training materials, including *Value Engineering for Highways: Study Workbook (1)* developed by the Federal Highway Administration, and a completed VE study conducted in Pennsylvania. A brief (20-page) guide prepared by the researchers was also distributed. Participants were then divided into two study teams, each of which conducted a value engineering study of a topic appropriate to municipal and county responsibilities. The rationale was that by performing a VE study themselves, participants could readily identify those concepts that were difficult to understand and the researchers could evaluate the appropriateness of VE training materials already available.

The two study teams were directed to develop project scenarios for shoulder maintenance and drainage. These were logical choices because they are of considerable interest to local agencies. Although hypothetical in nature, the project conditions and other factors were carefully chosen by the study teams as being typical of the type of work performed and the conditions routinely encountered.

The shoulder maintenance group selected a typical treatment of a 1-mi segment of roadway, which included rehabilitation of the full shoulder length and reconstruction of a 500-ft section. The shoulder was said to have been originally constructed of surface-treated gravel and was 6 to 10 ft wide. The drainage group selected a 1,200-ft section of secondary roadway subject to degradation because of standing water. The environment was considered to be suburban, with restricted speeds, and some private and commercial abutting properties. The sample project included a variety of drainage features, including underdrain, parallel drainage, driveway pipes, and heavy-duty storm drains at commercially developed intersections. The design features and costs of both projects were based on standard municipal and county practice, and, where applicable, on state and local specifications.

In the course of the workshop sessions, it became clear that having the participants select their own study problems caused some difficulties. In designing their problems, participants considered various alternatives for design, materials, equipment, and so forth. Thus, when they reached the speculation and evaluation phases of the study, they felt constrained by the analysis they had made earlier. The researchers believe that the participants would have engaged in greater creativity and experienced more satisfaction in conducting the studies if the study problems had been selected in advance.

From time to time the study teams needed assistance, and the researchers acted as facilitators. Certain concepts of value engineering appeared to present difficulty, particularly the con-

cept of worth. Also, participants were reluctant in the speculation phase to consider ideas that they "knew" to be impractical. The researchers elaborated on particular concepts and encouraged the study teams to be more wide-ranging in their search for alternative ideas.

This hands-on approach to learning about value engineering proved to be invaluable in identifying concepts that were most difficult to comprehend. Indeed, the researchers revised their approach to such VE elements as the FAST diagram and the concept of worth.

Input from Participants

As part of the overall development process, time was set aside at each session to discuss the materials assembled for the course and where improvements could be made by the researchers. Participants' input was solicited for the study guide, visual aids, and the study workbook.

Study Guide

Before the first workshop session, the researchers had condensed the 111-page FHWA guidebook *Value Engineering for Highways (2)* (used by state highway agencies) into a 20-page guide. This guide was a typical academic approach to the problem even though the text had been significantly simplified and condensed. Participants were quick to point out that the potential audience was not inclined to embrace this form of study guide, and a new draft was written before the third session. This version was reduced to eight pages and was written in a question and answer format. This draft was well-received by participants, and additional revisions were suggested. The guide subsequently was reviewed by representatives of municipal organizations and by the Pennsylvania Department of Transportation (PennDOT) and FHWA personnel. Among the suggestions made were to revise certain sections to make them more applicable to local situations, and to include specific examples of savings that had resulted from VE studies of smaller-scale projects.

Visual Aids

A ½-hour slide presentation using slides assembled for previous studies and activities was made at the first workshop session. Most of the slides contained relevant information but needed to be revised for uniformity of format, greater clarity and simplicity, and greater applicability to the problems faced by local roads and street managers. Moreover, the slide presentation was too long.

The researchers, together with the Instructional Design and Production Division of The Pennsylvania State University, arrived at a concept for a slide-tape presentation that was considered to be motivational rather than purely instructional. The concept was that of a municipal engineer buying, in a toy department, a value engineering kit that could be played like a game. The engineer brings the kit to his office and the "VE team" moves the pieces around the board, thus going through the various phases of the VE job plan. It was judged that in a 10-min presentation, the primary objective was to whet the appetite of seminar participants to learn more about value engineering rather than to try to explain the principles of VE in depth.

Study Workbook

The Value Engineering Study Workbook *(1)* developed by the FHWA is a blank workbook used to develop and record a value engineering study. It was found to be satisfactory for use at the local level, but workshop participants believed detailed instructions should be given on how it should be completed. The workbook as revised by the researchers has a page of instructions facing each page of forms to be completed. For each phase of the job plan, a checklist is included of questions to be asked, techniques to be used, and tasks to be performed.

Preview Session

Eight months after the fourth workshop session, participants were reconvened, together with personnel from PennDOT and FHWA, to review the plans for the pilot seminar. The purpose of the preview session was to review both the revised training materials and the outline for the conduct of the seminar in order to avoid any major problems at the pilot offering of the seminar. As a result of the preview, some suggestions were made for revisions to the slide-tape script and the VE guide. The value of the preview session was that it was held before master copies of the materials had been made and reproduced, and therefore the changes could be made easily and at little cost.

VALUE ENGINEERING FOR LOCAL AGENCIES

The VE Team

From discussions with the workshop participants it was clear that the usual, multidisciplinary, five-to-six person VE study team would be difficult to implement at the local level. Participants believed most local agencies could not marshall that number of people for a 40-hr study. The participants suggested that a team of three to five persons could be assembled, and even agreed with the statement (included in the revised guide) that "If necessary, one person can conduct a valid VE study as long as the systematic procedure of function analysis and the creative search for alternatives is followed."

In general, it has been found in VE studies that potential savings in construction are usually 10 percent of the construction costs. A $50,000 project can reasonably be expected to identify $5,000 in potential savings. However, all of the recommended savings may not be implemented. Implemented savings resulting from VE studies are estimated to be at least 5 percent of project costs. The cost of a VE effort is usually less than 10 percent of the implemented savings. For a $50,000 project, therefore, an effort of 3 to 4 person-days is justified. One of the workshop participants reported at the preview session that he had recently conducted a VE study at his agency,

with two other people (one of whom was a private citizen), and that they had worked at it part-time over the course of a week. He regarded the effect as successful.

Potential Study Topics

Local agencies often have responsibilities that are broader than highways and bridges. They may have concurrent responsibilities for fire and police protection, fee collection, utility monitoring, building and office construction, and so forth. Topics for VE review and analysis might include the following:

- Procurement: hardware, material, contractors, labor;
- Construction: new; improvements (capacity, alignment); reconstruction; (heavy maintenance); bridge replacement (priorities); bridge rehabilitation; and
- Maintenance: total program (priorities), routine, emergency, preventive.

CONCLUSIONS

The objective of the research project was to develop a 1 ½-day seminar on value engineering for local highway agencies. The training materials for this seminar were developed by means of a series of workshop sessions attended by persons typical of the intended audience for the seminar. In the workshop sessions, participants were given instruction in VE techniques; they conducted two VE studies and commented on the training materials distributed.

The workshop sessions proved immensely valuable to the researchers for the following reasons:

1. The suggestions made and the questions asked by workshop participants clarified for the researchers the needs of local agencies, the difficulty in understanding certain VE concepts, and the limited applicability, to local agencies, of the VE training materials already developed.
2. The training materials developed by the researchers could be tried out as soon as they were developed, and they could be revised at an early stage in the project, thus saving considerable time and expense.
3. The experience of the researchers with the workshop participants provided an initial confirmation of the assumption behind the project, namely, that the VE technique can be successfully applied by local highway personnel.

ACKNOWLEDGMENT

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Training Needs Analysis for Senior Managers: The Assessment Center Method

DAWN LANDACRE

Described is the implementation of a Management Development Assessment Center in the New Jersey Department of Transportation for the diagnosis of managerial skill strengths and weaknesses. The Assessment Center Method can be used as an effective training needs analysis. The need to assess the skills of middle managers after long careers in the agency became critical when a large number of retirements from high-level positions was imminent. A more speedy and effective analytical device than subjective and standard procedures was appropriate in this circumstance. The result of the implementation and continued use of the Assessment Center Method has contributed to more effective management throughout the agency in a variety of ways. The Assessment Center Method is therefore recommended as a training needs analysis for engineers and other professionals in state transportation agencies.

The Assessment Center Method is a structured procedure used to identify managerial skills and predict future behaviors. It has been used for more than 20 years in private and public sector organizations.

Assessment Centers have three objectives: (a) select personnel to fill immediate and specific positions, (b) determine (as a training needs analysis) individual development and career planning needs, and (c) identify (at a professional entry level) individuals with management potential. To better understand the application of the Assessment Center Method for needs analysis, it is necessary to define it for any purpose and acquaint the reader with the details of the method.

The Assessment Center Method consists of conducting an analysis on a targeted job, assigning and training an administrator, and selecting and training assessors. Subsequent to the job analysis, job behaviors are categorized and ranked in order of importance. These behaviors are categorized under a term known as a "dimension." The term dimension is used for specific behaviors, or groupings, in order that they not be misunderstood. This was in preference to the typical knowledge, skill, ability or attribute descriptor.

These dimensions categorize specific behavioral terms. For example, for oral communication observed in a supervisor-subordinate interview, such behaviors as eye contact, voice tone, facial and hand gestures are evaluated. Or in the case of delegation in an in-basket exercise, such behaviors as how many times items are delegated and whether they are delegated to appropriate or inappropriate persons are assessed.

Appropriate simulation exercises are designed around selected dimensions such as in-basket, leaderless group discussions, interview, fact finding, and problem analysis. Candidates participate in each exercise and are observed by assessors one-to-one, or more typically, one-to-two. The candidates have completed the center at this point.

The assessors remain and complete written reports on each of the candidates and then integrate the collected data and rate the candidates on each of the dimensions. Dimensions are evaluated by each assessor on a five-point scale from 1 = poor, significantly below criteria for successful performance at the next level, to 5 = excellent, significantly above criteria required for successful performance at the next level. For developmental purposes all ratings from 1 to 5 are considered in the discussion among the candidates, their immediate supervisors, and the administrator. However, ratings of 1 or 2 are focused on heavily with regard to the immediate need for development.

Following the 1-week Assessment Center and within 3 weeks, the candidate receives feedback from the center administrator and is provided a descriptive report of the results. In a subsequent meeting, the candidates, their immediate supervisors, and the administrator design a development plan for the following year.

HISTORY

In 1978 the New Jersey Civil Service Department offered the New Jersey Department of Transportation the opportunity to use the Assessment Center Method to test candidates for two top-level managerial positions as an innovative and desirable alternative to standardized civil service examinations. The first examination was conducted with 5 candidates and 10 assessors for the position of regional maintenance engineer. The second examination was conducted with 5 candidates and 10 assessors for the position of director of the division of central services.

A direct result of the participation of the New Jersey Department of Transportation managers was the transfer of newly learned skills centered on observing and defining job-related behaviors. The impact of the assessor training was acclaimed through feedback to the personnel officer; managers noted it was the best executive development program in their experience.

The effect of this positive feedback led to a discussion of how the Assessment Center Method could be useful in the New Jersey Department of Transportation. Although the department had a core of excellent training programs at the management level, the identification of needs and output was far too general. A revitalization of the management development effort department-wide was considered.

Specifically, a manager may be proficient in oral communication and not need an active listening course, yet a course might be held for a particular level of employee with no prior evaluation except an individual's belief in a possible need or a

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desire to attend. In the Assessment Center it is recorded by direct observation whether a candidate is an effective listener.

Another case would be the skill of delegation, which is rarely addressed in the classroom, but if a manager does not possess such a skill it can be dysfunctional to an organization.

It is explicit when a candidate is presented with 10 opportunities to delegate in an in-basket exercise and only does so two or three times; or actually delegates five times but each time to an inappropriate person.

The decision was made to use the Assessment Center for executive development, as well as a career development program for lower-level managers.

The project began with the early support of the commissioner and was implemented by the director of employee and support services, the director of personnel, and the bureau chief of training. The material, the training of the administrator, and the subsequent validation of the job analysis were all purchased from a consulting organization in the field of the Assessment Center Method.

The position for which the Assessment Center was designed was that of a division director/regional engineer. Generally, this person oversees a staff of from 150 to 800 employees. Responsibilities include developing middle managers, evaluating performance, determining work assignments, and ensuring results of activities.

The technical aspects of these positions have a diversity that was not addressed in the developmental system of the Assessment Center.

A job analysis was conducted to determine the performance behaviors required for the 21 positions at the level of division director and regional engineer. The job analysis is necessary as the foundation for defining the job behaviors that are categorized under a dimension and ranked according to importance. Exercises simulating these behaviors were then composed. An example of the necessity for conducting an accurate job analysis is the selection of exercises based on that analysis. For example, if the job analysis indicates that the supervisor is involved more frequently in areas of coaching, counseling, and directing in a one-to-one situation, then the exercise selected should be a supervisory-subordinate problem-solving or coaching exercise, not a leaderless group exercise. The behaviors sought here would be sensitivity, oral communication, and development of subordinates.

On completion of all of the facets of the job analysis, 22 dimensions were identified as important to success in the position of division director/regional engineer.

Once the dimensions were identified, questionnaires were completed by seven of the top managers who rated the importance and observability of each of the following dimensions:

Analysis
Control
Decisiveness
Delegation
Development of subordinates
Extra-organizational awareness
Extra-organizational sensitivity
Initiative
Job motivation
Judgment
Leadership
Listening
Oral communication
Oral presentation
Organizational awareness
Organization sensitivity
Planning and organizing
Sensitivity
Technical-professional knowledge
Tolerance for stress
Work standards
Written communication

After each dimension received a numerical ranking it was reviewed and 12 were selected. Of those, four (job motivation, tolerance for stress, initiative, and work standards) were removed because of the concern that they could not be easily developed. The final list of dimensions with substitutions, definitions, and appropriate clarifying information is given in Table 1.

Dimensions in the decision-making category were revised as follows:

Analysis: Identifying problems, relating data from different sources, securing relevant information, and identifying possible causes of problems.

Judgment: Making rational and realistic decisions that are based on logical assumptions and that reflect factual information and consideration of organizational resources.

After review of these data and consideration of the needs, four types of Assessment Center exercises were determined to be appropriate for use in the developmental system:

1. Interview simulation,
2. Leaderless group discussion,
3. In-basket, and
4. Analysis exercises.

To establish which exercises to use specifically, the Assessment Center administrator and the consultant reveiwed several exercises that were designed to elicit the desired behavior. Exercises were written to reflect experiences primarily within the government setting.

An example of such an exercise is the leaderless group discussion. Six candidates are seated around a table with an instruction sheet for the exercise. In this case the administrator reads the instructions to the candidates. They are required to role-play persons called in as consultants to a government agency to resolve four specific problems and are given 1 hour for this discussion. The assessors are each preassigned one candidate whom they observe closely using a checklist to record specific descriptions of behavior such as how long it takes the candidate to speak, what specifically is said, how many times declarative statements are made or questions asked, if the candidate keeps track of time or acts as mediator between disagreeing members, and many more specific behaviors. At the end of the hour the administrator prepares the candidates for the next exercise while the assessors complete their written reports and rate their candidates.

TABLE 1 FINAL DIMENSIONS BY DEFINITION

Category	Dimension	Definition
Decision making	Analysis	Relating and comparing data from different sources, identifying issues, securing relevant information, and identifying relationships
	Judgment	Developing alternative courses of action and making decisions based on logical assumptions that reflect factual information
	Decisiveness	Readiness to make decisions, render judgments, take action, commit oneself
Management	Planning and organizing	Establishing a course of action for self and others to accomplish a specific goal; planning proper assignments of personnel and appropriate allocation of resources
	Delegation	Using subordinates effectively. Allocating decision making and other responsibilities to the appropriate subordinates
	Control	Establishing procedures to monitor or regulate processes, tasks, or activities of subordinates and job activities and responsibilities. Taking action to monitor the results of delegated assignments or projects
	Development of subordinates	Developing the skills and competencies of subordinates through training and development activities related to current and future jobs
Interpersonal	Individual leadership	Utilization of appropriate interpersonal styles and methods in guiding individuals (subordinates, peers, superiors) toward task accomplishment.
	Group leadership	Utilization of appropriate interpersonal styles and methods in guiding groups toward task accomplishment
	Sensitivity	Actions that indicate a consideration for the feelings and needs of others
Communications	Oral communication	Effective expression in individual or group situations (includes gestures and nonverbal communication)
	Written communication	Clear expression of ideas in writing (includes grammar, organization, and structure)

IMPLEMENTATION OF THE ASSESSMENT CENTER

In March 1981, the Commissioner sent a memorandum announcing the establishment of the department's Assessment Center to all employees at the bureau chief level (third layer of management) and asking for self-nominations for the new program. An initial group of six candidates were to be selected from the nominations received. The six would be randomly chosen from different departmental units to participate in a 2-day Assessment Center.

Assessors were selected from individuals at the division director/regional engineer level and above. These individuals received 1 week of assessor training immediately preceding the Assessment Center during which they were taught skills in observing, recording, classifying, and rating behavior.

Following the Assessment Center, the administrator composed a final report with developmental recommendations and also conducted feedback sessions with each candidate. The candidate received a copy of the developmental report. The report was not placed in the individual's personnel file but remained confidential in the Assessment Center office.

During the first 2 years of the program, the candidate's supervisor did not participate in the feedback meetings nor receive a copy of the report. Of the original 80 managers notified about the Assessment Center in 1979 there were 62 volunteers and all have been assessed. Of the original 21 senior management positions toward which the Assessment Center was directed, 11 were vacated and promotions occurred from the ranks incorporating Assessment Center data.

A change in administrators of the Assessment Center accounts for changes in a number of elements, such as placing each participant in assessor training immediately following a center activity including the candidate's immediate supervisor in the feedback sessions, and also providing the supervisor with a copy of the candidate's ratings. In addition, the employee's progress is jointly planned and becomes part of the performance appraisal system. The behavioral weaknesses defined with a rating of "1 = poor" or "2 = less than adequate" are addressed in a number of ways that include training, counseling, job rotation, or special assignment, and preparing the candidate to increase skills for promotional opportunities. The individual development plan for Assessment Center candidates then plays a role in the future development of the candidate by itemizing skill needs on which to focus training opportunities.

ADVANTAGES TO THE CANDIDATE

Immediately following the assessor training, the new assessor becomes part of a task force for reviewing and evaluating the Assessment Center process and its effectiveness in the department.

Six managers who had been assessed and trained received regular counseling sessions, the results of which were significant behavior and attitude changes observed by their immediate supervisors.

Special leadership skills courses have been offered for those candidates who were rated below average in group and individual leadership skills. Feedback from participants is positive in changing ways to supervise subordinates and requesting the same program for foremen.

Involvement of the senior managers with the candidates in the feedback sessions models behavioral skills that the candidates need to view, as well as experience personally, in order to be effective in the development of subordinates.

The center also provides the environment for effective learning that focuses on the participants' responsibilities and opportunities within the organization. The experience of the Assess-

ment Center results in the participants personal awareness of their performance during the exercise, which carries over to their present job. Participants are also influenced by the feedback session in which their managers can attest to the results and enter into a dialogue responsive to the participant by discussing those job behaviors that need attention, as well as those rated well above adequate.

In a developmental center, feedback about performance is a significant factor that does not occur in the usual classroom environment of the ordinary training program. The knowledge acquired through the center, because of its specific focus on job behaviors and the discussion of those behaviors throughout the exercises, is important for the participant because it carries back to the job, as well as serves as preparation for future promotions. The exercises in the center are reality based in relation to the future job and the organization. Thus candidates acquire information in a hands-on experience from many vantage points and are provided the opportunity to discover what they might otherwise overlook with regard to managerial skills.

ADVANTAGES TO THE ORGANIZATION

An integral feature of the center is the use of senior managers who serve as assessors, conduct the center, and make recommendations regarding the management potential and developmental needs of the participants. They are prepared for this role in a 5-day training program where they learn to observe, identify, classify, and rate managerial behaviors.

The Assessment Center is a diagnostic instrument. Higher management and immediate supervisors recommend and provide opportunities for development, and the candidates who have been assessed are then responsible for contributing their energies to the process of development.

The entire effort is an involvement of managers from different levels of responsibility dedicating themselves and the organization to cultivating and supporting more effective management through the development of necessary skills.

The Assessment Center methodology has been shown to be an excellent career development tool. There now exists an established formal procedure that places managers in realistic simulations of situations that occur on the job. In order to handle the simulations effectively, candidates must demonstrate the extent to which they can display the behaviors and skills essential to the incumbent's position.

Department managers who have participated in assessor training declared it to be one of the most effective executive development programs they have experienced, and it is now under consideration as a training program for professional engineers who are not yet in the management ranks.

Results from a survey of attitudes toward the Assessment Center experience show that of the managers who have participated in a center, 82 percent indicate it was a very positive experience, 69 percent use the results of the center experience in their jobs, and 53 percent are relating to subordinates' problems on the job with Assessment Center data.

As a training needs analysis, 77 percent indicated the Assessment Center is an effective method for identifying specific needs, and 69 percent have been more interested in increasing their own skills.

Of the 62 senior managers trained as assessors, each has served at least once and many, two or three times. By keeping the requirements for participation to no more than once a year, more commitment is gained and a diversity of assessors can be drawn from the large number trained. Also, attending to everyone's own work and time constraints provides the support of high-level management to the concept and process of the Assessment Center, which assists in creating an environment for the participants to similarly view the experience.

In a recent interview with two of the seven senior directors in the department concerning the entire spectrum of human resources management, the following comments were made about the department's Assessment Center.

> The Assessment Center has been a fantastic experience for us. Most specifically because it offers the opportunity for self-appraisal. There is value in assessor training even more than the Assessment Center and I personally experienced the benefits of that. It is important to be with a group of very sharp people and taking the time to share judgments about the capabilities and experiences of those people. The chance to dialogue with other managers, the opportunity that I had to sit down with my own people led me to discover that when I first interviewed everybody as the new person, I had made some decisions and then these points were reinforced by the Assessment Center. For example, problems of control or planning and organizing that I noticed in the first interview showed up in the Assessment Center so my perceptions were confirmed.

The second director commented:

> I'm a strong proponent of the Assessment Center. I was very impressed with the results and the correspondence of the results to my own notions about peoples' strengths and weaknesses to the extent that I knew the people who were being assessed. So I think it's a very good barometer of developmental needs and managerial potential and I'd like to see it become a more pervasive practice because I think that it is a good developmental needs tool and that to wait until people have already achieved the management ranks and then disclose areas where their skills are wanting is really waiting too long. I'd like to see us make a commitment to expand Assessment Centers that would extend at least down to the principal professional level if not lower. I realize that I'm talking about a rather substantial commitment, but there's no one human resource development tool that I've become aware of that this Department has availed itself of that I think is more valuable than the Assessment Centers.

CONCLUSION

In its brief history in the New Jersey Department of Transportation, the Assessment Center Method has proven itself significantly enough to become institutionalized as an ongoing budgeted function serving many needs for continually increasing the skills of managers. The initial effort and results indicate that the Assessment Center Method can be used as a structured diagnostic instrument to determine skill weaknesses and strengths at different levels such as entry-level professional, or first-line supervisor. This effort is recommended as a useful and revealing evaluative technique for determining training needs of professional engineers in a transportation agency.

Abridgment

New Content for the Transportation Professional: The UMTA–West Virginia University Transportation Education Project

PETER H. WRIGHT AND PAUL W. DEVORE

Deregulation of the freight and airline industries and major structural stresses in public transportation have increased management responsibilities. Different skills and knowledge are now required of transportation professionals because of the variety and complexity of social, legal, economic, and technical factors. New systems and planning skills are needed along with knowledge of current research results. The Urban Mass Transportation Administration (UMTA) Office of Service and Management Demonstrations (SMD) has developed valuable knowledge about innovative transit services and management techniques. UMTA has initiated an effort to transfer such research findings to future transportation professionals. To transfer knowledge about new transit services and techniques, UMTA/SMD funded the Program for the Study of Technology at West Virginia University (WVU) to develop flexible, concept-based, introductory instructional modules based on SMD findings. Five instructional units were developed and tested in a variety of higher education classrooms. Most professors reacted positively to the new content and the instructional module design. A diffusion-adoption plan was also developed to promote the use of these units by transportation educators. This technology transfer method is promising and its use should be considered by other transportation agencies such as the Federal Highway Administration and the Federal Aviation Administration, which have a significant research base that should be transferred to educators for use in the preparation of future transportation professionals.

In recent years, transportation systems have experienced a number of significant changes in their operational environments. Deregulation has been a major factor in the airline and freight industries. Many private transportation organizations have undergone major restructuring, making them more rational and competitive to fit new unregulated environments. For example, the position of rate clerk is now obsolete and there is a demand instead for marketing and cost accounting personnel.

Large urban public transportation systems also appear in need of basic changes as a result of spiraling deficits, constrained resources, segmented markets, and structural inefficiencies. Public transportation management has revealed that the skills required to operate single modes are inadequate to deal with the complex communication, political, legal, and marketing demands of efficiently meeting the mobility needs within a region.

Today, transportation professionals require different skills and knowledge needed by future transportation professionals and the type of education necessary to acquire them were major questions faced by the participants at the Williamsburg Conference on Surface Transportation Education and Training in October 1984.

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WILLIAMSBURG CONFERENCE ON TRANSPORTATION EDUCATION AND TRAINING

Participants at this conference consisted of members of government, industry, trade, and academic organizations who were connected with surface transportation. Groups met to identify the skill and knowledge needs of future professionals in various career groups, including engineers, transportation planners, transit managers, carriers and physical distribution managers, and transportation-related technicians.

There was near unanimity among the groups as to the skills required by surface transportation professionals (with the exception of the technicians). Skill categories that were repeatedly mentioned as critical included strong academic fundamentals, communication, computer, and analytical skills; strategic thinking; entrepeneurship; group dynamics; a global perspective; a systems view; and creativity.

Conference participants differed on the question of what knowledge future transportation professionals should have based on the different information needs required to function in widely different surface transportation fields. Content areas cited as important included new practices from the field, government research, and an understanding of the complex social, economic, and technical variables in transportation.

Undergraduate courses are an important component in the preparation of all professionals. Participants at Williamsburg discussed how such courses might better prepare future professionals for careers in transportation. It was deemed difficult to teach the preceding knowledge and skills directly. Participants concluded that the more feasible approach was to teach them in the context of course content focused on the multivariate and interdisciplinary nature of transportation systems. An example of new content that can facilitate this process would be the knowledge gained from UMTA demonstration projects under the Service and Management Demonstrations (SMD) program.

UMTA/SMD RESEARCH AND DEMONSTRATIONS

Created in 1974, the UMTA/SMD program has developed new techniques and lessons in many areas of public transportation,

including bus and rail equipment design, automation, paratransit, rural transportation, and market-based coordinated transportation planning.

In the late 1970s UMTA became interested in the question of how to transfer the knowledge gained from federally sponsored research and demonstrations. After research and pilot projects, UMTA developed a Public Transportation Network of resource contacts, regional facilitators, and developer demonstrators to promote the use of successfully demonstrated service and management innovations by the transit industry.

Many of UMTA's major lessons from demonstrations have not been technical. For example, it has become clear that public transportation agencies cannot view themselves solely as "operators" of a single mode system but must become "providers of mobility" to a number of groups and segmented markets. Provision of urban mobility can usually be most efficiently arranged by using a variety of modes, services, and operators.

NEW CONTENT FOR TRANSPORTATION EDUCATION

Knowledge of UMTA/SMD research and demonstration projects and the application of these research findings is important for present, as well as future transportation professionals. As a synthesis of government research and direct field experience, the SMD reports are of direct relevance to the Williamsburg Conference call to teach new knowledge and skills in transportation education. Study of these reports provides reality-derived insight into the skills and knowledge needed for strong planning, sound implementation, and careful evaluation of public transportation arrangements.

In the late 1970s it became apparent to UMTA that the availability of published SMD reports in Washington, D.C., was having little effect on college and university transportation courses. Many students focusing on careers in transportation remained unaware of the significant, necessary, and exciting changes occurring in the management of transportation systems. At the same time, most transportation textbooks had little content on public transportation, particularly content that explored the complex forces and variables affecting public transportation systems.

With these issues in mind, UMTA funded the Program for the Study of Technology through the National Transportation Center at West Virginia University in 1983 to undertake a project to develop instructional modules based on UMTA/SMD innovations for use in the formal education of future transportation professionals.

IMPLEMENTATION OF A TECHNOLOGY TRANSFER APPROACH

The major question facing the Technology Education Project team in January 1983 was how can the results of UMTA/SMD demonstrations be made available to transportation educators in a form they will find valuable, acceptable, and easy to use? The answers to these types of questions are the focus of diffusion research, a branch of inquiry related to the social, communication, and marketing sciences that studies voluntary technology transfers and how to effect them. The project team began by investigating the content to be transferred, the characteristics of transportation educators (primarily professors in higher education), and the nature of university instructional materials.

It was found that the field of transportation education is highly diverse. Transportation educators are scattered throughout hundreds of colleges and universities and no national directory exists. They have a wide range of values and interests and they teach in many disciplines, including engineering, public administration, urban planning, technology, geography, and so on. This diversity presented unique problems.

The content selected for transfer consisted of concepts and knowledge derived from demonstrations in public transportation. The major lessons of UMTA/SMD research and demonstrations are conceptual rather than technical. Concepts such as market and needs-based planning, the use of a variety of transportation modes, and the importance of private-sector involvement emerged from the research. These are central lessons for public transportation professionals and users to understand if the mobility needs of communities are to be met adequately and efficiently.

Undergraduate and graduate instructional materials are of many types. After research and telephone interviews with professors teaching transportation courses, the research team decided to use text-based modules with illustrations that could be photocopied or made into overhead transparencies. Other instructional features that were selected included student review questions and activities, a thorough reference list, statements of content objectives, and an introduction designed to assist professors in effectively using the packages.

DEVELOPMENT OF THE INSTRUCTIONAL MODULES

The following criteria were developed to guide the module development process. The instructional modules were designed to

1. Fit a cross section of existing courses,
2. Be adaptable to varied class schedules,
3. Be concept oriented,
4. Ensure low-cost reproduction and use,
5. Be designed for use by faculty,
6. Allow for effective use by professors unfamiliar with the topic,
7. Be self-contained teaching units, and
8. Stimulate interest in new transportation methods.

The five instructional modules were developed using the following procedures:

1. Analyze UMTA-developed materials and, in conjunction with UMTA, select content best suited for redesign and inclusion into diffusable instructional modules. The five module topics selected were paratransit, transportation brokerage, market segmentation planning, public transportation pricing, and rural public transportation.
2. Analyze topic, content, and relevance of UMTA research

and produce draft instructional unit. UMTA-developed and other research documents were analyzed and synthesized to develop units that met the preceding criteria.

3. Arrange for review of module draft by selected content experts and transportation educators. A field review questionnaire was developed and sent with the first draft of each individual module (without illustrations) to persons with expertise in the topic area. Although most reviewers were transportation professors, system operators, consultants, members of nonprofit organizations, and state employees were also involved. Altogether, 33 completed field reviews of the five modules and a number of letters and phone calls were received. Many of the reviews at the first draft stage included written comments on the draft copy. The field review process resulted in the development of accurate, usable, and acceptable materials.

4. Revise drafts of each module based on external reviews and prepare finished modules.

5. Arrange for classroom field testing and evaluation of modules by college and university transportation educators. Each professor who volunteered to field test the modules was provided a draft copy (with illustrations) of a particular module, a field test questionnaire, and a request that the module be used for 1 hr in a graduate or undergraduate course with content related to transportation. Eighteen survey forms were returned.

6. Prepare and submit camera-ready copy of completed modules.

USE OF AND REACTION TO THE INSTRUCTION UNITS

The five modules developed in 1983 and 1985 were field tested formally in classrooms 18 times by 14 transportation educators. Eleven of the courses were in civil engineering departments, three were in city and regional planning, and one each in industrial studies, marketing, geography and planning, and transportation. The units were presented for from 1 to 6 class hr with a median of 2 hr. Nine classes contained undergraduate students, five were graduate classes, and four contained both graduate and undergraduate students. Thirteen of the field tests were conducted at major state universities. Three were conducted at smaller state universities; one each was conducted at a private university and a technical institute.

More than 60 people submitted written comments on the modules at different phases of their development. The following conclusions are based on 18 formal field test responses. The reviewer comments on first drafts provided background for interpreting the field-test questionnaires. When asked whether the criteria had been met, at least 15 of the 18 agreed that all of the criteria had been met except low-cost reproduction (11 yes, 5 undecided, 2 no), usable by teachers unfamiliar with content (9 yes, 7 undecided, 2 no).

On the ease of reproduction question, some of the respondents believed the materials were too lengthy. This comment was balanced by others who suggested inclusion of topics such as mathematical analysis, routing details, and vehicle types and costs. Because there were no comments on the question of use by teachers unfamiliar with content and because no one indicated there were criteria not met, it is possible that respondents were undecided because of their extensive knowledge of the topics. Some respondents agreed that the modules stimulated interest in transportation methods, but they did not believe the content of the modules was "new." "New" is an ambiguous word to ask people to judge.

Appendix A in the original paper (available from the authors) lists all 18 responses to the question, "What do you think the students got out of the module?" Respondents generally believed that the units helped the students understand the complexity of modern public transportation and the success of various new practices in differing situations. On the negative side, the most common criticism was a call for more quantifiable content and more or less space devoted to particular topics. The focus of the modules, like that of UMTA's entire demonstration program, is on planning cost-effective transportation systems to meet the real mobility needs and markets of people in target areas. The modules were designed to supplement, not replace, the usual content of courses in various transportation-related disciplines.

THE DIFFUSION/ADOPTION PLAN

During 1985 a plan was developed for use by UMTA to disseminate the instructional modules for adoption by transportation educators. The purpose of the plan was to appropriately and cost-effectively motivate transportation educators to gain awareness of, inquire about, order, and use the instructional modules. The plan has three major components: a mass-oriented diffusion phase, a personal contact-oriented adoption phase, and an ongoing evaluation and revision process.

Because transportation educators are widely scattered and teach in a variety of institutions and disciplines, it was found that the most effective way to contact them was through professional organizations related to transportation or their disciplines. The diffusion phase uses a brochure mailing, conference presentations, and professional publications to make as many transportation educators as possible aware of the instructional units and to stimulate orders and inquiries.

The adoption phase of the plan has been designed to use personal contacts to encourage the use of the modules in relevant courses through follow-up phone contacts, personal contacts at conferences, and the involvement of early adopters in the diffusion process. An organized evaluation process is an integral part of the plan. Implementation of the plan is scheduled to commence in 1986.

CONCLUSIONS AND RECOMMENDATIONS

The transfer of UMTA/SMD research results through the development and diffusion of flexible, concept-based instructional modules is a promising method for adding to the content of transportation education courses designed to meet the needs of future transportation professionals. Testing and refinement of this technology transfer process should continue. If the transfer methods developed during this research prove successful, they hold promise for effecting the transfer of other federally sponsored research findings to higher education classrooms.

Certainly, it is plausible that such an approach can aid students of highway construction by providing them with an introductory synthesis of FHWA findings on the development of life-cycle costing as a technique in deciding which highway construction methods and materials to use. Such a unit might be of interest in engineering, public administration, and economics classrooms.

Other transportation agencies, such as the Federal Aviation Administration, which have significant research bases that should be transferred to education programs, should consider the potential of the technology transfer process as it relates to the real goal of transportation research and transportation education—to better meet the mobility needs of all citizens.

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