

within the university. Courses in transportation can often benefit from the use of case studies obtained from community-assistance activities, and students in these courses are encouraged to attend formal conferences.

5. Involvement in an outreach program enables faculty to keep up with current activities in a topical area of transportation as well as with community problems and issues.

6. It is important to remain open-minded and flexible when programs are planned, developed, and implemented. This is particularly true with respect to community assistance. One should recognize that

community assistance is most effective when it is viewed as a learning experience for all parties involved. The attitude that "we're here to solve your problems" is rarely effective.

7. Finally, it has been learned that transportation outreach programs can be highly beneficial to both the community and the university. The community can benefit from greater access to professional expertise to assist in solving their problems. The university can benefit through a better understanding of problems faced in the world outside the university, which enables them to aim their activities in a more-relevant direction.

Transportation Engineering and the University: Past, Present, and Future Challenges

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Some of the major challenges faced by universities in developing transportation programs are discussed and the history of one program's response to these challenges is traced. Current challenges, such as the increasing number of foreign students in transportation programs, the shifting emphasis in management aspects, and the inclusion of women in technical programs, are also discussed as well as problems that are now waiting on the horizon, such as declining graduate enrollments.

In 1956, the federal government authorized the largest single public works project in the history of mankind--the construction of the 41 000-mile national system of Interstate and defense highways. With it was introduced a variety of federal road-user taxes to be placed in the Highway Trust Fund, created to finance part of the cost of the system; the federal government was to provide 90 percent of the total cost.

The system had been contemplated since the mid-1940s and strongly supported by the trucking industry, but it took more than a decade to become a reality, primarily due to two major issues: (a) how to pay for the system and (b) whether the system should be built into urban areas or around them as bypass or circumferential highways. The latter proved to be the thornier issue, which was eventually resolved in favor of building into cities, a decision that had drastic impacts on suburban development and, in some cases, urban deterioration.

The impact of the 1956 action was to take federal highway disbursements, which had totaled about \$7 billion in the 35 years between 1921 and 1956, and immediately increase them to \$4 billion per year and later to more than \$6 billion per year.

In 1962, the federal government introduced the requirement for ongoing comprehensive transportation planning for all urbanized areas (cities that had a population of 50 000 or more), thus giving rise to myriad metropolitan planning organizations (MPOs) and to the institutionalization of regional transportation planning. In 1964, the first Urban Mass Transportation Assistance Act was the federal government's formal recognition that highways were not the only mode of transportation and this provided the impetus for renewed interest in public transportation planning and development.

By 1968, some of the disbenefits of massive highway construction were now evident, and some legal brakes were applied, for example, the capping of the Interstate system at 42 500 miles and the requirement that two public hearings be held before a project was undertaken. Federal funding for arterial and street improvements through the Traffic Operations Program for Increasing Capacity and Safety (TOPICS) also began. In 1970, the Environmental Protection Act further retarded highway construction in urban areas and required the explicit consideration of environmental impacts in the planning and design process.

This brief history is merely background. In the 14 years between 1956 and 1970, the professional discipline of transportation planning and engineering was born and developed into the specialty now practiced. That is not to say that the decade of the 1970s did not also greatly influence the profession but to recognize that, before the 1970s, there was no generally recognized discipline and, most important, there were few systematic approaches to the emerging field in the universities.

INITIAL CHALLENGE

Highway engineering (i.e., highway construction and physical design) has long been an integral part of most civil engineering programs. Such courses have existed at the Polytechnic Institute of New York since the early 1940s. By the early to middle 1950s, programs that had a strong highway curriculum began to introduce traffic engineering (i.e., functional design and traffic control) as a distinct subject specialty. By the early 1960s, several universities (including Polytechnic) had established strong programs in the two key areas of highway and traffic engineering.

Comprehensive regional transportation planning entered the scene in the late 1950s by means of the Chicago Area Transportation Study (CATS), which became the model for many such studies. Such planning became critical in 1962 when the federal government mandated ongoing comprehensive transportation planning.

The university faced a number of major problems

in responding to the need for professionals who had specialized training in these new areas:

1. Adjustment of highway-oriented curricula to reflect multimodal transportation systems concerns;
2. Adjustment of engineering curricula to reflect the emerging emphasis on transportation planning;
3. Accommodation in this new area of undergraduates who had multidisciplinary backgrounds, many of whom were not engineering students (given that programs were traditionally housed in engineering departments); and
4. Formation for an emerging, rapidly changing field of curricula that both kept up with the latest developments (and indeed helped to forge the state of the art) and retained a sufficient core of basic principles and methodological approaches.

Of these problems, the interdisciplinary nature of the transportation field created a most difficult problem. First, the historical association of transportation curricula with civil engineering programs made acceptance of nonengineers procedurally difficult. Second, the interdisciplinary nature of transportation dictated that most of the initial programs be at the graduate level.

Further, the massive undertaking involved in the creation of totally new curricula--which involves new courses, new approaches, and new types of laboratories and workshops--is difficult to address without some form of external or institutional support. A brief recitation of how Polytechnic faced these challenges illustrates the point.

As has been previously noted, Polytechnic had offered highway and traffic engineering courses as part of its civil engineering program since the 1940s. In 1965, the Division of Transportation Planning was formed within the civil engineering department and, more important, a separate designated M.S. degree in transportation planning was initiated. The development of the division and the new degree program was greatly enhanced by a grant from the New York State Science and Technology Foundation. The formation of the division had several advantages in addition to the offering of one of the first such degrees in the nation:

1. The division could establish its own admission requirements, including the admission of nonengineering undergraduates;
2. The division was granted an operating budget separate from that of the rest of the civil engineering department; and
3. A director was appointed for the division, which provided clear-cut programmatic direction.

However, by 1969, the division still had only two full-time faculty members and two faculty members from other programs who devoted about one-third of their time to transportation education. From 1966 to 1969, the division achieved a number of valuable contracts, which aided its growth. In 1969, the division was awarded a university research and training grant from the U.S. Department of Housing and Urban Development [later the Section 11 program of the Urban Mass Transportation Administration (UMTA)]. Polytechnic has been funded continuously under this program since that time, which has provided the continuity needed to build a major program. This support provided two key opportunities: (a) ability to fund full-time fellows, which changed the character of the program from one in which 95 percent of the enrollment was part-time evening students to one in which a substantial full-time student body existed, and (b) ability to add full-time faculty to the program. As full-time faculty

were added, more research proposals were written, more funding was achieved, more fellows were supported, and additional faculty were added--a ripple effect. By 1975, the program had stabilized and had eight full-time faculty members devoted entirely to transportation, one of the largest such faculties in the country.

In 1970, in recognition of the program's steady growth, the division was granted full department status and remains today the only academic department for transportation studies in the United States. In 1975, the cost of the program's research activities was more than \$750 000 a year, and the Transportation Training and Research Center was formed to provide more-efficient administration of interdisciplinary research.

The research support of UMTA and other agencies also provided the ability to develop new courses and curricula in planning, public transit multimodal systems, and other areas. The program requirements in 1965 and in 1980 for a master's degree in transportation are compared below:

<u>Course</u>	<u>Credits</u>
1965:	
Elements of Probability	2
Elements of Mathematical Statistics	2
Introduction to Urban Planning	2
Highway Economics and Planning	2
Design of Traffic Facilities	2
Traffic Engineering I	2
Traffic Engineering II	3
Urban Transportation Planning	3
Traffic Workshop	2
Projects and electives	<u>10</u>
	30
1980:	
Applied Statistics (program prerequisite)	0
Transportation Studies and Characteristics	3
Travel-Demand Forecasting	3
Transportation and Traffic Workshop	3
Urban Planning Principles	3
Traffic Control, Operations, and Management	3
Transportation Economics	3
Projects and electives	<u>18</u>
	36

The program emphasis has shifted sharply from highway and traffic to multimodal planning and functional design. Further, in 1965, only 6 elective courses in transportation were available compared with 27 today in such special areas as highway and traffic engineering, urban planning, transportation planning, public transportation planning and operations, transportation safety, and transportation economics and management.

The department structure, unique to Polytechnic, has afforded a degree of visibility, independence, and ability to recruit an interdisciplinary faculty in a single academic department that is generally not available in other forms of organization such as interdepartmental programs and the traditional civil engineering approach. It was only after substantial external funding was achieved, however, that the administration of Polytechnic agreed to such an arrangement.

THREE KEY CHALLENGES FOR THE 1980s

The previous segment of this paper treated the historical challenges that Polytechnic and many other institutions have faced and overcome during the formative years of the transportation profession. This section deals with three key areas in which the Polytechnic program currently faces challenges and briefly outlines the approach being

pursued in each case. Again, these are problems that are common to many transportation programs across the United States.

Influx of Foreign Students

By 1975, almost one-third of the students enrolled in Polytechnic's transportation program were from outside the United States; more than 90 percent of these came from the developing nations. By 1980, this percentage had increased to about one-half the total student body and more than three-fourths of the full-time student population.

This has presented a number of administrative difficulties, which include the evaluation of foreign transcripts, communication problems, etc. The most difficult problem, however, is the curriculum: Developing nations view transportation as a critical tool for economic development. As such, their approach to planning considers goals and objectives that are far different from those usually used in the United States, in which all transportation improvements are incremental rather than basic. Other differences also exist. The technology of transportation used in most developing nations differs substantially from our own. For example, the manual construction of earth or simple penetration roadway surfaces still predominates in many areas. The movement of goods and materials rather than the movement of people is often of paramount importance. Further, unlike the United States, in which the most challenging transportation problems exist in the urban areas, many developing nations must still solve serious intercity transportation problems, including the development of ports. In light of this, it must be noted that a portion of the standard transportation curriculum is irrelevant to a student from a developing nation. The challenge is to provide more-useful and more-relevant professional training for such students.

After extensive surveys of such students and discussions with noted consultants who are working in developing nations, a number of key areas of need have been isolated:

1. Decision making: In the United States, the decision to implement a particular transportation improvement and the selection of the particular plan or design to implement are based on a variety of complex incremental analyses of direct impacts such travel time and mobility and environmental effects and on secondary impacts such as the effect of the improvement on a local or regional economy. This is proper, because a single improvement in a dense transportation environment would not have a marked effect on the overall economy (although there are clearly some specific examples that would). In the developing economy, these secondary impacts are the primary consideration, and incremental considerations such as travel time, travel costs, etc. are of minor interest. This changes the entire nature of the decision-making process, including the proper implementation of benefit/cost and cost-effectiveness analyses of proposed transportation projects.

2. Financing: The financing of capital and operating costs of transportation systems in the United States is accomplished through a complex but well-defined combination of private and public monies. Public funding on a massive scale occurs through established federal, state, and local governments that use a variety of tax measures to pay these expenses. In the developing economy, bureaucracy for financing the huge expenses of massive transportation systems is not as well defined. Further, the ability to tax is often hindered by the general state of the economy. Although funding from

within is often difficult in a developing economy, there are a variety of international sources of funds that can be tapped in several ways. The international student must have these sources better highlighted rather than have detailed analyses of the structure of the U.S. system.

3. Construction techniques: In developing nations, many rural roads are still being constructed as compacted-earth or penetration surfaces. The foreign student needs instruction in the construction of such roads, which are no longer built and are considered substandard in the United States. Further, construction in developing countries is often accomplished by using labor-intensive manual techniques rather than the highly mechanized procedures used in this country.

4. Management: The foreign student often returns to his or her home country in a supervisory capacity and often finds himself or herself in the position of managing complex construction projects. Construction will often involve foreign (U.S. or other) consultants and a variety of local companies. Managing such multinational efforts presents special management problems with which foreign students should be prepared to deal.

Because of these special problems concerning foreign students, the department found it necessary to decide to either develop a curriculum geared to their needs or discourage their entry into the program. The department chose the former course in the belief that a substantial portion of the demand for programs in transportation will continue to be from developing nations and that the educational need for specialized training in this area is acute.

A special program for a master's degree in transportation planning and engineering for students of developing nations was introduced in 1978. Its requirements, which reflect the above concerns and extend substantially beyond the standard master's degree program, are listed below:

<u>Course</u>	<u>Credits</u>
Transportation Studies and Characteristics	3
Travel-Demand Forecasting	3
Urban Planning Principles	3
Traffic Capacity and Design	3
Economic Analysis of Transportation Projects in Developing Countries	3
Case Studies in Regional and Transportation Development	3
Managerial Accounting	3
Projects and electives	33
	54

Electives specially developed for this program include the following areas (3 credits are given for each course): financing transportation projects, design and construction of roads, construction of transportation projects, and energy alternatives.

It had been hoped that contractual agreements with foreign governments and universities would support the program, but this has generally not occurred. Agreements with two foreign universities--National Chiao Tung University in Taiwan and Yarmouk University in Jordan--have caused several doctoral students to enter this degree program, but broader arrangements have not yet been achieved.

Although individual courses in this program have been greeted with enthusiastic interest, the program as a whole has been less successful than had been anticipated for several reasons:

1. Individual foreign students are reluctant to take the additional credits required for the program,
2. Support for extensive marketing (including

foreign travel) to achieve contractual arrangements with foreign governments has not been available, and

3. A major source of foreign students (Iran) has been disrupted.

While the contractual arrangements that would make the overall program a success are still being pursued actively, program material has been made available to foreign students through special seminars, offerings of selected topics, and individual guided studies. Some material has also been incorporated into the courses for the standard master's degree program.

Emphasis on Management Aspects

Over the past several years, transit operators and transportation agencies have expressed the need for students who are more highly trained in the economic and management aspects of the transportation profession and who also have a basic understanding of planning and engineering. In fact, approximately 30 percent of the program's graduates are employed in managerial positions, even though they lack specific training in management and transportation economics. Further, as the number of nonengineers who enter the transportation field increases, it is clear that a less technically oriented program might serve their needs better.

Polytechnic approached this subject cautiously. First, a series of elective courses was developed based on economic and management issues. These courses were placed into the regular master's degree program as a minor. In 1976, a joint degree program was initiated with the Department of Management, which resulted in the awarding of a dual M.S. degree, one in transportation planning and engineering and one in management. The total number of credits required for the dual degree (although 9 units were double-counted) was a severe drawback.

In 1979, a single program in transportation management was introduced at the master's degree level. It consisted of a core that included basic management skills, basic transportation operations skills, the initial series of transportation economics and management courses, and additional courses specific to the program, such as analysis of transportation markets, legal and regulatory aspects, behavioral and societal aspects, and intercity passenger and freight transportation. To bolster registration in the new courses, they were also made available to students in either the transportation or the management programs as electives.

The program has been quite successful to date and had five full-time students and five part-time students during its first year of operation. The first degrees from the program were awarded in June 1980, and total enrollment for fall 1980 appears to be about 15, a rewarding figure for the program's second year of operation.

Role of Women in Technical Professions

In response to governmental requirements for affirmative action, both schools and employers have been making an extensive effort to involve women in technical fields. At the graduate level, this has been and continues to be a difficult problem, since the number of women undergraduates in technical areas is not high (although it has been increasing in recent years). Transportation programs, because of their interdisciplinary character, are an ideal means by which women who do not have technical backgrounds can enter a technical field.

At Polytechnic, the percentage of women in the transportation program has varied between 5 and 15

percent and has generally been considerably higher than in the other graduate programs. However, to increase the involvement of women in transportation, Polytechnic, through its Transportation Training and Research Center, recently applied for and received one of six new Women in Science grants from the National Science Foundation.

The grant is aimed at the retraining or reorientation of college-educated women who are underemployed or who have been out of the job market for several years. The grant will provide a tuition-free program that consists of (a) special short courses and seminars and (b) a selection of regular graduate courses. The program will accommodate as many as 40 women, each of whom will receive a graduate certificate and earn 15 units toward a master's degree. The program will be given over a three-semester period that begins in spring 1981 on a part-time basis. The part-time basis is important, since it will allow women currently working to continue to do so while studying. The three-semester program plan is outlined below:

1. First semester
 - a. Special seminars: Careers in Transportation (two days), Planning (two days), Applied Statistics (eight weeks for 4 h/week), and Analytic Concepts and Techniques (four weeks for 4 h/week)
 - b. Regular courses: Transportation Studies and Characteristics (3 units)
2. Second and third semesters
 - a. Special seminars: Technical Writing (20 h), Public Speaking (10 h), Working in Design Teams (10 h), and Job Resume and Interview Techniques (one day)
 - b. Regular courses: 6 units per semester in selected areas such as planning, public transportation, traffic engineering, transportation economics, and management

It is hoped that many of the women trained in this program will be placed in entry-level positions in the profession. Special job-placement services will be made available to the participants. It is also expected that many of the women in this program will continue their studies toward a master's degree, as has been the case in similar programs in other disciplines at Polytechnic.

BUILDING A CURRICULUM

In the 15 years between 1965 and 1980, Polytechnic established a new academic department, three new degree programs, a research center, and more than 30 new courses in the field of transportation. The building of such a curriculum is a gradual process, which was aided by two key operating principles:

1. Research funding should be used in a way that permits the support of full-time students and provides material for the development of new and/or revised course curricula, and
2. When new programs or courses are introduced, it is wise not to rely on a totally new student market; making courses available as electives to students in other programs allows a new program to develop a student body over a number of years without causing a major economic strain on the university or the department that offers the new program.

In Polytechnic's case, both principles were of great importance. Early support from UMTA permitted the broadening and extension of the curriculum into the all-important area of public transportation and the strengthening of the planning curriculum. Over

the years, the results of funded research projects have contributed to the development of such diverse specialized courses as highway capacity, goods movement, transportation system safety, and numerous others. Today, the program is more or less stable, and curriculum inputs are geared more to refining existing courses than to introducing new ones, but the role of new courses is just as vital. Only in the case of the program for regional and transportation development did Polytechnic attempt to introduce a large number of new courses at one time without making them available as electives to students in other programs. This remains the sole case in which Polytechnic's programmatic and enrollment expectations have not been met.

It is also necessary to maintain an environment in which faculty members are encouraged to assess existing programs and promulgate new academic and research programs, especially those of an interdisciplinary nature, and to devise innovative and imaginative approaches to the educational process.

Academic programs should be evaluated on a regular basis to determine their future direction or workability. The following guidelines should be used as an aid in determining whether to maintain, initiate, or eliminate academic programs:

1. Is the program academically important?
2. Is there now and will there remain significant student interest to warrant its continuance?
3. Is there a high probability that the program will achieve a high level of excellence?
4. Is there a high probability that the program can be adequately and securely financed?

SOME CHALLENGES FOR THE FUTURE

We would be sorely remiss if, in any paper of this type, we did not treat (even in a cursory way) some of the problems and challenges that are beginning to appear and that will have to be faced within the coming decade.

No problem will be greater than the general national trend of declining graduate enrollment in engineering and science programs. Transportation programs could be severely affected by this trend, since most exist primarily on a graduate level. The reasons for the decline are many and complex and cannot be adequately discussed here, but one principal cause over the past several years has been the extremely high salaries offered to undergraduate engineers. Even with fellowship support, it is difficult to attract as full-time graduate students those who are given initial job offers that pay \$20 000 per year and more. Whether these students ever rejoin a graduate school on a part-time basis is still not clear, but the impact on graduate transportation programs is that

1. A greater percentage of transportation-program students have nontechnical backgrounds,
2. A greater percentage of transportation-program students are from foreign countries, and
3. Total enrollments in transportation programs have leveled off and are declining.

This is indeed a multiple challenge. Although transportation is an interdisciplinary field, it retains a strong engineering component, and the profession requires many transportation specialists who have engineering backgrounds. The problems associated with increasing percentages of foreign students have already been discussed and relate to their special educational needs. Declining enrollments, of course, stifle growth and limit the number of faculty who can be supported in any given program.

One potential solution, which will require careful consideration over the next few years, is the movement of transportation curricula to the undergraduate level, at least for engineers. This may involve new undergraduate degree programs or minors in existing programs. New degree programs would face the problems of professional accreditation and high school recruiting programs in addition to the many internal university problems associated with starting a new undergraduate program, particularly if it were also to be accompanied by a new academic department.

The increasing percentage of nontechnical students may eventually force the issue of separate curricula and the difficult task of differentiating transportation planning from transportation engineering. Indeed, the whole issue of specialization within the transportation field, including such areas as economics, management, law and regulation, operations, and design, must also be faced. Most programs, including Polytechnic's, attempt to merge parts of many of these specialties to provide a broad professional base of knowledge. Further, enrollments to date would not justify multiple programs. If, however, transportation curricula begin to move to the undergraduate level, then the question of graduate specialization would be a real one and each university would have to carefully select its areas of interest.

Of course, if a clear understanding of the needs of the profession existed, i.e., the number and types of professionals needed over the next 20 years, many of these questions would be more easily answered. Such crystal-ball answers, however, are not available, which leaves the university to face the future with only the advantages of foresight, creativity, and perseverance with which to advance. These have always been sufficient in the past and, we trust, will probably continue to be so in the future.

Training of Transport Specialists

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It is generally recognized that the success of any policy or plan depends on the quality of those who administer it; thus the development of human capital becomes one of the important investments in economic growth, especially in the Third World countries, in which the availability of well-trained personnel is often the main obstacle to economic development. This paper reviews a re-

cent experience in training future transport planners and policy administrators in Argentina. A short description of this program is followed by a discussion of the lessons learned and the training options that other such programs should consider.