Transportation Education and Workforce Development

THIS FEATURE DISCUSSES WORKFORCE ISSUES RELATED PRIMARILY TO U.S. CIVIL AND TRANSPORTATION ENGINEERS AND EXPLORES ENROLLMENT AND GRADUATION TRENDS. METHODS ARE IDENTIFIED TO ADDRESS CHANGES IN THE HISTORIC TRANSPORTATION WORKFORCE POOL AND ACCOMMODATE THE PROFESSIONAL DEVELOPMENT NEEDS OF THE CURRENT AND FUTURE TRANSPORTATION WORKFORCE.

BY JOHN M. MASON JR., PH.D., P.E.

NATIONAL SCIENCE AND ENGINEERING PERSPECTIVES

The overall science and engineering workforce in the United States is of national concern. It is clear from numerous accounts that fewer college students are majoring in mathematics, the physical sciences and engineering than in the past. Several science and engineering issues have been cited by the National Academies, including the following findings:[1]

- The U.S. General Accounting Office cites human capital needs as a high-risk issue.
- The federal science and education workforce is shrinking.
- Foreign students are finding challenging job opportunities in their home countries.
- There is a significant education gap between providing new jobs and training the workforce (specifically, with necessary knowledge, skills and abilities).
- Workforce changes require long lead times and well-coordinated government, industry and university actions.

While the demand for an engineering workforce generally remains strong, the number of students planning to enter engineering continues to decline. A recent report issued by the ACT Office of Policy Research cites U.S. needs for maintaining a strong engineering workforce.[2] The report presents college enrollments, academic preparation and diversity issues for 12 years of data and more than 750,000 college-bound students planning to major in engineering. Among those students, approximately 52,000 from the graduating high school class of 2002 indicated that they planned to major in engineering—15,000 less than one decade ago.

CIVIL ENGINEERING TRENDS

Civil engineering undergraduate programs continue to serve as a primary source of human capital for the transportation profession. The American Society for Engineering Education's (ASEE) database provides some indication of the quantity of the pipeline supply: Approximately 10,000 students received civil engineering bachelor's degrees in 1999; by 2002, the number of degrees awarded decreased to 8,799.[3]

Approximately 215 schools grant bachelor's degrees related to civil engineering. The number of degrees granted per year ranges from 2 to 180 per school and the top 15 institutions graduate more than 100 undergraduates per year.[4] Future trends for civil engineering programs appear to contain broadly based core requirements with transportation courses as electives. At many institutions of higher education, reducing the total credit hours required for graduation is becoming the norm.

During the period from 1999 to 2002, the number of master's degrees awarded in civil engineering also decreased slightly, from approximately 4,100 to 3,800. Doctoral degrees remained reasonably constant, averaging 625 graduates per year. The data represent U.S. and Canadian schools that offer undergraduate and graduate engineering and engineering technology programs.[5]

The total full-time and part-time civil engineering enrollment in 2002 consisted of 43,346 undergraduates, 9,337 master's degree students and 4,653 doctoral students. It is relevant to note that in all engineering disciplines, it appears that the number of degrees has been leveling since 1996.[6]

Finding jobs in the current market has not been problematic for civil engineering graduates. The civil engineering degree has been reported as very "marketable" by the *Engineering News-Record*.[7] Although some firms are hiring less, positions

Market strategies	Developmental stages				
	Pre-college (grade level)			College (year of study)	
	Kindergarten–grade 6	Grades 7, 8 and 9	Grades 10, 11 and 12	1–2	3–4
Awareness	Environment	Engineer	Civil engineer	Introduction to civil engineering disciplines	Summer/cooperative employment
Retention	Field trips	Role models	Peer mentors	Clustering	Professional mentors
Curriculum	Technology applications		Math and science emphasis	Introduction to design	Project design

SOURCE: National Cooperative Highway Research Program (NCHRP). *Civil Engineering Careers: Awareness, Retention, and Curriculum. NCHRP Report 347–Part I.* Washington, DC, USA, Transportation Research Board (TRB) and National Research Council (NRC), 1992; and NCHRP. *Civil Engineering Careers: A User's Guide for Awareness, Retention, and Curriculum Programs. NCHRP Report 347–Part II.* Washington, DC, TRB and NRC, 1994.

Figure 1. This conceptual model shows attributes of recruitment and retention programs for students interested in civil engineering.

remain available, with the best opportunities in the area of rebuilding state funded civil/public works infrastructure.

The *Engineering News-Record* also reports increasing numbers of students seeking employment within the public sector, particularly within the federal government and the military. Job placement opportunities for bachelor's degree students in civil engineering reportedly have been good, with approximately 10 percent joining the government/nonprofit sectors, 40 percent in private consulting and 50 percent in industry (manufacturing or construction).[8]

According to a survey by the National Association of Colleges and Employers, starting salaries for engineers have remained steady. Starting salaries for civil engineers have risen slightly to an average of approximately $41,000.[9]

Although there was a slight increase in the number of students pursuing graduate degrees in science and engineering programs in 2001, overall graduate student enrollment has not changed significantly over the past decade. Civil engineering graduate enrollment decreased from about 20,000 in 1994 to 16,600 in 2001.[10]

Graduate degrees not only supply employers in the public and private practice sectors. They also provide a base for the future teachers of science and engineering students. As with the general population, the peak pool of academic expertise is moving toward retirement age, resulting in a smaller group of teachers and researchers from which to draw for academic programs. ASEE reports that full-time civil engineering teaching faculty numbered 3,375 in 2002. These numbers have been stable, with some tendency toward a decline.[11]

Another recent trend is on the rise: International students with advanced degrees are returning to their home countries to pursue career opportunities.

Statistics from the National Science Foundation note that doctoral degrees in science and engineering continue to decline. Approximately 500 civil engineering doctorates were awarded in 2001; approximately 600 were awarded in 1996.[12] Engineering doctorates recently have tended to stabilize, with some expectation that graduate enrollments may see an increase due to slowing job market opportunities.

Because the civil engineering profession finds itself competing for high quality, competent individuals who are simultaneously considering the appeal of other careers, many programs have surfaced in the last decade seeking to increase the awareness and retention of students interested in civil engineering and, more specifically, the field of transportation.[13] Attributes of these recruitment and retention programs are presented in the conceptual model shown in Figure 1. Creative and proactive programs have been developed and sponsored by various sectors of the transportation profession.

Central to these programs has been the recognition of commensurate intervention approaches at the various stages of development. As efforts progress from general awareness to specific retention and curriculum elements, the target audience likewise narrows. Beyond the stage of formal undergraduate degrees, graduate students tend to focus more narrowly while the need for broader based professional programs increases in demand by the practicing professional.

In support of continued professional development, the American Society of Civil Engineers (ASCE) has adopted Policy Statement 465, "Academic Prerequisites for Licensure and Professional Practice," which states, "ASCE supports the concept of the master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at a professional level."[14]

A committee is charged with the further development of the overall ASCE plan. The body of knowledge is being identified for the civil engineer of the future. Knowledge beyond the undergraduate degree may be attained via traditional on-campus graduate education courses or via distance education mechanisms.

It will be important for the transportation profession to be engaged in these discussions to be appropriately represented in future developments, particularly because the civil engineering discipline remains the backbone of many state departments of transportation and transportation engineering consulting firms.[15]

TRANSPORTATION WORKFORCE

In 1985, a noteworthy study was conducted on the professional needs for highway and mass transit agencies in state, local and federal government and individuals in private sector consulting firms. A committee was formed under the National Research Council to evaluate the future skill requirements of the transportation workforce and briefly address the education and training of transportation

professionals. The impetus for the study was the concern that "a large number of professionals who entered highway and mass transit organizations during the past 30 years are expected to retire soon."[16]

The Transportation Research Board's (TRB) *Special Report 207* recognized that civil engineers will continue to be a significant component of the transportation profession.[17] While transportation programs have broadened in scope over the past 20 years, traditional transportation engineering and planning programs compose the majority of the professional transportation workforce.

The committee's foresight for "certification procedures to ensure the necessary professional expertise is preserved while the skills of planners, environmental specialists, and other professionals are fully used" has been addressed with numerous continuing education post-baccalaureate programs at several universities.

In transportation, the Institute of Transportation Engineers has provided leadership in conceiving and advocating for continued development of the Professional Transportation Operations Engineer™ certification and other pertinent transportation related certification efforts.

Several predictions cited in *Special Report 207* have been experienced across the transportation field, including:[18]

- A shift in the mix of skills required by transportation professionals;
- Increased use of consultants;
- Provision for adequate training and certification procedures; and
- Dependence on computer applications for data collection, analysis and management of the overall transportation system.

Many of the 1985 recommendations continue to be relevant today in both the initial preparation and the continual professional development of the transportation workforce, such as adapting to changing knowledge, skills and abilities; increasing interaction between educational programs and government and industry; and continuing efforts to enhance diversity.[19]

More recently, TRB's special committee on "Future Surface Transportation Agency Human Resources Needs: Strategies for Recruitment, Training and Retaining Personnel," was formed to examine the changing roles and responsibilities of public transportation agencies over the next two decades.

WHILE THE DEMAND FOR AN ENGINEERING WORKFORCE GENERALLY REMAINS STRONG, THE NUMBER OF STUDENTS PLANNING TO ENTER ENGINEERING CONTINUES TO DECLINE.

The study was requested by the Federal Highway Administration (FHWA) with funding support from FHWA, the Research and Special Programs Administration and the National Cooperative Highway Research Program.[20] The intent of the study was not to determine specific numbers of particular individuals in agencies but to identify expertise areas that will be needed and to describe the envisioned capabilities of that respective workforce.

The committee recognized that the key issues identified in the 1985 study still remain among the essential elements of concern to the transportation profession. However, studies of current U.S. demographics note the difficulty in predicting the effects of changes in any one economic sector. The 2003 committee subsequently focused on how transportation agencies can adjust to future workforce challenges. The committee noted several key factors as affecting the future U.S. workforce:

- Technological advances (integrated telecommunications systems);
- Globalization (highly mobile and distant workforces); and
- Workforce composition (age, demographics, diversity and experiences).

These broader issues directly affect the future of the transportation profession. The implications may be more poignant within the context of state transportation agencies, where there is:[21]

- Increasing retirement;
- Work elements that continue to shift from principally roadway building to increases in operations, maintenance and modal integration;
- Agency downsizing and reorganization;
- Increased program funding and a broadening scope of responsibilities; and
- Contracting out for various products and services.

Transit agencies face some similar and some unique workforce challenges:[22]

- Daily contact with the public (which is constant and, often, direct);
- Usually unionized operators and maintenance staff;
- Heightening daily public safety responsibilities (and associated security issues);
- Almost all local governmental agencies; and
- Wages and benefits packages in addition to usual competition for skilled personnel.

To meet the workforce needs of state departments of transportation and transit agencies, the committee's *Special Report 275* emphasizes the importance of entities' focusing on continuous recruiting, training and retraining, retention of employees and succession management.

While no single organization model possibly could accommodate the variability across the breadth of transportation related services and providers, the committee clearly notes the need for strategic-level planning regarding human resource functions within transportation organizations. Additional recommendations include:

- Enhancing training programs to keep pace with ever-changing knowledge, skills and abilities;
- Increasing investment to develop

and sustain training programs; and
- Creating and maintaining strong partnerships with academia and existing local transportation assistance programs.

For transportation entities (both public and private) to adequately address the trends and needs for continued workforce development, quantitative assessments of related workforce issues are necessary. Much of the fundamental transportation human resources information is lacking to more clearly identify future knowledge, skills and abilities; mix of workforce staff levels; and experiences and succession planning. Key data and pertinent assessment studies appear limited and mostly anecdotal evidence exists on the capacity within public agencies.

Similar limitations are found when discussing "outsourcing" services, grade level/wage related issues and retired transportation professionals providing continued service via the private sector.

WORKFORCE AND PROFESSIONAL DEVELOPMENT

Entry into the engineering profession and, more specifically, into the transportation sector is not linear. Attracting the most talented technical workforce does not mean forcing individuals into particular avenues or into a shrinking pipeline.[23] The need for continuous professional development in one's chosen field is intuitive.

The motivation for life-long learning for transportation professionals should begin during the undergraduate experience. Students (and practicing professionals) evolve through stages of novice, advanced beginner, competence and proficiency to individual expertise.[24]

While professional development stages are principally a progression of cumulative work experience, the transportation profession also is characterized as having many entry points. Individuals gain employment in various fields and areas of transportation. Their technical, demographic and personal experiences are as varied as their education preparation. Fortunately, those attributes do not limit entry to the transportation field by a specific pipeline.

The National Workforce Summit recognized the importance of addressing workforce development effective through one's own organizational support, with other partners to promote and create a well-trained transportation workforce. The group noted that professional development includes not only knowledge training but also mentoring and other related professional opportunities.[25]

CONTINUING AND DISTANCE EDUCATION

To accommodate public and private sector workforce needs, institutions of higher education recently have shown growth in the number of students fulfilling their desire for continued professional development via distance education alternatives. The General Accounting Office has reported continued growth in distance education involvement by undergraduate and graduate students.[26]

Distance education includes off-campus, live interactive television/audio, prerecorded video, CD-ROM, or other computer based systems. Distance education students generally are older and more likely to be married. They work full-time, are part-time students and have higher average incomes.

Institutions are using the Internet more than any other mode of delivery, with most distance education subjects related to business, humanities and education. Transportation distance education programs are slowly entering the mainstream of distance education but currently vary greatly in breadth and depth of subject matter.

Continuing and distance programs are available through various institutions of higher education and private sector entities. The media, methods and credit options also vary across a broad spectrum. While several of the recommendations mentioned above reference the needs and opportunities for continued professional development, the creation of quality programs via institutions of higher education is advancing cautiously. Some engineering schools have extensive experience with the production of high-quality distance education programs; others are entering the "outreach" mission with new and partnered investments.

Post-baccalaureate continuing education programs (such as conferences, seminars, short courses and Web-based courses) historically have been among the alternatives for acquiring professional development knowledge. The "courses" are offered either for full academic credit or as continuing education units. However, ASEE reports that only a few schools offer undergraduate engineering degrees online.[27]

Most continuing/professional development programs will remain an extension of the traditional mechanisms until some of the undergraduate program issues are more fully addressed. Additionally, the overall initial program development and subsequent long-term commitment to full programs online are expensive. The principal hurdle is the manner in which to handle laboratory experiences for a dispersed student body.[28] Institutions are meeting the challenge using simulation techniques, compressed on-campus lab activities, industry/private sector cooperation with in-house labs and training facilities.

Most institutions are making progress on an incremental basis, beginning with core courses that have potential for credit transfer across disciplines and between other institutions. Although detailed discussion of distance programs cannot be fully addressed in this feature, academic institutions including community colleges, technical institutes, private sector training entities and four-year engineering programs are logical and relevant partners in meeting the professional development needs of the future transportation workforce. ■

References

1. Jackson, S.A. *Envisioning A 21st Century Science and Engineering Workforce for the United States.* Washington, DC, USA: The National Academies Press, 2003.

2. Noeth, R.J., T. Cruce and M.T. Harmston. *Maintaining a Strong Engineering Workforce.* ACT, 2003. Accessible via www.act.org/research/policy/index.html.

3. *Profiles of Engineering and Engineering Technology Colleges—2002 Edition.* Washington, DC: American Society of Engineering Education (ASEE), 2003.

4. Ibid.

5. Ibid.

6. Ibid.

7. Maisler, R. and B. Snyder. "Class of 2003 Finds Jobs Tight But More Interest in Engineers." *Engineering News-Record,* June 9, 2003, page 23.

8. *Salary Survey.* National Association of Colleges and Employers, Spring 2001.

9. National Society of Professional Engineers (NSPE). "Starting Salary Offers for Graduates Plateau This Year." *Engineering Times,* June 2003.

10. Burrelli, J.S. "Graduate Enrollment Increases in Science and Engineering Fields, Especially in Engineering and Computer Sciences." National Science Foundation (NSF) Division of Science Resources Statistics, NSF 03-315, Arlington, VA, USA, April 2003. Accessible via www.nsf.gov/sbe/srs/infbrief/nsf03315/start.htm.

11. ASEE, note 3 above.

12. NSF Division of Science Resources Statistics. Science and Engineering Doctorate Awards: 2001, NSF 03-300, Arlington, VA, 2002. Accessible via www.nsf.gov/sbe/srs/stats.htm.

13. National Cooperative Highway Research Program. *Civil Engineering Careers: Awareness, Retention, and Curriculum. NCHRP Report 347–Part I.* Washington, DC, Transportation Research Board (TRB) and National Research Council (NRC), 1992.

14. American Society of Civil Engineers. Policy Statement 465, "Academic Prerequisites for Licensure and Professional Practice." Accessible via www.asce.org/pressroom/news/policy_details.cfm?hdlid=15.

15. NSPE. "Civil Engineers Propose to Raise the Bar." *Engineering Times,* June 2003.

16. *Transportation Professionals: Future Needs and Opportunities (Special Report 207).* Washington, DC, TRB and NRC, 1985.

17. Ibid.

18. Ibid.

19. Ibid.

20. *The Workforce Challenge—Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies (Special Report 275).* Washington, DC, TRB and NRC, 2003.

21. Ibid.

22. Ibid.

23. Muller, C.B. and S.S. Metz. "Burying the Pipeline and Opening Avenues to Engineering." *PRISM.* Vol. 12, No. 4 (December 2002): 72.

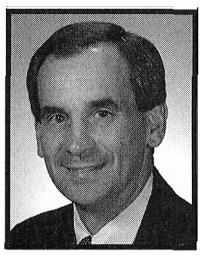
24. Gandolfo, A. "Motivating Students for Life-Long Learning: Developing Metacognition." *Journal of Professional Issues in Engineering Education and Practice,* Vol. 127, No. 3 (July 2001): 93–97.

25. Martin, C. and V. Glenn. "Filling the Pipeline." *Public Roads,* Vol. 66, No. 3 (November/December 2002): 6–11.

26. Ashby, C.M. "Growth in Distance Education Programs and Implications for Federal Education Policy." Testimony before the Committee on Health, Education and Pensions, U.S. Senate, September 26, 2002.

27. Grose, T.K. "Can Distance Education be Unlocked?" *PRISM,* Vol. 12, No. 8 (April 2003): 19–23.

28. Ibid.



JOHN M. MASON JR., *Ph.D., P.E., is associate dean of graduate studies, research and outreach and professor of civil engineering at the College of Engineering at Pennsylvania State University. He served as a member of the Human Resource Issues Transportation Research Board Committee for* Special Report *275. He received a B.S. from Pennsylvania State University, M.S. from Villanova University and Ph.D. from Texas A&M University. He is a fellow of ITE.*