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RESEARCH RESULTS DIGEST

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These Digests are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may do so through contact with the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

Areas of Interest: IA Planning and Administration
VI Public Transit

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A Unique, Hands-on Educational Program for High School Mathematics and Science Classes

An NCHRP Digest on the background, research results, and prototype materials produced under the NCHRP Project 20-24(3)A, "Civil Engineering Careers in Transportation—Outreach Program," prepared by Alan W. Shute, American Association of State Highway and Transportation Officials, Washington, D.C.

THE ARISING PROBLEM

The transportation profession is being challenged to diversify its work force with well-qualified individuals. For years, national trends have predicted an increasing need for diversity in the transportation profession as it approaches the next century. Currently, the most critical need is in civil engineering. Civil engineers compose about 75 percent of the professional work force of state transportation agencies.

Where will the future labor pool come from? Engineering, civil engineering included, has been dominated by white males. But by the year 2000, the Hudson Institute predicts that women and minorities (especially Hispanics and African Americans) will constitute one of the largest shares of new entrants into the work force. Immigrants will represent the largest share of the increase since World War I; white males will represent one of the smallest shares of new entrants to the work force.

According to the Bureau of Labor Statistics, in 1992, of the total 217,000 civil engineers in the nation, 7.9 percent were women, 3.4 percent were African American, and 3.9 percent were Hispanic. Compare these numbers to a breakdown of the national labor pool overall during the same year: 45.2 percent women, 10.9 percent African American, and 2.7 percent Hispanic. As the minority population represents a more significant share of the general population and labor force, will qualified minorities be available to the transportation profession in sufficient numbers? Probably not unless the transportation profession intervenes.

According to the National Action Council for Minorities in Engineering, the fall 1992–93 minority undergraduate enrollments in engineering for African Americans, Hispanic Americans, and American Indians represent only 12.6 percent of the total population. Overall, women represented under 15 percent of the total enrollments. And civil engineering represented an even smaller number within the overall engineering curriculum.

Not only are women and minorities under-represented, but are the few who graduate from engineering schools available to state transportation agencies?

The transportation profession must refocus its recruitment and outreach strategies. Most importantly, the profession needs to provide national leadership in developing interest about transportation among a diverse population of pre-college students today, who can become the transportation students and professionals of tomorrow.

A response to this important diversity issue is AASHTO's and FHWA's leadership in the conduct of a high school educational outreach program called TRAC (TRAnsportation and Civil engineering). TRAC, which began as a pilot project in September 1991, is working in six states—California, Florida, Maryland, New York, Pennsylvania, and Washington—to increase awareness about transportation and civil engineering. The primary targets of the TRAC career message are female and minority high school students.

The concept for TRAC emanated from a 1989 AASHTO Task Force that began its work (with some financial support from NCHRP Project 20-7,) by producing a recruitment guide now used nationally by state transportation agencies. The TRAC concept was formally created in 1990. Under the auspices of AASHTO, FHWA, and the NCHRP, the TRAC concept was developed. In January 1991, AASHTO, FHWA, professional societies, and other industry and minority organizations agreed to jointly sponsor a TRAC pilot project through financial support and participation on a steering committee.

THE SOLUTION

Prototype Classroom Materials

At the same time that TRAC was evolving, The Pennsylvania Transportation Institute (PTI) was conducting NCHRP Project 20-24(3), "Expanding the Civil Engineering Pool." The overall objective of this project grew to include recommendations on various actions that would improve not only the number of civil engineers interested in transportation careers, but also the quality of these engineers and the recognition of the increasingly diverse demographics of the U.S. population.

PTI catalogued and described existing techniques that are being used to promote among students an awareness of civil engineering career options as well as those techniques that provide an awareness for mathematics and science studies. Seventeen focus groups at four locations were conducted with students, teachers, parents, and counselors to gain insight into attitudes on civil engineering as a profession and career option. As a result, PTI recommended a series of actions that span kindergarten through college. Acknowledging that other programs promote mathematics and science, the degree to which these recommended actions stress civil engineering as a career option increases as the level of education increases. These various actions have been categorized under three themes: Awareness, Retention, and Curriculum, and are now referred to as the ARC model. The results have been published as *NCHRP Report 347*, "Civil Engineering Careers: Awareness, Retention, and Curriculum."

Subsequently, PTI produced a user's guide for implementing the ARC model and a directory of programs and services categorized by the various ARC components. The user's guide has been published as *NCHRP Report 347 - Part II*, "Civil Engineering Careers: A User's Guide for Awareness, Retention, and Curriculum Programs," and the directory is available on request.

The NCHRP believed there was a unique opportunity through TRAC to advance specific portions of the ARC model with the actual development, application, and evaluation of prototype material. Consequently, under NCHRP Project 20-24(3)A, "Civil Engineering Careers in Transportation - Outreach Program," the NCHRP accepted a proposal from the staff at the AASHTO TRAC Careers Center, who, in turn, hired The Naidus Group (a New York based educational consulting concern), to develop prototype material for TRAC and recommend suitable delivery mechanisms and evaluation criteria.

The TRAC program was created with the primary mission to interest high school students, especially minorities and women, in the transportation profession and civil engineering. Like any other initiative that wanted to get career messages to students, TRAC would have to gain entry into the classroom.

But since there were many outreach efforts already underway throughout the nation that were delivering a career message using the traditional method of having professionals visit students for a class period, it was clear that a new method would have to be used in order to position the TRAC program in a way fundamentally different from those that were currently in use. In a review of research conducted by PTI, it was evident that high school teachers could not afford to sacrifice any more precious classroom curriculum time for career guidance purposes.

Thus, TRAC's challenge was to incorporate its career message into a set of curriculum-relevant teaching tools that high school teachers would find broad uses for in the classroom and that students find exciting and easy to use.

This approach, if successful, would allow TRAC to bypass the traditional methods used to get a career message into high school classrooms—that is, asking teachers to stand aside while discussions between students and professionals occurred.

TRAC's consultant, The Naidus Group, undertook this research effort to find ways of incorporating the career message directly into high school math and science curriculum.

The basic concept that The Naidus Group used when conducting its research and development was to produce a set of tools that math and science teachers and their students could use to engage in meaningful, curriculum-relevant problem-solving activity that directly related to the profession. Realizing that classroom curricula would differ from school to school, these tools would also have to be flexible enough to meet the requirements of different teachers.

The research effort, which occurred over a compressed time frame of 6 months, resulted in an innovative kit of classroom materials that complement present-day high school math and science topics. The career message—that transportation and civil engineering are exciting fields that need talented people of all kinds to address our future challenges—is embedded in the materials.

The prototype materials, appropriately called the "Transportation Research Activities Center" (TRAC) is the result of this research effort.

This kit (TRACPAC) contains all of the equipment teachers and students need to conduct real engineering investigations in their math and science classes (see Figure 1). These investigations link some part of current-day math and science high school classroom curriculum to the work of civil engineers in the transportation profession.

The kit is a mobile laboratory of over two dozen transportation engineering activities and projects that fit in neatly with existing high school math and

Figure 1. TRACPAC kit (left) and guides (right)

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Figure 2. Magnetic levitation (Maglev) experiment

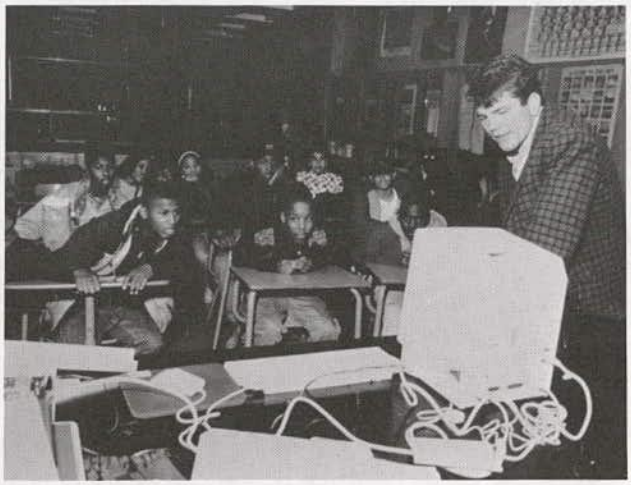

Figure 3. Instruction in TRACPAC use

science curricula and are exciting and fun for the students to use. It consists of a Macintosh computer; a set of electronic probes (i.e., force, motion, sound, and the like) that connect to the computer; a set of materials that can be used to build realistic models; and student and teacher guides. The kit also includes of software for data collection and analysis, an integrated spreadsheet and graphics program, a probabilities distribution and queuing tutorial and simulation, and an urban traffic management simulation.

The nature of how this program—engaging students in learning by doing—is based on the idea that students will as much as possible, teach themselves if given the right situation, encouragement, guidance, and the proper tools. Most of the TRAC classroom experience is entirely self-paced.

This appears to be the only outreach program where the career message is embedded within a relevant and useful curriculum tool delivered by practitioners in existence today.

Use in the Classroom

Two-person teams of practicing civil engineers and college students majoring in civil engineering deliver the kit into schools. All TRAC Teams are trained and certified in the use of classroom materials prior to working with schools. The program is built and delivered around the understanding that the teams are most often not professional teachers. Instead, the teams offer students practical experience in conducting projects with the kit and serve as role models that the students can look up to (see Figure 2). Using the teams in these ways allows TRAC, unlike other outreach efforts that are exclusively "career-message oriented," to make the career message indirect, subtle, and very personal.

When working with schools, first, TRAC teams introduce teachers to TRAC's kit and help "fit" the materials into the teachers classroom curriculum. Next, teams visit the classroom and introduce the students to the materials and initiate a hands-on project (see Figure 3). From then on, the teams are a technical resource to the students and teachers for as long as the materials stay in the classroom—which can range from 1 day to permanently.

Because the successful delivery of this program is dependent on getting people into the classroom, with the teachers' cooperation, TRAC is portable to other existing outreach programs. Programs such as the **Mathematics, Engineering Science Achievement** (MESA) in Washington State and the **Select Program for Interest Science and Engineering** (SPISE) in New York City have successfully delivered TRAC into the classroom using networks they already established through work on other outreach initiatives. The California

Department of Transportation has successfully integrated TRAC's classroom materials into classrooms within an existing adopt-a-school program. Right now, TRAC is focusing exclusively on creating awareness about civil engineering. It is expected that starting in Fall 1995 TRAC will begin to expand the scope of its career message by developing additional prototype materials that illustrate the practices of other fields within the profession.

The National Outreach Program will be pilot tested through August 1994, at which time TRAC plans on becoming a self-supporting operation and will be introduced nationally.

For more information about the prototype material produced under NCHRP Project 20-24(3)A and TRAC, contact:

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