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Workforce of the Future: Ideas for Improving K-12 Outreach by Transportation Engineering Educators through Near-Peer Involvement and Leveraging Contextual Exposure

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Workforce of the Future: Ideas for Improving K-12 Outreach by Transportation Engineering Educators through Near-Peer Involvement and Leveraging Contextual Exposure (Research to Practice)

Strand: Principles of K-12 Engineering Education and Practice

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ABSTRACT

Safe and efficient transportation systems are essential to our modern lives. They also require a sustainable supply of an educated and competent workforce for smooth functioning in the future. The Transportation Research Board and National Academy of Engineering anticipate a shortfall in this workforce in the future to meet increased demand for moving goods and providing services. This study reviewed outreach efforts to K-12 students for transportation engineering workforce development and proposed ideas which have the potential for success in this regard. Federal Highway Administration (FHWA) sponsored summer transportation institutes are the most common transportation engineering outreach efforts. Hands-on activities at these summer institutes, such as collecting vehicle speed data using a radar gun and urban planning using the computer game SimCity, are popular with high school students. However, the review found no longitudinal study rigorously evaluating these efforts. Outreach efforts from other fields show that the near-peer activities and leveraging of contextual exposure to transportation in daily lives can make the transportation specific outreach programs more effective. This paper recommends an approach to address a significant need for workforce development by generating student interest in the field. The approach should: i) have tangible connections between a course concept and the professional aspects of transportation engineering in order to enhance the students' cognitive learning; and ii) facilitate activities by near-peers to enhance the learning process.

Key words: Workforce development, contextual exposure, near-peer involvement, K-12 outreach.

INTRODUCTION

Modern society is built around transportation and its close cousin, land use. Transportation systems are pervasive in our lives, and their geographical expanse is unparalleled. They are a vital component of the economy, and a competent workforce to operate and maintain the transportation systems is critical to maintaining our living standards. The National Academy of Engineering identified moving goods and providing transportation services more efficiently as one of the key challenges of the future in a publication titled "The Engineer of 2020" (1). In a recent update on "Critical Issues Facing Transportation", the Transportation Research Board identified the shortage of investment in human and intellectual capital as one of most critical issues facing the profession. This is due to retirement by professionals from the baby-boom generation (2). In addition to the overall shortage, women and minorities are underrepresented in the national transportation engineering workforce (3).

Some of these issues have been known for quite some time. For example, the demographic trends leading to retiring baby boomers and in turn causing workforce shortages have been apparent for a while. With the support of federal and state transportation agencies, educators have attempted to overcome these anticipated shortfalls. Transportation-related workforce development falls into two categories: i) attracting K-12 students to transportation engineering through outreach efforts (4); and ii) attracting current students in engineering (primarily Civil Engineering) to the field of transportation by incorporating active learning and other pedagogical innovations into their first transportation engineering courses (5). The objective of this study is to review K-12 outreach efforts and make recommendations for transportation outreach activities for developing the transportation workforce of the future.

We provide a comprehensive review of the outreach efforts that are aimed at attracting K-12 students to transportation engineering and related professions. The review of successful outreach efforts from various fields identifies two areas of improvement: i) involvement of undergraduate students in K-12 outreach; and ii) the leveraging of students' contextual exposure to transportation in their daily lives. Based on the findings in the literature on near-peer role models and motivation for learning, we believe these two ideas can be leveraged for successful outreach.

EXISTING OUTREACH EFFORTS TO K-12 STUDENTS

General Engineering Outreach

There have been significant efforts over the years towards engineering outreach to K-12 students. Several engineering programs organize these efforts, and transportation engineering faculty regularly participate in programs, similar to the Engineering Possibilities in College (EPIC), a residential outreach program at Cal Poly (6). A summary of such programs run by colleges of engineering at institutions of higher learning and what they encompass may be found in Jeffers et al. (7).These activities are typically organized as summer camps and are a good venue for faculty to exert a broader impact of their research.

Transportation Engineering Outreach Efforts

The most significant of K-12 outreach effort for transportation engineering is funded by the Civil Rights division of the FHWA. It is called the National Summer Transportation Institute (NSTI).

Any institution of higher learning may apply to the local FHWA division office to host outreach efforts. It typically involves two to three weeks of events and programs where K-12 students interact primarily with faculty members along with graduate students and transportation professionals. It is funded by the FHWA, and the importance of this program is apparent in the funding levels that have been on an increasing trend even since the 2007-08 financial crisis, as shown in Figure 1.

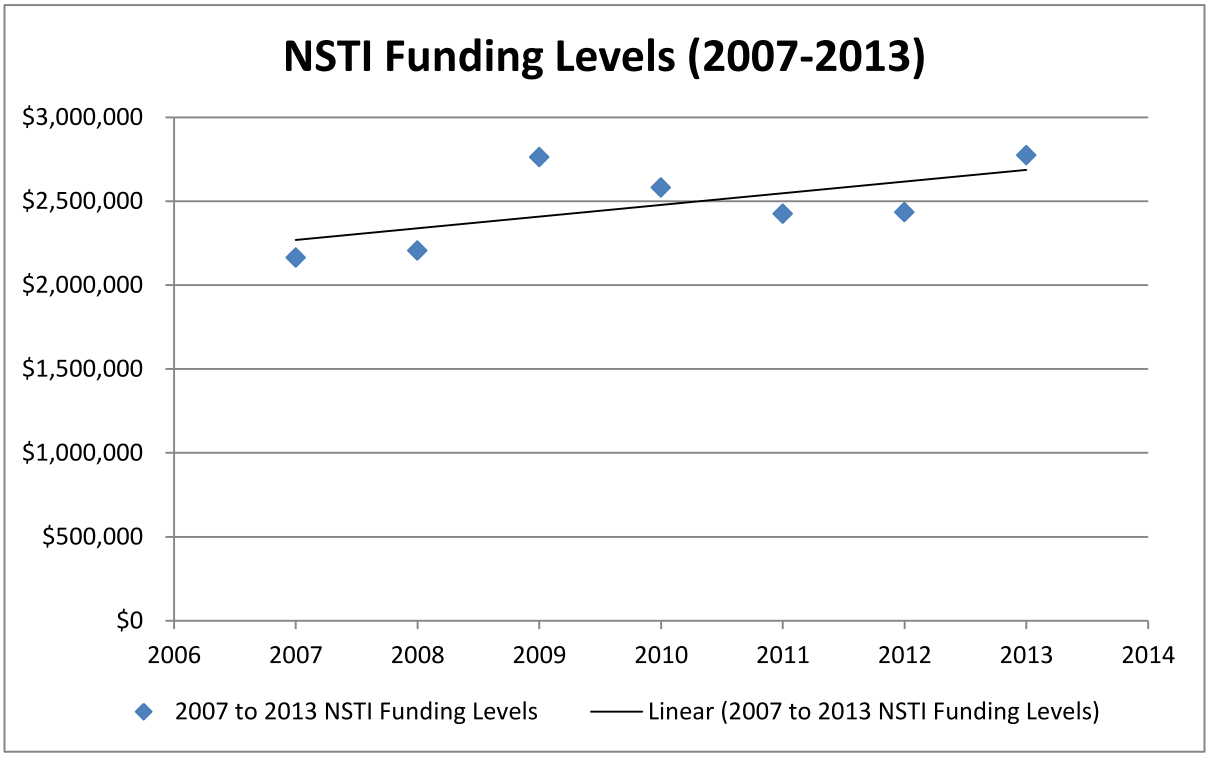

Figure 1: NSTI Funding Levels (4)

NSTI is an annual program hosted by many universities and some community colleges. A list of host institutions for the year 2013 can be found at the FHWA website (8). In 2013, the program covered 44 states and territories including the District of Columbia, and the territories of Guam, Puerto Rico, and American Samoa. The US states with no designated host institution in 2013 were Alaska, Indiana, Nebraska, New Hampshire, North Dakota, South Dakota, Utah, Washington, and Wyoming.

The activities presented to the middle and high school students relate to several topics, including traffic engineering, urban planning, aviation, safety, and human factors. Professionals representing public and private sector transportation organizations are invited as speakers to these summer camps to discuss career opportunities (9–12). These programs are hands-on, and students gain real-life experience working with faculty. Aelong and Aelong (12) described the programs delivered in Delaware and Vermont and evaluated the students' attitudes about the programs both quantitatively and qualitatively. Both of the programs were described as a resounding success based on the participant responses. In some instances, undergraduate students interacted with the camp participants informally and learned about the steps to get into college (11). The NSTI program at Arizona State University was termed a role model of collaboration between federal/state agencies, industry, and academia as early as 1999 (13).

In addition to NSTI, there are some privately funded transportation outreach activities. One such program, Transportation Engineering Careers (TREC) at the University of Memphis, was studied by Ivey et al. (3). The study detailed the experiences of program organizers over the first two years. Six male and six female undergraduate engineering students were selected to serve as mentors to the program participants each year. Program evaluation consisted of a pre- and post-survey instrument administered online on the first and last days of the program. The paper noted that these survey instruments were based on the previously developed Girls Experiencing Engineering (GEE) programs (3).

Evaluations of K-12 Outreach Activities by Transportation Educators

Evaluation of the programs described so far provided significant insights and areas for improvement. Gallagher (11) reported that students at the 2011 NSTI at the University of Montana felt they were better prepared, more knowledgeable, and confident about making college and career choices. Ivey et al. (3) noted that because of the preponderance of boys taking leadership roles in coed groups, a women-only program was started. They were able to discern factors affecting students' choice of major. The survey also elicited motivating factors and barriers. It was found that parents, who are more interested in aspects such as salary and work opportunities are key persons influencing the decisions of their children. The literature has also shown that parental influence is more important for the underrepresented groups in particular (e.g., women in engineering (3)). These evaluations have been helpful and, as discussed later in the paper, provide some indication for the potential of near-peer learning and contextual exposure to be the key elements of the transportation outreach efforts. It should be noted, however, that there are no long-term longitudinal studies demonstrating the benefits of transportation engineering related outreach activities.

IDEAS FOR ENHANCING THE OUTREACH PROGRAMS

Role of Near-Peer Mentors

Knight and Cunningham (14) argued that K-12 students' images and stereotypes about engineers and engineering are critical in their decision to pursue engineering as a field of study. In a classic book about enrollment and retention of women in computer science majors, the stereotype of computer science majors being secluded hackers was termed "geek-mythology" that discourages women from pursuing the field (15). K-12 students who do not have a family member or a close relative with an engineering background are unlikely to be exposed to a role model outside of school who can introduce them to the interesting aspects of engineering (16). The issues documented here are something the "near-peer" mentors can address. We propose that undergraduate students should be key facilitators in outreach events such as residential summer camps, campus visits, and in-school demonstrations. The term "near-peer" could include kinship in a number of ways: age, ethnicity, gender, interests, etc. We are of the opinion that undergraduate students are ideal near-peers for high school students, as they have recently been through the system. However, in the current transportation engineering outreach activities, their role has been somewhat limited in nature.

Aelong and Aelong (12) noted that there is significant leeway for the faculty to experiment with these outreach programs. This should give faculty the flexibility to experiment in delivering the content at these programs via undergraduate students. In the field of sciences, near-peers have been used as science partners to provide college science students with teaching experience and to enhance teachers' skills in inquiry-based science instruction (17). The experience as a science partner also helped undergraduate students gain a better understanding of science as a result of teaching basic elements of the subject to children. It has been shown that by participating in these programs, university students gain teaching skills, greater understanding of education and diversity issues, and confidence (18). Not only can the undergraduate students provide extra resources for the K–12 schools, but they also serve as effective role models and promoters of their respective colleges (7). In addition to these benefits for the undergraduate students, K-12 students also benefit by having undergraduate students as role models. Detailed longitudinal research has shown that the K-12 students' science identities benefited from having role models in the STEM (science, technology, engineering, and mathematics) fields (19).

Hence, there are several demonstrated benefits in the literature from the fields of basic sciences for the undergraduate students as well as for the K-12 students. It should be noted, though, that science and mathematics are integral parts of the K-12 curriculum; outreach and educational activities are natural for these fields. The challenge for transportation engineering educators would be to carefully identify material from undergraduate classes in transportation engineering that uses high school physics and mathematics materials as pre-requisites. This prerequisite knowledge required at the undergraduate level could be used to design the activities that undergraduate students can deliver. Another recent development that should be of interest to transportation educators is to get engineering education elements in K-12 classrooms (e.g., (20–22)). If this integration of engineering in K-12 classrooms continues, there could be many more opportunities for interaction between K-12 students and their near-peers, undergraduate students in transportation engineering and planning fields.

Contextual Exposure

After evaluating the outreach efforts, Ivey et al. (3) suggested that traditional highway design topics are appealing to both genders because as drivers they are invested in the design of the system which impacts their lives on a daily basis. It leads us to a second idea for improving outreach efforts: leveraging contextual exposure to transportation systems that people have in their daily lives. This exposure provides K-12 students with some prior knowledge, which is the medium through which one views and absorbs new information (23). This medium is acquired by K-12 students through not only their academic experience, but also through their everyday experiences. The key to learning involves leveraging and engaging with students' prior experiences (23).

The idea of contextualization is grounded in a conceptual framework that relates the transfer of skill and student motivation (24). The key idea is that if students do not think the skills are relevant to their personal goals, they would not learn the related material (25). On the flip side, if one can identify students' personal goals and relate those to academic skills, it can generate significant motivation to learn the material. Transportation educators can leverage the contextual exposure of K-12 students by associating transportation concepts with the students' prior knowledge. They activate the student's interest and curiosity, and infuse instruction with a sense of purpose. In pedagogical terms, this is referred to as contextualization of instruction. It utilizes the situations or events that occur outside of class or are of particular interest to students to guide the outreach activities designed to achieve learning objectives (26).

Contextualization can also motivate students to learn their school curriculum if the exercises are related with the content they are about to learn in their classrooms. There is evidence that contextualization of mathematical topics is more effective than standard problem sets in learning the concepts (27). One such activity that contextualizes transportation education for K-12 is listed on the teachengineering.org web portal, which is a collection of peer-reviewed materials for K-12 outreach activities (28). The activity is titled “What’s up with all this traffic?” Its list of pre-lesson question includes the following: “Have you ever noticed times when there are a lot of cars on the road and other times when there are not so many?” (28). Davis et al. (29) compared the difference in delivery of highway design concepts by professional engineers and engineering instructors to highlight the need for context-sensitive delivery of transportation education to undergraduate-level students.

CONCLUSIONS

Safe and efficient transportation systems are absolutely essential to our modern lives. They also require a sustainable supply of an educated and competent workforce for smooth functioning in the future. Workforce shortage is anticipated in transportation engineering in the coming years. This paper reviewed general engineering and transportation specific outreach efforts to K-12 students aimed at grooming this future workforce. We found two ideas which have the potential for success in this regard: near-peer outreach efforts and the leveraging of contextual exposure to transportation.

Transportation engineering outreach programs exist, but they lack a unified framework and suffer from the lack of involvement of undergraduate students in the near-peer roles, especially in content facilitation. The implementation of the near-peer outreach program presents a circular challenge: without a significant proportion of underrepresented groups in the program it is difficult to find them for mentoring in a near-peer program. Another challenge is that most undergraduate students interested in transportation do not typically work closely with faculty on research. These outreach activities are organized in the summer, when most undergraduate students go away for internships or are occupied with other activities.

Outreach activities that are facilitated by undergraduate students would be the key to success. Undergraduate students as near-peers to high school juniors and seniors should be a key component of outreach activities. A thorough review of high school mathematics and science curricula is necessary to find elements that fit with the college students’ experience in the undergraduate transportation engineering curriculum and practical training. Based on this review, learning activities (e.g., field and in-class demonstrations) appropriate for high school students should be designed, and undergraduate students should be trained to facilitate those activities.

High school students, just like any other members of a community, have a contextual exposure to elements of transportation engineering (e.g., traffic signals and signs, public transportation, airports) which need to be leveraged in implementation of these activities. There are very limited examples of these activities out there (e.g., teachengineeirng.org), but more needs to be done.

The approach recommended by this paper to increase transportation outreach to K-12 students should: i) have tangible connections between a course concept and the professional aspects of a field in engineering (elements of which they have contextual exposure to) in order to enhance the students' cognitive learning; and ii) facilitate the outreach activities by near-peers to enhance the learning process. The High Schools from neighboring communities with student bodies from diverse socio-economic backgrounds should be involved. This effort can address a significant need for workforce development by generating student interest in the field at an early stage. The framework for executing near-peer facilitated activities and assessing the resulting learning outcomes could be adopted for other STEM fields as well.

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