Title: Review and Business Case Analysis of Transportation-STEM Programs with State DOT Involvement

Authors:
Adjo Amekudzi-Kennedy, Ph.D. (Corresponding Author)
Professor
School of Civil & Environmental Engineering
Georgia Institute of Technology
790 Atlantic Drive, Atlanta, GA 30332
Tel: 404-894-0404
Fax: 404-894-2278
Email: adjo.amekudzi@ce.gatech.edu

Margaret-Avis Akofio-Sowah, Ph.D.
Graduate Research Assistant
Transportation Systems Program
School of Civil & Environmental Engineering
Georgia Institute of Technology
790 Atlantic Drive, Atlanta, GA 30332
Tel: 404-919-6527
Fax: 404-894-2278
Email: manas3@gatech.edu

Stefanie Brodie
Graduate Research Assistant
Transportation Systems Program
School of Civil & Environmental Engineering
Georgia Institute of Technology
790 Atlantic Drive, Atlanta, GA 30332
Tel: 203-910-1966
Fax: 404-894-2278
Email: sbrodie3@gatech.edu

Yanzhi (Ann) Xu, Ph.D.
Research Engineer II
Transportation Systems Program
School of Civil & Environmental Engineering
Georgia Institute of Technology
790 Atlantic Drive, Atlanta, GA 30332
Tel: 404-723-0543
Fax: 404-894-2278
Email: yanzhi.xu@ce.gatech.edu

Submission Date: November 15, 2015
Word Count: 5,888 words + 1 table (250 words) + 3 figures (750 words) = 6,888 words
ABSTRACT
In the decade from 2012 to 2022, 40 to 50 percent of the transportation workforce is expected to retire taking valuable knowledge with them. State Departments of Transportation (DOT) are expected to play a significant role in efforts to replenish the workforce pipeline by raising awareness about transportation careers, providing internship and apprenticeship opportunities, supporting workforce development programs and research, implementing mentoring programs for new workers and emerging leaders, and supporting partnerships with education and workforce organizations. This paper reviews state DOT involvement in transportation-related science, technology, engineering and mathematics (STEM) outreach programs and identifies opportunities to engage kindergarten through high school (K-12) students in STEM programs and enhance their interest in the transportation field. Information on DOT involvement in STEM programs was gathered from the literature, DOT and other websites; a targeted online survey administered to DOTs and University Transportation Centers that have hosted STEM outreach programs; and semi-structured phone interviews conducted with selected survey respondents to gather additional information on their programs. Results showed that over 40% of state DOTs are involved in K-12 STEM outreach programs: most commonly residential or non-residential summer programs; teacher training and curriculum development programs; internship and shadowing opportunities; one-day awareness events; and periodic employee visits to schools to present on transportation STEM. A business case analysis, together with STEM theory and existing empirical evidence, showed that agencies will benefit from including both longer-term and shorter-term alternatives in their STEM programming to cultivate STEM efficacy and build long-term relationships with a smaller percentage of students while increasing STEM awareness broadly among K-12 students. Such strategic programming will contribute to the development of a pool of students for future recruitment to replenish the transportation workforce.

Key words: Transportation, Education, STEM, K-12
INTRODUCTION

In 2012, it was reported that 40 to 50 percent of the transportation workforce, mostly in the baby boomer generation, is expected to retire by 2022 (1, 2). At the National Transportation Workforce Summit in 2012, State Departments of Transportation (DOTs) were called to play a more significant role in replenishing the transportation workforce pipeline by creating and participating in opportunities to raise awareness about transportation careers. Research has shown that many students, specifically civil engineering students, who do not choose transportation as a specialization are ignorant of the field, rather than actively opposed to it (3). Many arguments have been made for exposing children to fields like transportation that are in the science, technology, engineering, and mathematics (STEM) pathway at younger ages (4–6). Researchers have shown that during the early years, there is higher potential to build a child’s confidence and self-efficacy in relation to their ability to succeed in STEM fields, and that an early interest in pursuing science and engineering is a better indicator of whether a student will pursue a career in these fields than a student’s grades in school (7).

Furthermore, there is evidence that STEM out-of-school time (OST) programs that engage students for longer periods of time (e.g., summer programs) hold greater potential for affecting intermediate and long-term outcomes than do short-duration programs. STEM OST programs are designed to supplement school work, ignite student interest, and extend STEM learning. Program outcomes include STEM awareness and interest, positive attitudes toward STEM fields and careers, program-specific knowledge and skills, continued participation in STEM programs, STEM self-efficacy, STEM course taking, STEM degree pursuit and STEM learning and achievement (8, 7). Evaluation of STEM programs in the afterschool (i.e., before school, after school and summer learning opportunities) show that participants are more likely to pursue higher education and study STEM fields. For example, 69% of students reported an increased interest in STEM careers as a result of their participation in FIRST (For Inspiration and Recognition of Science and Technology), a STEM OST that provides several leagues in which K-12 student teams compete in robotics. Moreover, 89% reported an increased interest in science and technology generally, 89% reported increased self-confidence, and 70% reported an increased motivation to do well in school as a result of their participation in FIRST. The benefits of afterschool programs are generally well documented, showing positive impacts on both academic and behavioral development (7).

Beyond empirical evidence, the literature shows a theoretical basis for investing in STEM enrichment experiences. Funded by the National Science Foundation, the ITEST Learning Resource Center at the Education Development Center in Waltham, MA, commissioned a literature review in order to better understand the pathway for students from early exposure to STEM experiences to pursuing a STEM career. The study focused on OST activities in informal environments. The study reiterates that young people cannot choose a specific STEM career or field of study if they do not know of its existence: lack of knowledge of STEM careers may be one reason why students choose non-STEM careers. Furthermore, the study references Super’s Career Development Theory (1957) that divides career development into stages roughly corresponding to age: young people pass from the growth state to the exploratory state during their teenage years, and eventually into the establishment stage. As young people begin to make choices about their futures, one way to make sense of their decisions is using the Possible Selves Theory. “Possible Selves” are positive or negative visions of what one might become and people tend to make decisions in order to work toward what they would like to be, and avoid what they fear. Thus, if
girls and boys cannot envision themselves as scientists or engineers, they will not make the choices necessary to pursue STEM fields, such as enrolling in advanced mathematics for example. The study also references Social Cognitive Career Theory (SCCT). SCCT suggests that three personal factors -- self-efficacy, outcome expectations, and interests -- operate together and interact with external barriers and supports to inform a person’s career goals and actions (9). Thus, a lack of knowledge of STEM fields and STEM role models, and a lack of STEM self-efficacy are key factors preventing students from pursuing STEM fields and choosing STEM careers.

State DOTs can therefore contribute to the development of the transportation workforce pipeline by participating in and supporting kindergarten through high school (K-12) STEM outreach programs and infusing transportation applications into activities, partnering with education and workforce development organizations that run those types of programs, or even providing internship and apprenticeship opportunities where possible. This paper discusses state DOT participation in transportation-related STEM outreach programming and identifies opportunities to engage K-12 students in STEM programs to enhance their interest in the field of transportation.

STEM education has received increasing attention over the past decade and remains a national priority in the U.S (11). In response to a request from the nation’s Congress in the mid-2000s, the National Academies identified actions that federal policy-makers could take to enhance the science and technology enterprise in the U.S. to enable the nation to successfully compete, prosper and be secure in the global community of the 21st Century. In the report: Rising Above the Gathering Storm, STEM education was not only viewed with urgency as essential to preserve the nation’s science and technology leadership, but also as a strategic and economic security initiative to optimize the nation’s knowledge-based resources by sustaining the most fertile environment for new and revitalized industries and their associated well-paying jobs (10).

STATE DOT INVOLVEMENT IN STEM PROGRAMS

To investigate how state DOTs have participated in STEM outreach programs, published literature on the topic was reviewed. Findings revealed that only limited information on transportation-STEM programs is published. This led to a review of agency websites. In order to improve the accuracy of information collected, an online survey was distributed to gather additional information from those DOTs identified. Based on a finding from the preliminary research that most DOTs partner with universities, colleges and University Transportation Centers (UTCs) to conduct their STEM programs, a second online survey was also distributed to UTCs to gather more information on these outreach programs. For those programs considered potentially good case studies, additional information was gathered through phone conversations. While DOT employees may be involved on an individual basis in STEM programs through professional organizations and other groups, this study focused on identifying programs that were officially affiliated with the state DOT. Events such as employee participation in career fairs were excluded unless the agency played a significant planning role.

From the preliminary searches, 57 programs were identified with participation from 26 DOTs. From the survey, there were 43 programs with participation from 22 DOTs and there was some duplicate information relative to the preliminary search. Altogether, there were 87 programs with participation from 33 state transportation agencies or divisions of the agencies. While only 14 of the 87 programs (18%) targeted elementary school students (grades K-5), 33 (42%)
targeted middle school students (grades 6-8) and 59 (75%) targeted high school students (grades 9-12). There were some programs that invite a mix of these students to participate.

Figure 1 shows the duration of programs that DOTs participate in. Program duration varies from a few hours to more than six months, with a significant proportion of the programs (37%) running from two to four weeks. These programs usually occur over the summer months. Programs lasting up to one day include workshops such as Utah DOT’s Girls in Transportation Workshop, while programs with an estimated duration of 6 months are mostly competitions such as West Virginia DOT’s West Point Bridge Design Competition that engage student teams throughout most of the school year. Programs lasting more than six months also include the development of transportation-related modules that are incorporated into the school curriculum, such as the AASHTO TRAC & RIDES program. Out-of-school time (OST) time programs are usually distinguished from in-school or curricular STEM programs.

For programs identified from the preliminary search, it was found that most involved more than one partner organization with the highest representation from research institutions (UTCs) and universities and colleges as shown in Figure 2. While not collected in the online surveys, information was gathered on financial support (Figure 3), revealing that over 50% (23) of the programs receive some financial support from the DOT involved, with 9% (4) receiving in kind support. Furthermore, 9% (4) of the programs also receive financial support directly from the Federal government through the USDOT.
In general, these findings provide a broad view of DOT involvement in K-12 STEM outreach programs, however, they are not necessarily comprehensive - they are simply an indication of the agencies that are responsive and forthcoming with information about their programming. Nonetheless, this information shows that many DOTs around the country are involved in a number of different STEM outreach programs, although comprehensive information on the programs is not readily available. The information generated through this research can form the basis of a catalogue of STEM programs at State DOTs to illustrate how these agencies are helping to fuel the workforce pipeline.

STEM OUTREACH PROGRAM ALTERNATIVES AND BUSINESS CASE ANALYSIS

Out of the 87 programs identified, there are five common types of programs that state transportation agencies are involved in: (i) residential or non-residential summer programs, e.g., the National Summer Transportation Institute; (ii) teacher-training and curriculum development programs, e.g., AASHTO’s TRAC and RIDES program; (iii) internship and shadowing programs,
e.g., internships; (iv) one-day high publicity STEM awareness workshops; and (v) year-long employee visits to schools. Each type of program involves different levels of agency investment and employee engagement and results in different levels of reach for the agency or STEM exposure and development for the student. A business case analysis of the five program alternatives was conducted to characterize their relative investment requirements (in agency funds and staff hours) and impacts based on their potential to expose students to the field of transportation, engage and develop them in the field, and build long term relationships between practitioners and students that are likely to foster longer-term interest in the field. Below the programs are described and their costs and benefits evaluated.

Residential/Non-Residential Summer Programs: National Summer Transportation Institute

Description: The first type of transportation STEM outreach program lasts for a number of weeks over the summer months, usually two to four weeks. The most common among state DOTs is the National Summer Transportation Institute (NSTI), the first transportation career education program for secondary school youth to be authorized by the United States Congress. This federal program was authorized under Section 1208 of the 1998 Transportation Equity Act for the 21st Century (TEA-21). With oversight from the U.S. Department of Transportation (USDOT), the Federal Highway Administration (FHWA) through its Division Offices implements the program by approving proposals and funding requests from accredited colleges and universities working with state DOTs. The objectives of the program are to increase understanding of transportation engineering and promote awareness of transportation-related STEM educational and career opportunities among disadvantaged and at-risk middle and high school students, while working to improve students’ STEM abilities.

State agencies support host sites to implement Summer Transportation Institutes (STIs) as a free, two to four-week, residential or non-residential program and FHWA Division offices oversee the program. Host sites are typically educational institutions (universities and research centers). Funding grants are provided from the FHWA through the state DOT; however, NSTI programs can also be supported by other sponsors. In 2013, 68 grants were awarded for NSTI programs totaling $2.77 million in 42 states, Puerto Rico, and American Samoa. While most states had just one program, 11 had two host sites, five had three host sites, and the state of New York had four host sites. Grants provided by the FHWA to individual host sites ranged from $12,200 (American Samoa Department of Public Works) to $63,689 (Idaho State University).

Associated Program Costs: With FHWA financial support, state transportation agencies do not have to contribute financially to NSTI programs, although some report that they make contributions. Most provide in-kind support by hosting tours and sending employees as speakers, instructors or competition judges. Employee participation will be on a volunteer basis primarily within a required program advisory committee, as challenge facilitators, competition judges, field trip hosts, and as panelists for any applicable sessions. With this program, employees can be as engaged or as disengaged as they want, although more engagement is more desirable from a program outcomes point of view.

Expected Program Outcomes: This study found evidence that participation in NSTIs across the country improved students’ understanding of transportation, familiarity with transportation and
other STEM fields, and general feelings of preparedness for college. Such programs can have significant impacts on students and provide a platform for the formation and development of relationships between student participants, program staff and agency personnel. Although the main benefit to the agency is student exposure to and awareness of transportation that can fuel the workforce pipeline in the long run, additional benefits can be found in publicity opportunities and increased employee satisfaction for those employees who value such opportunities to give back to their communities. In addition, this type of program has a high potential to develop STEM self-efficacy in the student. Research on summer school programs shows that programs lasting 60-120 hours are more effective at achieving academic outcomes than programs lasting less than 60 hours (X3). These programs typically have the involvement of university transportation centers and may also have contributions from professional organizations and private consultants.

**Teacher Training & Curriculum Development: AASHTO TRAC & RIDES**

A second common type of program that DOTs are involved in is teacher training sessions aimed to equip K-12 teachers with tools to incorporate transportation and STEM applications and examples in their classrooms throughout the school year. The American Association of State Highway and Transportation Officials (AASHTO) has two educational programs of this type: TRAC™ (Transportation and Civil Engineering) and RIDES (Roadways Into Developing Elementary Students). TRAC and RIDES are hands-on education programs developed by AASHTO for use in classrooms. The goal is not only to encourage critical thinking and develop problem-solving skills, but also to introduce students to the fields of transportation and civil engineering and related careers.

AASHTO provides TRAC and RIDES toolkits for purchase by state agencies who then partner with schools and teachers to implement the modules in their classrooms. Schools participate for free in training workshops hosted by the state agencies. Instructors for the training sessions are also provided by AASHTO. The costs for TRAC modules in the toolkit vary between $299 and $1495 and include curricula and materials for hands-on activities on bridge building, construction, maglevs, safety, and city planning, among others. TRAC modules are targeted at middle and high school students. The RIDES module is targeted at K-8 grade students and there is one RIDES module available for purchase at $1500.

**Associated Program Costs:** For this program, state transportation agencies are expected to purchase curriculum toolkits from AASHTO. DOTs can either join as a member state or purchase modules a la carte. To become a member state, the fee is $7,000. This fee covers the entire state. It includes training for teachers by AASHTO, as well as participation of students in the National Bridge Competition for students in grades 7 to twelve. If a state purchases a module without joining as a member, teacher training will not be provided by AASHTO.

In addition to the cost of purchasing the modules, agencies will also need to appoint an individual to oversee implementation. This person will coordinate with AASHTO to purchase the toolkits and arrange the teacher training; work with the schools to identify teachers, facilitate teacher training, and coordinate any state DOT volunteer activities; and communicate volunteer opportunities to DOT employees. Additionally, this person could seek a corporate sponsor to underwrite the cost of TRAC and RIDES materials.

Financial resources are available through On-the-Job-Training (OJT) funds from FHWA, which are commonly used to purchase the modules. Additionally, AASHTO has established an
Adopt-A-State program, in which private companies provide sponsorship to a state DOT to join as a member, defraying the cost to the state DOT.

Expected Program Outcomes: The main benefit of a TRAC and RIDES program to transportation agencies is pipeline development. By implementing transportation-related activities in schools, agencies would expose students to the field of Transportation while giving them an opportunity to develop skills that would be useful in a transportation career. Moreover, this type of activity allows the students to engage at a deeper level with transportation applications. In addition to training the students who participate in the activities, this kind of program also trains teachers who have influence over future students. The TRAC and RIDES program offers a more indirect approach for pipeline development, but is an alternative with other benefits that are of value to the development of the students and to the profession at large.

Internship & Shadowing Opportunities
Several transportation agencies provide internships to students, giving them exposure to transportation careers, as well as basic job training during working hours. Internships may be paid or unpaid, part-time or full time, and may run only during the summer months or throughout the whole year. An alternative to a full-fledged internship program is a shadow program. These programs pair students with DOT staff for one week, during which the student follows individual employees throughout their work day exploring the DOT’s work and the employee’s role in the organization. Shadow students may be assigned to a particular division or a particular district to spend a week rotating through various functions. It is the responsibility of each division or district to expose the students to the agency and the transportation industry.

In either of these programs, each student will have a mentor who will serve as the primary point of contact. Throughout the week, however, the student will spend time with various other employees in the division. Activities during the internship or shadow program may include small-scale research projects, informational interviews with employees, assisting employees with work, and preparation for various meetings. Either model could be scaled up to increase the number of students or increase the program duration. Students who have taken basic or advanced STEM courses may be recruited from STEM schools.

Associated Program Costs: The most critical resource for the internship/shadow program is agency staff to act as mentors for participating students. The program requires one full time employee per division or district for each week of the program. Students are assigned to one staff member; however, during the week, students may shadow other employees for short periods of time. Additional staff is also needed to coordinate the student application and selection process and staff recruitment for the program. Also, staff will be required to create and deliver the division presentations. Organizing the supporting events will require additional resources, such as employee time to coordinate logistics for special events.

An internship program will not require one full time employee per student for the duration of the program. Employees mentoring the intern will devote some time to teaching and training the students; however, the students will also contribute to ongoing work within the divisions. As such, one resource specific to the internship program and not the shadow program, is intern salary. Some states with existing high school internship programs pay students $10-$14 per hour. For a month of full-time work, total salary accrues to $1,600 to $2,240 per intern.
Expected Program Outcomes: One of the main benefits to these programs is the relationships that can be established between agency employees and the students. This occurs while the students are also offered first-hand transportation experience. The program may also produce students who continue into the collegiate internship program and, eventually, into full-time employment after graduation. This continuing relationship has the potential to produce prospective employees already familiar with the agency at the entry level. Additionally, for the internship program in particular, the divisions or districts would provide tasks that offer students opportunities to contribute to the work of the Department, creating a mutually beneficial relationship, and advancing the STEM development of the student.

One-Day STEM Awareness Events

Many transportation agencies around the country also participate in outreach programs that are up to one full day, exposing students to transportation careers through guest speakers, hands-on activities and one-on-one interactions. Examples of these activities are Introduce a Girl to Engineering day, or DOT Career Day.

Introduce a Girl to Engineering Day is an event held all around the country by different engineering-related organizations including the Society of Women Engineers (SWE). This program is also included as part of the National Society of Professional Engineers’ (NSPE) annual Engineers Week which occurs in February. Agencies can adapt the model for this event to place an emphasis on introducing a child to the transportation field. A number of agencies also participate in Construction Career Days, as part of a national initiative developed by the FHWA. This program was born out of the need for more skilled highway construction workers. It was first held in Texas in 1999. The National Construction Career Days Center is located at the University of Rhode Island Transportation Center. While this event is technically named for the construction industry, agencies can adopt a version that emphasizes various areas of specialization in the transportation industry: a DOT Career Day.

Associated Program Costs: Depending on the specific one-day event being implemented, there may be different resource requirements. A critical resource besides financial resources is labor. A dedicated coordinator is needed to recruit volunteers, publicize the event and handle logistics. A coordinator may put together a committee of other employees to assist with successfully implementing the programs. In addition, as few as five and as many as 20 volunteers may be necessary. Space is another necessary resource. Interactive activities planned and any catered food should also be considered in the budget.

Expected Program Outcomes: The one-day event has the potential to be a highly publicized event that provides positive visibility for the agency while increasing awareness of transportation-related careers. These single events will give interested employees opportunities to engage in K-12 outreach. The advantage of these one-day workshops is that a large number of students can be targeted for participation and potentially exposed to transportation fields in a short period of time. However, the measured impact will probably not be as significant as with more sustained programming like the STI or TRAC & RIDES which involve more substantive STEM development of students.
Employee School Visits
This program alternative involves sending agency employees out to schools within their communities to give presentations on their jobs and particularly on STEM applications in their jobs, and, possibly to engage students in transportation-related demonstrations and/or hands-on activities. Here, a central coordinator or a governing/advisory board can promote and coordinate presentations, assigning visits as necessary. The talks, given by employees at any level throughout the agency, will provide interactive, hands-on, problem-based learning activities to engage the students and generate excitement about and interest in careers within the transportation industry. Students will have the chance to learn first-hand about the opportunities and challenges faced by industry professionals within the various divisions, and the broader societal benefits created by the transportation profession. Speakers may be trained and provided with an overview of speaker resources and expected content. During this training, each speaker may be provided with a manual that explains responsibilities, program guidelines, and a database of approved topics and interactive activities. A critical factor for the success of this program alternative is for the employees to perceive and have easy access to the necessary resources for successful school visits.

Associated Program Costs: This program alternative will also require a headquarters program coordinator to manage partnerships with schools, and manage the program schedule. The coordinator will be responsible for connecting transportation professionals to classrooms in order to educate students about transportation careers and STEM-related topics. This program lead can work with district or regional coordinators to facilitate requests within each of the districts (or regions); together they will make up the leadership team responsible for fielding speaker requests and recruiting volunteers to join the program on a continuing basis. Supporting resources such as public speaker training, presentation content and templates, and advice/training on how to teach K-12 students would be necessary to support the implementation of the School Visits program.

Expected Program Outcomes: Based on similar programs run or supported by other transportation departments, offering a program of this type increases a student’s awareness and understanding of existing and potential opportunities in the field of Transportation Engineering. This increased awareness and understanding could in turn result in increased interest to potentially feed the pipeline. However, the STEM development of the students may be less significant than longer-term and more focused programs like the STI.

Benefit/Cost Assessment of the STEM Alternatives
Table 1 below details some estimated benefits and costs to compare and contrast the program alternatives discussed above. This information can be used in supporting the development of transportation STEM outreach programs in transportation agencies. These numbers were generated based on estimates of the number of students each program could potentially reach. Numbers can be scaled up or down as needed. As shown, programs have varied cost requirements for different types and levels of effectiveness in ultimately replenishing the transportation pipeline, and other associated benefits. In particular, the relative effectiveness of the various program alternatives is a function of the program’s reach, level of engagement of the student in Transportation concepts and applications, and quality of relationship-building opportunities between transportation practitioners and students. The cost-effectiveness analysis showed that programs with strong STEM self-efficacy and strong relationship-building capabilities (e.g.,
summer transportation institute, internship and shadow programs) tend to require a higher level of investment of agency resources (employee time, funds, etc.) but also have higher potential to replenish the transportation pipeline in the long term. On the other hand, one-day STEM awareness programs (e.g., Introduce a Child to Transportation Day) tend to require less investment but also have lower potential for building STEM self-efficacy and longer-term relationships between DOT employees and students. Nonetheless, such programs create STEM awareness in a larger number of students, and support enhancement of STEM culture in the agency as employees find opportunities to give back to their communities. The programs that can develop STEM self-efficacy and help build stronger relationships between employees and students in the long term have a higher potential to offer a recruitment pool in the future. The determination of which program alternative or alternatives to invest in will ultimately depend on the specific agency, its priorities and constraints. However, agency programs can be designed from one or more of the existing T-STEM alternatives to create an awareness of the Transportation profession in a broad range of K-12 students, while focusing on a subset of students to develop higher levels of transportation-STEM self-efficacy, and stronger, longer-lasting relationships with state DOT officials and other transportation professionals. Such programs are likely to cultivate a pool of students who can be recruited to replenish the transportation workforce.

SUMMARY AND CONCLUSION
Transportation workforce development has been recognized as a national issue. State transportation agencies have a significant role to play in replenishing the workforce pipeline by raising awareness about transportation careers and developing transportation STEM self-efficacy in K-12 students, as a large percentage of the baby-boomer generation retires from the workforce. The literature presents a theoretical basis for engaging K-12 students in both in-school and out-of-school time STEM to expose them to STEM and enable STEM careers to be part of their realistic set of choices when it comes to making career decisions and choosing courses to support those career decisions. Furthermore, the literature shows empirical evidence that K-12 students who engage in STEM are more likely to pursue higher education and study STEM fields, in addition to having increased self-confidence and increased motivation to do well in school. The benefits of afterschool programs are generally well documented, showing positive impacts on both academic and behavioral development. In addition, STEM out-of-school time programs that engage students for longer periods of time (e.g., summer programs) hold greater potential for affecting intermediate and long-term outcomes than do short-duration programs.

The results of the study presented in this paper show that over 40% of state DOTs are involved STEM programming outreach to K-12 schools, several in partnership with university transportation centers and other STEM stakeholders such as professional organizations (e.g., ITE, WTS, ITS and ASCE); private consultants, and the Federal Highway Administration (FHWA). The majority of state DOT STEM programs target high school students and last between two to four weeks. A majority of the programs have some financial support from state DOTs; and a number have financial support from the FHWA and in-kind support from state DOTs.

The STEM programs identified can be classified into five categories: (1) Residential or non-residential summer programs (e.g., the Summer Transportation Institute); (2) Teacher training and curriculum development programs (e.g., AASHTO’s TRAC and RIDES programs); (3) Internship and Shadow Programs; (4) One-Day STEM awareness events (e.g., Introduce a Child to Transportation Day); and (5) Employee School Visits (involving periodic employee visits to
schools to present on transportation and STEM). The business case analysis showed that STEM program alternatives that develop strong long-term relationships with students have a higher potential for payoff in terms of future recruitment to replenish the transportation pipeline.

To this end, the Summer Transportation Institute and Internship/Shadow Programs are recommended as stronger STEM development, relationship building and career awareness programs to cultivate a pool of students from which future transportation professionals can ultimately be recruited. On the other hand, one-day STEM awareness and employee school visit programs are good for cultivating STEM culture within agency employees while developing transportation career awareness broadly, rather than in-depth, among a larger number of students. Teacher and curriculum training programs such as AASHTO’s TRAC and RIDES programs are more useful for the agency to develop relationships with teachers rather than directly with students of local elementary, middle and high schools. Agency programs may include one or more of these alternatives to increase STEM awareness broadly among K-12 students, and focus on cultivating higher levels of STEM self-efficacy in a subset of students that can form a recruitment pool for the agency, while simultaneously cultivating STEM culture within the state DOT by offering employees opportunities to give back to their communities.
<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>NSTI Program</th>
<th>TRAC &amp; RIDES</th>
<th>Internship &amp; Shadow Program</th>
<th>One-Day Event</th>
<th>School Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internship</td>
<td>Shadow</td>
<td>DOT Career Day</td>
</tr>
<tr>
<td>Reach per Year (Students)</td>
<td>20-25</td>
<td>70-140</td>
<td>7-10</td>
<td>7-10</td>
<td>150-200</td>
</tr>
<tr>
<td>Cost per Student ($)</td>
<td>$1,600</td>
<td>$107-$690</td>
<td>$3,200-4,500</td>
<td>$20</td>
<td>$3</td>
</tr>
<tr>
<td>Cost to Agency ($)</td>
<td>$10,000</td>
<td>$2,700-$11,000</td>
<td>$32,000 – $45,000 for 2 months full-time salary at $10/hr - $14/hr for 10 students</td>
<td>$400</td>
<td>$350</td>
</tr>
<tr>
<td>Employee Commitment</td>
<td>First year: 50 employee-hours over 1 month, minimum of 2 employees required</td>
<td>First year: 40 employee-hours over 8 weeks, minimum 1 employee required</td>
<td>560 employee hours over 2 months; minimum of 7 employees plus 10 hours for planning</td>
<td>280 employee hours over 2 months; minimum of 7 employees plus 10 hours of planning</td>
<td>45 employee hours over one day; min of 15 employees plus 12 hrs for planning</td>
</tr>
<tr>
<td></td>
<td>Subsequent years: 20-employee-hours over 3 weeks, minimum of 2 employees required</td>
<td>Subsequent years: 10 employee-hours over 4 weeks, minimum 1 employee required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Measure</td>
<td>NSTI Program</td>
<td>TRAC &amp; RIDES</td>
<td>Internship &amp; Shadow Program</td>
<td>One-Day Event</td>
<td>School Visits</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-----------------------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internship</td>
<td>Shadow</td>
<td>DOT Career Day</td>
</tr>
<tr>
<td><strong>Relationship</strong></td>
<td>High</td>
<td>Low potential for agency personnel to build long-term relationships with students.</td>
<td>High potential for agency personnel to build individual long-term relationships with students.</td>
<td>High potential for agency personnel to build long-term relationships with students.</td>
<td>Mid-range - High potential for agency personnel to build long-term relationships with school officials and teachers.</td>
</tr>
<tr>
<td><strong>Building</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Potential</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High potential for agency personnel to build long-term relationships with teachers.</td>
<td>High potential for agency personnel to build long-term relationships with students.</td>
<td>High potential for agency personnel to build long-term relationships with students.</td>
<td>Mid-range - High potential for agency personnel to build long-term relationships with school officials and teachers.</td>
</tr>
<tr>
<td><strong>Awareness of</strong></td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td>(Transportation presented with other disciplinary material in class)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Engineering</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>discipline and</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>career</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15
<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>NSTI Program</th>
<th>TRAC &amp; RIDES</th>
<th>Internship &amp; Shadow Program</th>
<th>One-Day Event</th>
<th>School Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internship</td>
<td>Shadow</td>
<td>DOT Career Day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

The work reported in this study was funded by Georgia Department of Transportation under research project RP 14-08: STEM and Our Future Transportation Leaders. Tara Rabinek, Graduate Research Assistant at the School of Civil & Environmental Engineering at Georgia Institute of Technology contributed to the literature review of STEM programs. Audrey Leous, formerly Research Scientist I (National Transportation Center for System Productivity and Management) and Valerie Curtis, Undergraduate Research Assistant at the School of Civil & Environmental Engineering, Georgia Institute of Technology, contributed to the development of the case studies on the STEM program alternatives. The authors remain exclusively responsible for the information presented in this paper.

REFERENCES


