The partnership of University, Industry and K-12 Schools to improve awareness of STEM fields

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Abstract

While there has been much debate about the existence of a shortage of future workers in science, technology, engineering and math (STEM), in certain sectors, America will need more engineers with advanced skill sets to address 21st century needs of engineering industries, such as construction, environmental, automobile, energy and information technology. Despite sufficient undergraduate and graduate programs available in STEM, the focus recently has been on how to attract students to the field. STEM attrition resulting from the lack of knowledge about the field, especially after graduation, occurs both in the K-12 pipeline and in the undergraduate terms. Universities, Industries and K-12 Schools in improving understanding of STEM opportunities among youth is emphasized in this work. A few case studies on partnerships among Universities, Governments, Industries and K-12 Schools have been analyzed and a roadmap to address this partnership is attempted in this paper.

Keywords

STEM, Partnership, Universities, K-12 Schools, Industries.

Introduction

Education for students in STEM has received increasing attention over the past decade which calls both for greater emphasis on these fields and for improvements in the quality of curricula and instruction. In response, numerous new instructional materials, programs, and specialized schools are emerging. While most of these initiatives address one or more of the STEM subjects separately, there are increasing calls for emphasizing connections between and among the subjects.

Advocates of more integrated approaches to K–12 STEM education argue that teaching STEM in a more connected manner, especially in the context of real-world issues, can make the STEM subjects more relevant to students and teachers. This in turn can enhance motivation for learning and improve student interest, achievement, and persistence. And these outcomes, advocates assert, will help address calls for greater workplace and college readiness as well as increase the number of students who consider a career in a STEM-related field.

An increasing number of jobs require knowledge of STEM and in addition, individual and societal decisions increasingly require some understanding of STEM, from comprehending medical diagnoses to evaluating competing claims about the environment to managing daily activities with a wide variety of computer-based applications.

Several reports have linked K-12 STEM education to continued scientific leadership and economic growth in the United States. At the same time, there are many reasons to be concerned about the state of STEM learning in the United States in the face of research that suggests that many students are not prepared for the demands of today's economy and the economy of the future. For example, as measured by the National Assessment of Educational Progress, roughly 75 percent of U.S. 8th graders are not proficient in mathematics when they complete 8th grade. Moreover, there are significant gaps in achievement between student population groups: the black/white, Hispanic/white, and high-poverty/low-poverty gaps are often close to 1 standard deviation in size. A gap of this size means that the average student in the underserved groups of black, Hispanic, or low-income students performs roughly at the 20th percentile rather than the 50th percentile.

U.S. students also lag behind the highest performing nations on international assessments: for example, only 10 percent of U.S. 8th graders met the Trends in International Mathematics and Science Study advanced international benchmark in science, compared with 32 percent in Singapore and 25 percent in China. Employers in many industries lament that job applicants lack the needed mathematics, computer, and problem-solving skills to succeed, and international students fill an increasing portion of elite STEM positions in the United States. Indeed, in 2007, "international students constituted more than a third of the students in U.S. science and engineering graduate schools," and more than 70 percent of those students currently remain in the United States after earning their degrees. However, an increasing number of foreign students are finding viable career options in their home countries. This is particularly true for China and India, which, in December 2009, provided 47 percent of the approximately 248,000 foreign science and engineering students in the United States, thereby limiting the talent pool available to U.S. employers (National Research Council, 2011).

Case Study 1

Partnerships between STEM practitioners and educators also have "an amazing power" to support teachers. For example, as part of the 25-year-old Science and Health Education Partnership at the University of California, San Francisco, scientists contribute more than 10,000 hours per year, are active in 90 percent of the San Francisco Unified School District schools, and benefit 21,000 students. Outstanding teachers have much to teach other educators about the best ways to teach (Steve, 2014).

Case Study 2

As leaders in higher education, industry, and government regret the limited academic success of students in STEM, many practices of academe impede the ability of college and university faculty to address these issues. Also, the bureaucracies that hinder collaboration between STEM faculty, K–12 teachers and administrators contribute to the attrition of students' success in STEM.

The U.S. National Science Foundation's Math and Science Partnership (NSF-MSP) program is taking steps to address such obstacles. Since 2002, the NSF-MSP has funded nearly 100 partnerships between institutions of higher education and K–12 school systems to build upon and

generate knowledge of the impact of partnerships as a basis for STEM education reform, and about how to improve K–12 STEM outcomes.

The El Paso Math and Science Partnership influenced the University of Texas at El Paso to adopt a new tenure and promotion policy, rewarding faculty engagement in K–12 educations. A PRISM (ASEE Magazine) core strategy, built on long-standing K–16 reform work, contributed to a University System of Georgia Board of Regents statement advocating for work in schools. Further recommendations included revising the Academic Affairs Handbook and Board of Regents Policy Manual to ensure recognition for improving teaching and learning at the post-secondary level.

Structural reform efforts by faculty engaged in K–12 education research are consistent with broader efforts led by several professional organizations. For example, the Association of Public and Land Grant Universities (APLU) is undertaking an NSF-supported initiative that includes 123 universities committed to increasing the amount and diversity of mathematics and science teachers and to building partnerships to assess and meet state needs. At the institutional level, APLU convenes university leaders to address practices that might enable STEM faculties' engagement in teacher preparation, support, and development. At the faculty level, APLU is working with the American Physical Society and the American Chemical Society, associations with commitments to involving members in increasing the number of teachers in their disciplines (C Kutal, 2009).

Case Study 3

Partnerships have also enlarged and strengthened the teacher corps. As part of the Boston Science Partnership, between 2005 and 2010, 478 teachers from Boston area school districts have taken an average of 2.38 graduate science courses specially designed and offered with the development needs of the teachers and the schools in mind. Many have used these courses toward additional science teaching licensing. In 2005, Boston served a total of 57,000 students, but only 14 teachers in the district were licensed to teach high school physics. The partnership contributed to 272 teachers' adding new science licenses to their credentials as of 2009, with 170 of them in Boston and 28 of those in physics (K.M.Foster, 2010).

Case Study 4

In a panel discussion of partnerships between schools and external organizations to enhance their capacity to offer quality STEM education and learning experiences, Martin Gartzman, Vanessa Lujan, and Linda Rosen discussed aspects of the education system that can be positively influenced by different sorts of partnerships.

Vanessa Lujan emphasized that partnerships can influence district and state policy (from the top down) and teacher and district capacity (from the bottom up). Foundation-supported and community-based partnerships (including informal science institutions such as museums), she suggested, that are focused on afterschool programs, curriculum implementation, and professional development can be designed in part to build networks of leaders, superintendents, science coordinators, curriculum leaders, and lead science teachers and out-of-school-educators

who can bring new skills to their work. However, districts and schools may encounter policy barriers. For example, schools that have been placed in program improvement status because of inadequate test scores may opt out of such opportunities, she explained. Schools move in and out of this status, which makes it difficult for informal science institutions to build and sustain partnerships within a district. Teacher turnover and layoffs resulting from severe budget problems also undermine team-building and engagement.

Linda Rosen described the contribution of Change the Equation, a network of more than 110 CEOs (chief executive officers, of corporations) who "pledge to connect and align their work to transform STEM learning in the United States." The very existence of the organization, she suggested, sends an important message. The participating companies have been interested in and supported STEM education for a long time, but they recognized that their investments "have not brought the return they might have hoped for." Together, the companies are investing more than half a billion dollars annually, as well as allowing release time for their employees to volunteer for STEM programs during working hours.

The organization partners are increasingly aware of the importance of third-party evidence of effectiveness, however, they have focused on evaluation, Rosen said. They are looking for programs that are not "dependent on a charismatic visionary," but have been demonstrated to be replicable, she explained. Many of their investments are in nonprofit organizations that develop STEM education programs with a track record for effectiveness. They are willing to invest in formal programs that support teachers and students in schools but are particularly drawn to informal education, in part because schools and districts can be very challenging for them to understand and navigate, while they can work with out-of-school partners more easily and see the impact of their work more immediately.

When working with schools and districts, they often seek a commitment from the district so that there is a reasonable expectation that the program can be sustained after the partnership ends.

All three panelists agreed that it is important to find programs that can be scaled up to benefit not just one or two schools but hundreds, but they also noted how difficult that can be in practice. Gartzman reminded the group of earlier discussions of the importance of school context to outcomes. He suggested that the business community may underestimate what is required to achieve the desired outcomes. A participant noted that the focus on informal partnerships and working around district policies was a cause for concern and wondered what it takes to develop successful partnerships within formal K-12 STEM education.

Lujan agreed with Gartzman that listening carefully to districts to understand the challenges that impede their progress is critical. In the context of the Lawrence Hall of Science's BaySci project, she noted, teachers worried that they could not teach science effectively, given the constraints on classroom time because of testing requirements for mathematics and English language arts. BaySci staff worked with the districts and school leaders to help them convey to teachers that they had "permission" to spend time on science and help them reconcile competing demands from the district, the school, and the classroom. Rosen added that the CEOs had found success in focusing on formal professional development, and Gartzman cited as just one example the

Chicago algebra initiative, which was designed to increase the number of students taking algebra by 8th grade. They worked with Chicago-area universities to help increase the number of teachers who had the preparation and credentials to teach algebra: the universities created 1-year course, which they taught jointly, as well as a credentialing exam (Alexandra, 2011).

Case Study 5

State Department of Transportation (DOT) Involvement in STEM Programs

A literature review was conducted to investigate how State (Department of Transportations) DOTs have participated in STEM outreach programs. 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. Overall, there were 87 programs with participation from some 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.

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.

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) programs are usually distinguished from in-school or curricular STEM programs.

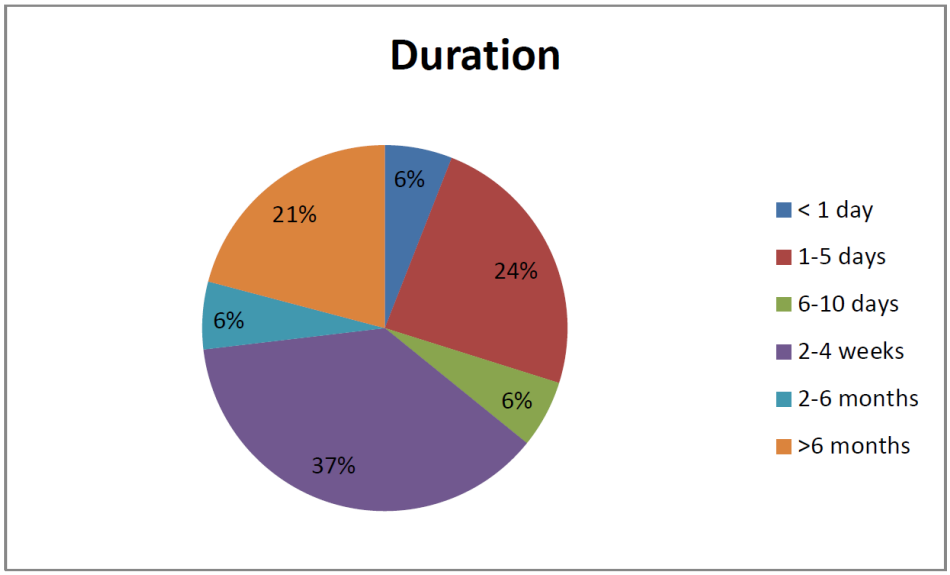

Figure 1 Program Duration of 87 Programs Identified

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 are shown in Figure 2.

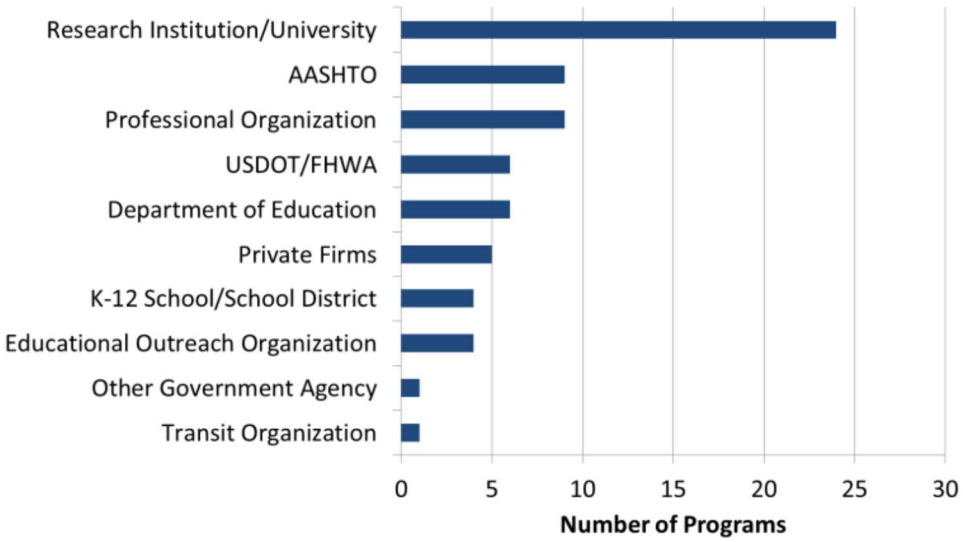

Figure 2 Partner Organizations for Programs from Preliminary Search

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.

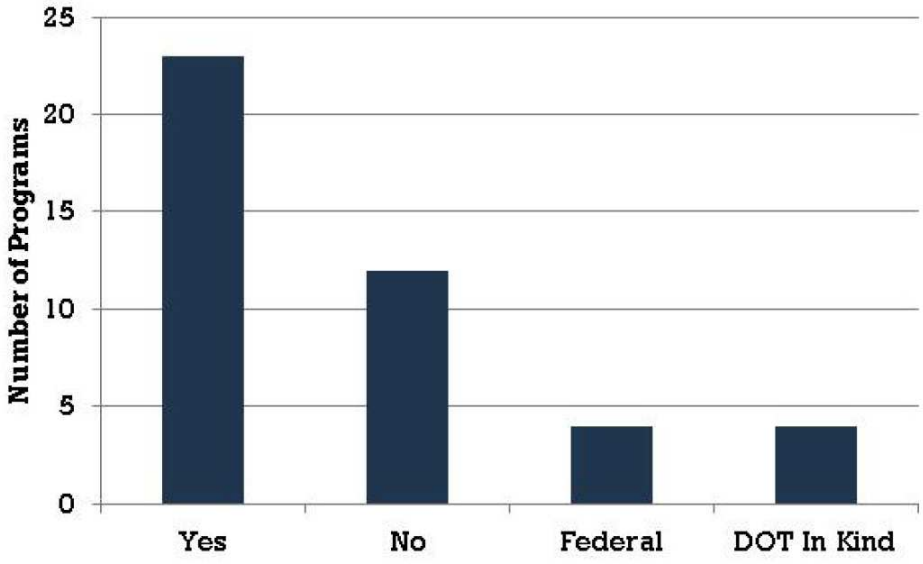

Figure 3 Financial Support of 43 STEM Programs from State DOTs

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. 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) (Adjo, 2016).

Case Study 6

Partnerships, both within schools and between schools and other institutions, can play a big role in addressing the challenges posed to STEM field awareness activities. Partner members complement each other in bringing their own resources and know-how to the collaboration. For example, the Discovery Science Center houses more than 120 stimulating interactive exhibits within its 59,000 square foot museum site, but it has also long been committed to enriching science education in the community through outreach and field trip programs. As part of Orange County, Los Angeles, California STEM, for schools lacking teachers with strong STEM expertise, the Discovery Science Center offers a series of hands-on, inquiry-based teaching

activities using do-it-yourself science kits based on its Future Scientists and Engineers of America project (https://fsea.squarespace.com/). The museum provides materials, curricula, and professional training to frontline teaching staff who want to implement these programs, said Janet Yamaguchi, the center's vice president of education. Discovery Science Center staff also have made "pop in" classroom visits to observe and coach teachers not just on how to use the activity kits with competence and confidence but also with the enthusiasm that gets students fired up. "We were excited to see that that system worked," Yamaguchi said (Steve, 2014).

Case Study 7

P21, The Partnership for 21st Century Learning (formerly the Partnership for 21st Century Skills) was founded in 2002 as a coalition bringing together the business community, education leaders, and policymakers to position 21st century readiness at the center of America's K-12 education and to kick-start a national conversation on the importance of 21st century skills for all students. P21's mission is to serve as catalyst for 21st century learning to build collaborative partnerships among education, business, community and government leaders so that all learners acquire the knowledge and skills they need to thrive in a world where change is constant and learning never stops. P21 believes that

- All learners need and deserve 21st century learning opportunities to thrive as tomorrow's leaders, workers, and citizens.

- Learning takes place throughout life in many places and spaces. From birth through their careers, learners need a broad range of experiences that develop their skills, dispositions and abilities to succeed. A strong foundation for success is rooted in learning that happens in and out of school.

- 21st century learning environments and opportunities are essential to prepare all students for the challenges of work, life, and citizenship in this century and beyond, as well as ensure ongoing innovation in our economy and the health of our democracy.

- Emphasize deep understanding rather than shallow knowledge. Engage students with the real world data, tools, and experts they will encounter in college, on the job, and in life students learn best when actively engaged in solving meaningful problems (Partnership, 2007).

Conclusions and Recommendations

Partnerships can thrive based on whether the partners respect and honor each other's experiences and skills. Partners' unique expertise should be acknowledged by everyone who is involved with the partnership.

Engineers, Scientists and Practitioners and educators know lot of different aspects of knowledge that the students and other groups do not know. Working together in partnership requires mutual respect and understanding.

Industries bring the real life situations into student's academic life to show them how they function facing crucial challenges in their daily affairs. They demonstrate the procedures, the steps in the methodology they follow in making their products or carrying out their services within their industry.

Governments, whether State or Federal also help K-12 students in making them understand about the Science and Transportation Engineering programs. Especially DOTs programs are very useful in forging great partnership with K-12 schools to achieve STEM awareness among the young minds.

Partnerships develop rapidly and successfully when the partners focus on spreading the science and engineering related knowledge continuously among the students of K-12 schools with proper follow-up activities to keep the interest level high at all grades from 1st grade to 12th grade.

Also, it would be better if the students, teachers and partnership players are rewarded for their participation in the STEM related activities to accomplish something noteworthy for the success of the awareness of STEM fields among the youth.

More and more rewards and accolades are to be provided to the high achieving STEM faculty at K-12 and higher education schools. The salary and fringe benefits need to be increased to attract more and more talented workforce that are ready to opt for STEM fields.

At the K-12 school level, the reasons as to why there is poor response towards picking up STEM fields has to be found out by conducting surveys that include questions to be asked to the senior and experienced STEM faculty.

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