Engineering our Future New Jersey: Partnerships, the Critical Element

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Abstract: *Engineering Our Future NJ* is a multi-pronged initiative whose goal is to ensure that all K-12 students in New Jersey experience engineering as an integral component of their elementary, middle, and high school education. Launched by Stevens Institute of Technology's Center for Innovation in Engineering and Science Education, EOFNJ has formed alliances with two- and four-year colleges, industry, government, education associations, school districts, and other stakeholder groups to demonstrate the need for and benefits of infusing engineering into mainstream K-12 education. Partnerships provide opportunities for: large-scale, statewide programming; sharing of curricula and effective models; and coalition-based lobbying efforts. It is a reality that partnering organizations often compete for participants and support; but when relationships are built on mutual goals and complementary strengths, partnerships are an essential component of large-scale change efforts.

Introduction

Engineering Our Future NJ (EOFNJ) was launched in 2005 with a goal to ensure that all K-12 students in New Jersey experience engineering—with a focus on innovation—as an integral part of their elementary, middle, and high school education, not merely as an elective or extracurricular activity. By exposing *all* students (not merely those who self-select to take elective courses) to hands-on design and problem-solving and the application of science and mathematics principles toward the solution of relevant, real-world problems in the context of required K-12 courses, we expect that more students will be motivated to enroll and succeed in gatekeeper courses in middle and high school and pursue engineering and other STEM careers.

Inspired, in part, by Massachusetts's leadership as the first state to introduce science and engineering standards[1], program developers of *Engineering Our Future NJ* planned a two-phase campaign designed to strengthen the New Jersey Core Curriculum Content Standards[2] to: (1) articulate *engineering* in the language of the standards; and (2) assess student learning of identified engineering competencies at the elementary, middle, and secondary levels.

The objective of Phase 1 was to demonstrate the need, the value, and the impact of engineering education on a sample of elementary, middle, and high school students and teachers. We aimed to measure increases in students' understanding of engineering and technology at progressive levels of sophistication—from differentiating technology from nature at the most basic level, to the ability to apply the engineering design process, to understanding and application of specific engineering principles related to fluids and thermodynamics and electrical and communications systems in physics and technology education courses.

With the participation of curriculum developers and research staff at the Museum of Science, Boston, the Society of Automotive Engineers Foundation, Columbia University's Institute for Learning Technologies at Teachers College and assistance from the NJ Department of Education, we recruited 35 teachers from 32 schools throughout New Jersey. The schools and teachers were selected to ensure a geographically-, socio-economically-, and academically-diverse sample of schools. Teacher training was held over two days in December 2005; classroom implementation occurred during the spring of 2006; data was collected and analyzed during the summer and fall of 2006; and evaluation reports were finalized in fall 2006 and January 2007.

In Phase 2, currently underway, EOFNJ's goal is to provide professional development, engineering curriculum recommendations, technical assistance, and leadership training to at least 2,000 teachers and administrators throughout New Jersey within three years in anticipation of new educational policies that strengthen the engineering requirement for all students. In addition, we seek to influence other educational stakeholders, including parents, education organizations, informal educators, and policymakers, to support the campaign to embed engineering within the context of critical skill sets needed by all students in preparation for success in the 21st century global economy.

Partnerships: Mission Critical

At the most fundamental level, meeting our numerical goals requires partnering with other, geographically-distant organizations. Conducting meaningful teacher training for 2,000 teachers within three years is a significant challenge without a statewide infrastructure. Adding to this challenge are new constraints on teacher release time, particularly for workshops related to subjects not included on mandatory statewide tests. Through a combination of models, EOFNJ is benefiting from partnerships with two- and four-year institutions to reach the goal of training 2,000 teachers. Mini-grants to sponsor regional training programs for practicing teachers and undergraduate and graduate education students have been awarded to: Montclair State University, Princeton University, The College of New Jersey and Rowan University. Teacher workshops, offered at no cost and conducted by Stevens instructors on elementary, middle, and high school engineering curricula, have been conducted or are planned at: St. Peter's College, the County College of Morris, Brookdale Community College, Middlesex County College, Newark Public Schools, Camden City Public Schools, and Saddle Brook Public Schools. Additionally, intensive professional development programs for teachers also carry the opportunity for graduate credit from two colleges of teacher education. Beyond merely meeting our near-term numerical goals, these partnerships are embedding engineering into college-level teacher education programs for ongoing sustainability while at the same time, providing incentives for teachers to participate in engineering-focused professional development.

Further, providing teachers with engineering curricula that is engaging, research-based, and standards-based has necessitated partnering with other organizations to identify appropriate curricula at various grade levels. Partnerships have enabled us to successfully align the engineering curricula with the NJ Core Curriculum Content Standards; deliver teacher workshops on such curricula; and assess the impact of the curricula on teachers and students. Working with the Museum of Science, Boston and with Columbia University Teacher's College, external evaluations were conducted to better understand the impact on student learning of engineering curricula as well as teacher implementation issues[3]. Partnerships have been forged with the Museum of Science, Boston, developers of the *Engineering is Elementary* curriculum series for Grades 3-5 and the *Engineering The Future* high school engineering course; with the Society of Automotive Engineers Foundation, developers of the *A World in Motion* curriculum for middle school; Montclair State University, utilizing the *Children's Engineering* program; and the College of New Jersey's *Children Designing & Engineering* curriculum.

Promotion and leveraging of the EOFNJ effort has been possible through partnerships with a variety of other educational organizations, including other higher education institutions, but also public agencies, informal science education providers, and professional associations representing various segments of the K-12 education community. Partnerships with organizations such as the Technology Educators Association of New Jersey (TEANJ); the New Jersey Principals and Supervisors Association (NJPSA); Liberty Science Center, New Jersey's interactive science museum in Jersey City, NJ; the New Jersey Department of Education; the National Museum of Education's *Inventucation* Center; and NACME (the National Action Council for Minorities in Engineering) are all advancing the shared goals and key messages to ensure all New Jersey students participate in engineering in elementary through high school.

For example, we have partnered with the New Jersey Principals and Supervisors Association, the New Jersey Department of Education and Verizon Communications to co-sponsor a one-day summit at Stevens in May 2007 for principals and administrators to share a vision of the technological competencies needed by citizens and workers in the 21st century. This conference will present research on student impact of K-12 engineering programs; provide an orientation to exemplary K-12 engineering curriculum resources; showcase best practices and strategies for integration of engineering/technology into existing curricula; and link K-12 engineering efforts to New Jersey's policy and plans for STEM education and workforce development. Five New Jersey engineering universities will present model programs at the conference, and leaders from business and New Jersey government will share perspectives on K-12 engineering. Among the programs being presented are:

> Science and Engineering Connections: Unique & Compelling K-12 Curricula, *Stevens Institute of Technology*
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> Engineering Clinics for Middle School Teachers and Guidance Counselors, *Rowan University*
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> Dual-Degree Engineering Programs, *The Richard Stockton College of New Jersey*
>
> Using Princeton University Materials Academy (PUMA) Activities & Modules, *Princeton University*
>
> Engineering Experiences for Pre-Service Elementary Teachers, *The College of New Jersey*
>
> The K-12 Engineering Pipeline: A 30+ History of Success , *New Jersey Institute of Technology*

Often, industry, public grant-making agencies, and private foundations are seen merely as the source of financial support to conduct programming. However, each of these types of organizations has much more to offer than merely funding. Industry, for example, can provide expertise and staff support to implement a communications or PR campaign. Working with our partner Verizon Communications, we have implemented a media campaign that includes op-ed articles, a newsletter, and local press releases. High profile industry executives who endorse the program's mission and activities lend credibility to the effort. Public grant-making agencies, such as the National Science Foundation, offer effective models for building communities of practice around shared goals as well as standards of rigor related to program evaluation and measurement of program results. Private foundations may offer valuable insight and strategic direction to advance the mission using creative and entrepreneurial approaches.

Schools and districts should be thought of not only as recipients of our programming, but also as contributors to a shared research agenda. Through action research, teachers and districts participate as scholars to vet innovative approaches against the realities of the classroom, helping to reveal "what works" in order to refine implementation models for scale-up and further dissemination.

Spotlight on Key Partners

Stevens has introduced a mini-grant program to help other universities and organizations develop the capacity to deliver teacher workshops on exemplary engineering curricula. A $5,000 mini-grant is available for institutions that participate in turnkey training of faculty and K-12 outreach program administrators, and who deliver workshops for teachers in their neighboring school districts or through pre-service undergraduate and graduate programs. Through this program, the College of New Jersey has trained seven faculty and staff and members from the School of Education and Department of Technological Studies in the *Engineering is Elementary (EiE), A World in Motion*, and *Engineering the Future* curricula. TCNJ is targeting both pre-service K-8 teachers and in-service K-12 teachers. One of

the EiE modular units- "Catch The Wind" is being offered in all four elementary education science methods courses in Spring 2007. Over 100 pre-service teachers will receive the training in one class period. In the fall another EiE unit will again be included in the elementary education science methods courses, impacting another 100 pre-service teachers. In addition to working with pre-service teachers, TCNJ will also conduct workshops for practicing teachers by offering three workshops as part of the Department of Technological Studies Professional Development Workshop Series during the 2007-2008 school year, resulting in another 50-60 teachers being introduced to exemplary engineering curricula. In total, the TCNJ model in will reach approximately 230-250 pre-service and in-service teachers in its first year of implementation.

The Museum of Science, Boston, and Stevens Institute of Technology signed a memorandum of agreement in the fall of 2005 with the mutual goal of integrating engineering as a required component of K-12 education in New Jersey. During the ensuing 16 months, this multi-dimensional partnership has conducted turnkey training by Museum curriculum developers for Stevens staff; conducted strategic planning to advance mutual goals; jointly planned educational research design and conducted evaluation studies[4,5]; collaborated on joint proposal development; conducted lobbying efforts in Washington; and exchanged data and recommendations on curriculum and implementation issues.

In addition to the EOFNJ partnerships, a new coalition has formed in the state of New Jersey to advance K-16 engineering education. Partners in the New Jersey Engineering Education Coalition (NJEEC), which was formed in December 2006, include representatives from the New Jersey Commission on Higher Education, engineering universities, industry, and representatives of the state Chamber of Commerce. While still in its early stages, this coalition is working to increase the number of students, traditional and underrepresented, who enter and succeed in undergraduate and graduate engineering programs, who pursue engineering careers, especially in New Jersey, and who bring the benefits of a solid engineering foundation to their lives as citizens. The NJEEC is a perfect example of a partnership that has mutual goals, complementary strengths, and shared benefits.

Lessons Learned

Through the EOFNJ initiative, as well as a series of long-term partnerships with other institutions over the last decade, we have learned that:

- Partnerships must be built on mutual goals, complementary strengths, and shared benefits.
- The health of partnerships depends, to a great extent, on personal relationships between key representatives of each organization.
- Institutional culture is often a subtle, but important, factor in the effectiveness of the partnership.
- Diverse organizations, such as community colleges and research universities, or colleges of teacher education and technical universities, offer opportunities to expand the impact of programs to new audiences, but require clarity of goals and synergy of mission.

References

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