Engineering for Every K−12 Student
A Landscape Analysis of K−12 Engineering Education in the Greater Boston Region

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Overview

K–12 STEM teachers, university faculty, industry representatives, out-of-school time administrators, and other stakeholders who are engaged in engineering education in the Greater Boston region stand together on many of their general beliefs about K–12 engineering education:

- They agree that the goals for K–12 engineering education should be to “help students see how science and engineering are instrumental in addressing major challenges that confront society today1 and to prepare children to be STEM-literate citizens, but they don’t agree on a common definition of engineering education.

- They want to work on building awareness about engineering education and the resources and opportunities available, and they also believe that there needs to be a mechanism that matches those resources and opportunities with those who need them.

- They believe that teacher professional development is a priority for improving K–12 engineering education, and they recognize the need for assessments, though they don’t expect to work on developing assessments in the near future.

- They recognize the challenges and opportunities of working more collaboratively within and across stakeholder groups, and between in-school and out-of-school contexts.

Our landscape analysis, funded by the National Science Foundation (#DRL-1450532), uncovered these findings and others. Findings were based on targeted interviews and a survey of a small number of stakeholders (45 interviews and 137 survey respondents) to understand their knowledge, beliefs, and attitudes about K–12 engineering education in the Greater Boston region, and to learn where overlapping interests and needs exist. The analysis has been augmented by a review of literature and websites. Massachusetts is clearly a frontrunner in K–12 engineering education and home to a great many stakeholder groups invested in improving engineering education, collaborating in a variety of ways. However, findings from this study indicate that stakeholders recognize that while opportunities abound for students, there are particular gaps. We recommend leveraging one of the area’s key assets—National Science Foundation (NSF) awardees involved in educational research and development—through further collaboration to help address some of these gaps and opportunities.
Background

The National Research Council (NRC) report *A Framework for K–12 Science Education*\(^2\) suggests a more expansive role for engineering in formal learning. Coupled with the recommendations from the National Academy of Engineering (NAE) reports *Engineering in K–12 Education*,\(^3\) *Standards for K–12 Engineering Education?*,\(^4\) and *STEM Integration in K–12 Education*,\(^5\) momentum has been built around making engineering education accessible to all K–12 students and teachers. And now, *The Next Generation Science Standards*\(^6\) (NGSS) have provided performance expectations for students that include engineering.

Engineering and technology are featured alongside the natural sciences (physical sciences, life sciences, and earth and space sciences) for two critical reasons: (1) to reflect the importance of understanding the human-built world and (2) to recognize the value of better integrating the teaching and learning of science, engineering, and technology.

These goals for student learning are influencing the curriculum, instruction, and assessment choices of states across the country. Leaders from Massachusetts have informed the national dialogue in K–12 engineering education by serving as design team members for the NRC Frameworks\(^7\) and writing team members for the NGSS,\(^8\) developing and disseminating curricula,\(^9\) and conducting research on student and teacher understanding of engineering education.\(^10\)

Massachusetts—and the Greater Boston region in particular—has served as a major center for K–12 engineering education research and development activities for over a decade.\(^11\) In fact, when Massachusetts applied for Phase 2 Race to the Top funding in 2010, the proposal stated, “In 2001, Massachusetts became the first state to incorporate standards and assessment for technology and engineering within the science frameworks; it is still the only state to include technology and engineering prominently in our standards at all age levels.”\(^12\) Engineering education is supported in the Governor’s STEM Advisory Council foci.

and the Massachusetts STEM Plan 2.0;13 it is integrated in the current state education standards and assessments; it exists at all levels of education, in and out of schools, and in partnership with industry and nonprofits; regional STEM networks and alliances connect educators, school districts, business and industry partners, and community members; and a large number of K–12 engineering education research and development projects, including those funded by the NSF, are active in Massachusetts compared with other areas of the country.14 The progress of engineering education in Massachusetts has been supported by dedicated leaders, policies, and a rich collection of engaged stakeholders from across sectors, including entities who provide a wealth of resources and services, many of which are coordinated through various networks and collaborative efforts. With all of this expertise, activity, and stakeholder engagement, especially within the Greater Boston region, there is tremendous potential to realize the promise that engineering can play a key role within current and future K–12 teaching and learning in Greater Boston, the Commonwealth of Massachusetts, and beyond.

What opportunities are there to further improve engineering education in the Greater Boston region, and by proxy, in Massachusetts and across the nation? If and how could new collaborations among NSF awardees and between NSF awardees and non-awardees play an important role in innovation, synergistic research, development, dissemination, and implementation activities for K–12 engineering education within the Greater Boston region (where there is a higher concentration of awardees)? The NSF funded Tufts University, in partnership with Education Development Center, Inc. (EDC), to conduct a landscape analysis of K–12 engineering education in the Greater Boston region to respond to these questions. Rather than cataloging all of the people, organizations, efforts, and resources committed to K–12 engineering education, this study was designed to provide insight into priority areas of focus and opportunity for improving K–12 engineering education—based on the perceptions, observations, and opinions of a sampling of current stakeholders—and areas of overlapping interest and needs between NSF awardees and other local stakeholders.
The study lays the groundwork for further exploration of potential purposes, means, and impacts of engaging local NSF awardees who work in the field of engineering education. The report that follows describes the findings and implications of the landscape analysis. The underlying assumption of the analysis is that NSF awardees may be an underutilized asset in the region, and identifying areas of common interest to address perceived needs may provide the foundation upon which stakeholders, including NSF awardees, could collaborate to improve engineering education. Therefore, through interviews and a survey, augmented by a review of literature and websites, Tufts and EDC gathered information about the following:

- **Goals for engineering education:** What do stakeholders believe should be the goals for K–12 engineering education?
- **Engagement of stakeholders:** Which people, organizations, and efforts do stakeholders recognize as contributing to K–12 engineering education in the Greater Boston region?
- **Resources:** How do stakeholders view the status of resources for meeting the goals they named (funding, personnel, curriculum, etc.)?
- **Areas of current interest:** What do stakeholders find to be the most compelling opportunity and challenges within the arena of engineering education, and which opportunities and challenges might they want to address through their collaborations in the future?
- **Relationships:** Whom do stakeholders report collaborating with in the past, or expect to collaborate with in the future, to address some of these areas of interest?

The report presents a synthesis of the data gathered and concludes with recommendations for future actions that can leverage the assets of NSF awardees focused on engineering education, support improvements in K–12 engineering education in the Greater Boston region, and have implications for other regions and states seeking to improve engineering education in their schools and communities.

This is a valuable first step in determining an appropriate design and function of a collaborative community that can address the gaps and challenges highlighted in this report, in addition to capitalizing on the available opportunities to enhance K–12 engineering education in the Greater Boston region. Collaboration requires not just a common goal but also a set of invested stakeholders, which may vary by model, issue at hand, and context. Collaborative models may include networked improvement communities, communities of practice, collective impact, strategic alliances, working groups, and/or communities of learning, inquiry, and practice (CLIP).15 Ultimately, whatever model is adopted should have K–12 educators and NSF-funded researchers at its core to ensure the sustainability of innovation and proper dissemination of existing and newly developed resources and tools. With this in mind, it will be essential to get a focused understanding of how NSF-funded researchers decipher the findings from this landscape study to determine the feasibility of a collaborative community for the Greater Boston region.

Establishing what we nationally describe as K–12 engineering education has not been straightforward. K–12 engineering education has had an interesting trajectory given its initial beginnings under the umbrella of what has traditionally been defined as technology education. As technology education began to take root in the early 1990s, engineering had been called out as a central element yet had not been fully embraced as a standalone form or subject of teaching and learning.\textsuperscript{16}

In 1996, NASA and the NSF supported the development and dissemination of a report entitled *Technology for All Americans*, written by the International Technology and Engineering Education Association (ITEEA). This report, along with another commissioned by NASA and the NSF, entitled *Standards for Technological Literacy*,\textsuperscript{17} would set the stage for the inclusion of engineering in formal school curricula.\textsuperscript{18} The National Academy of Engineering (NAE) also made tremendous efforts to carve a niche for engineering education in K–12 settings. NAE assembled a series of committees between 2000 and 2010 to address issues related to technology and engineering education. In 2002, NAE and the NRC published *Technically Speaking: Why All Americans Need to Know More About Technology* to create commonality around the understanding and value of technological literacy, with implications for the intersection of technology and engineering as core subjects in the development of curricula and teacher professional development. Then in 2009, and shortly after in 2010, NAE released two publications (*Engineering in K–12 Education: Understanding the Status and Improving the Prospects* and *Standards for K–12 Engineering Education*, respectively). These two reports set the tone for a more robust conversation at the national level about how best to incorporate engineering into existing K–12 standards and frameworks.\textsuperscript{19}

As ITEEA and NAE were supporting the national dialogue concerning K–12 engineering education, Massachusetts was charting its own course. Massachusetts was the first state to fully articulate a set of K–12 standards for engineering education. The Massachusetts 1993 Education Reform Law made it possible to include technology and engineering into state education standards, and this led to the creation of the Massachusetts Science and Technology Curriculum Frameworks in 1996. In 2001, the frameworks...
were revised and included more engineering principles and the engineering design process.\textsuperscript{20} These steps taken in Massachusetts contributed to the national evolution of engineering education and will be described in more detail later in this section. Massachusetts then played a major role in the creation of the NGSS, which have established a national science education framework that embeds engineering across what the NGSS describe as “science and engineering practices, disciplinary core ideas, and crosscutting concepts.”\textsuperscript{21} The state’s involvement in the creation of the NGSS has catalyzed a current reorganization of its own standards for K–12 engineering education in an effort to further strengthen engineering as part of formal K–12 teaching and learning.

The Emergence of K–12 Engineering Education for All Students in Massachusetts

Formal Education

The mid-1990s marked a shift in formal K–12 education in Massachusetts as the state legislation worked to differentiate and redefine what had previously been called “industrial arts” to “technology education.” Engineering emerged as part of technology education, but adoption of technology/engineering into curriculum and instruction was met with resistance because of the lack of clarity around fit and ownership among science educators, as well as administrators and parents. Full buy-in did not begin to be realized until the Massachusetts Department of Elementary and Secondary Education led efforts to create uniformity by aligning policies that would give equal attention to technology/engineering as that of other science disciplines. These developments created a cascading effect that enabled schools and districts to allocate time and resources to support the development of technology/engineering programs. Other factors, such as agreement between national technology education organizations (e.g., ITEEA) and influence from Boston’s Museum of Science’s National Center for Technological Literacy (NCTL), helped to reposition and champion technology/engineering education.\textsuperscript{22}

Dr. Ioannis Miaoulis and the Museum of Science, Boston, served a critical role in the evolution of engineering education both locally and nationally. Dr. Miaoulis, the museum’s current president, has served as a national leader and spokesman for K–12 engineering education since his former role as dean of the School of Engineering at Tufts University during the late 1990s to early 2000s. While at Tufts, Dr. Miaoulis and Professor Chris Rogers made early arguments for K–12 engineering education and advocated for the creation of what is currently the Center for Engineering Education and Outreach (CEEO) at Tufts. The Center for Engineering Education Outreach was established and it created curricula and professional development programs for educators spanning all grade levels. The center also partnered with LEGO and created Robolab, the software that enabled the LEGO Mindstorm robotic kit to be used in classrooms.\textsuperscript{23} Other notable products also emerged from the CEEO, such as the Engineering is Elementary (EiE) curriculum, which was developed to reach elementary school students and their teachers.\textsuperscript{24} EiE was later adopted by the Museum of Science, and while taking root, the Engineering the Future (EtF) curriculum was created to support engineering education for high school students. In parallel, the Museum of Science also led the charge for engineering education through the creation of the National Center for Technological Literacy (NCTL). Finally, Dr. Miaoulis was influential in the effort to include engineering in the state’s curriculum frameworks. With these components and the infrastructure in place to support curriculum and professional development, outreach, and dissemination, the Museum of Science has served as a local, regional, and national catalyst for K–12 engineering education.

“There is no standard first-year college course in engineering, and therefore there is no single course a high school student could take to prepare for this course. Therefore, there is no standard curriculum, and we are left creating our courses on our own.”

—Survey respondent
Other contributing factors to the foundation for formal K–12 engineering education in the state include the creation of the Governor’s STEM Advisory Council, the STEM Pipeline Fund, and the Regional STEM Networks, which span across the entire state. These structures (which will be described in more detail later in this report) have provided a platform for engineering to continue to gain a stronghold in formal K–12 STEM teaching and learning, placing Massachusetts as a leader among a number of states that have embraced engineering in their set of articulated frameworks. However, work still needs to be done to articulate engineering education across K–20, especially so that graduates from high school are prepared for and have access to introductory college-level engineering courses.

Informal Education

The informal educational space (e.g., out-of-school, after-school, and non-school programs and opportunities) has also served as a conduit for engineering education activities. Afterschool programs, competitions, summer programs, and websites have played a role in facilitating how students engage in engineering-related activities. Given the nature of informal learning, there are opportunities to reach diverse audiences and demographics in ways that differ from traditional, formal learning. In this context, the learning experiences are not bound by frameworks, learning assessments, and other traditional forms of teaching and learning. In the Greater Boston region, a number of museums, community centers, universities, and other entities have worked with a broad range of students and teachers, many in collaboration with business and industry, to expose them to engineering. For example, funders and volunteers from local industry support efforts such as First Robotics, supported in part by the local business PTC, and the South End Technology Center @ Tent City (The Tech Center), supported in part by the Massachusetts Institute of Technology (MIT) and a local community development corporation. (A list of engineering-related organizations discussed in this study, with links to their websites, can be found in Appendix C.)
Frameworks and MCAS

In the spring of 2001, Massachusetts released a revised science and technology/engineering curriculum framework as one of seven curriculum frameworks to help advance the state’s education reform in learning, teaching, and assessment. The framework was developed with assistance from preK–12 teachers and administrators, college/university professors, and practicing engineers and scientists working with the Department of Elementary and Secondary Education. The framework derived from two reform initiatives: the Education Reform Act of 1993 and Partnerships Advancing the Learning of Mathematics and Science (PALMS). The requirement for periodic review of the technology/engineering framework initiated a review panel that, with assistance from science and technology/engineering teachers and other educators, led to the development and dissemination of a comprehensive set of standards with a particular focus on the high school level. Other revisions to the framework were completed in 2006 and, most recently, in January 2016. There is a fundamental difference between the new framework and the older versions. For example, the newer framework calls attention to engineering design concepts as a critical facet of K–12 science and engineering education, and further defines design practices as an application of science and engineering.

The Massachusetts Comprehensive Assessment System (MCAS), a test given to all public school students in Massachusetts, includes technology/engineering items. Currently, the Mass. Department of Elementary and Secondary Education is revising the MCAS, in part to respond to the recent revision of the state’s frameworks.

Governor’s Advisory Council and Regional STEM Networks

Beginning in 2009 under executive order of Governor Deval Patrick, the state of Massachusetts initiated the creation of a STEM advisory council to support the enhancement of STEM education for all students in the state. This initiative would connect diverse stakeholders representing various cross-sections of academia, industry, government, and the nonprofit sectors. The goal of the council was to establish a platform by which these stakeholder groups could advocate for STEM education and collaborate more effectively with the state legislators and key agencies in the Executive Office of Education (e.g., the Department of Higher Education, Department of Elementary and Secondary Education, Department of Early Education and Care). The council is organized by subcommittees and working groups focused on different facets of STEM education, which have included “developing a statewide STEM Plan [most recently the STEM Plan 2.0]…; assessing how best to bring to scale the most effective STEM programs in Massachusetts…; building communities for state-wide collaboration and supporting the annual STEM Summit; and providing recommendations for a campaign to build public support across the Commonwealth for the STEM disciplines.” In July 2014, the STEM advisory council was officially codified into law by the state legislature.

A regional system of STEM networks has been implementing the plans of the STEM Plan 2.0, which was announced in the fall of 2013. “The Council relies on the STEM Plan to help guide its work as it seeks to promote a greater understanding of the importance of the essential disciplines of science, technology, engineering and math to students’ academic achievement and successful preparation for entry into the 21st Century workforce.” To meet this goal, “the Regional STEM Networks bring together public and private K–12 schools and districts, public and private higher education institutions, business and industry, regional employment/workforce investment boards and non-profit organizations around STEM to address local education and workforce needs.” There are presently nine Regional STEM Networks across the state: Berkshire, Boston, Cape Cod, Central, Metro North, Metro West, Northeast, Pioneer Valley, and Southeast. Support for the Regional STEM Networks is made available through the STEM Pipeline Fund.
The Massachusetts Mathematics, Science, Technology & Engineering Grant (Pipeline) Fund was established under the Acts of 2003 Economic Stimulus Trust Fund. The Massachusetts Department of Higher Education (DHE) was directed to administer the Pipeline Fund, with a focus on three goals:

1. To increase the number of Massachusetts students who participate in programs that support careers in fields related to mathematics, technology, engineering, and science;
2. To increase the number of qualified mathematics, technology, engineering, and science teachers in the Commonwealth; and
3. To improve the mathematics, technology, engineering, and science educational offerings available in public and private schools.

This fund is supported by an annual appropriation from the state legislature and, to date, has seeded the development of a number of key initiatives broadly related to STEM.

Since its inception, the STEM Pipeline Fund has supported a number of activities and initiatives, including the @Scale Grant Program, which has provided resources since 2010 across four distinct phases of strategic implementation to help replicate and scale what have been vetted as successful STEM efforts that align with the goals and objectives of the state’s STEM Plan 2.0. Some examples of projects that have been funded with a specific focus on engineering education are as follows:

- Advanced Robotics Initiative, a programming and construction program for middle school students
- Gateway Project, an effort to support strategic development of engineering education across grade levels in districts throughout the state
- Future City, a middle-grades design competition

**Stakeholder Groups**

The engagement over time of multiple stakeholder groups has contributed to the current landscape of K–12 engineering education. These groups and examples of their engagement are described below.

K–12 schools in the Greater Boston region, and throughout Massachusetts, have increased attention to engineering education since the inclusion of the discipline into the state standards. Prior to that, the state had a history of engineering-related education in career, technical, and adult education (CTE) schools and in technology classrooms in comprehensive schools. Teachers have been supporting engineering education through professional network organizations, such as the Massachusetts Technology and Engineering Collaborative (MassTEC). In 2006, the state science fair added “engineering” to its name to become the Massachusetts State Science & Engineering Fair, which is supported by a consortium of industry, individuals, foundations, institutions of higher learning, and professional and trade organizations.

Massachusetts elected officials and Mass. Department of Education staff have worked toward the goal of instituting K–12 engineering education as part of a larger, long-term STEM education improvement effort, as outlined earlier in this report. As the state has developed comprehensive plans, advisory groups, regional networks, and K–12 standards, they have worked closely with business and industry, education, and informal sectors.

Massachusetts is home to over 30 colleges and universities that provide engineering degrees and certificates. Support from institutes of higher education has been a vital element in Massachusetts’ progress. In addition to working closely with industry and preparing students for careers in engineering education, university researchers have provided expertise,
materials, and professional development for the K–12 formal and informal education systems. They have contributed to the knowledge base and development of policy and standards in the state. Many of these researchers have been NSF awardees. Situated in universities or nonprofits, NSF awardees are also linked to a national network of K–12 engineering education stakeholders.

Businesses in Massachusetts and the Greater Boston region have contributed funding and personnel to support engineering education. They have underwritten and organized competitions, supported mentoring and apprenticeship programs, and contributed to the vision for aligning K–12 through college and career opportunities. Many colleges, universities, community colleges, and CTE schools have strong partnerships with industry that align efforts to educate and employ a local workforce. For instance, the Boston Private Industry Council (PIC) works in strategic alliance with the Boston STEM Network to create a pipeline from education to employment.

Most student time is spent out of the classroom, so there is great opportunity to bring more engineering education into their lives through informal learning contexts. Local groups are leveraging enthusiasm from across the country for efforts, such as the Maker Movement, hackathons, and robotics competitions/challenges. Even while informal learning is largely driven by local efforts and more often efforts focus on STEM rather than engineering, some large organizations are involved in engineering education (e.g., Boston’s Museum of Science and Boston Children’s Museum). Efforts such as the Cambridge Science Festival (a collaborative effort of the City of Cambridge, Cambridge Public Library, Cambridge Public Schools, Harvard, MIT and the MIT Museum, Boston’s Museum of Science, and WGBH) are working to bring engineering more explicitly into their programming.

Finally, engineering education in Massachusetts has benefited from the leadership of several key individuals. These individuals have championed the importance of engineering education at the national, state, and local levels, and networked with individuals across sectors. They have made connections and supported partnerships over time, often leveraging the assets and influence of their associated institutions. It is with their support that key policy initiatives have moved forward, ensuring that engineering education is a component of K–12 education.
Landscape Analysis

Methods

The study design included 45 interviews with key informants (i.e., those who represent various stakeholder groups (see Figure 1) and bring particular knowledge of K–12 engineering education problems, needs, and opportunities based on their connection to the topic), and a survey administered to a purposeful sample of individuals named during interviews or identified through a literature and website search (resulting in 137 responses). A description of each method is included within full interview and survey reports, available as Appendix A and Appendix B.

Findings and Interpretations

Data collected for this landscape analysis illustrate a picture of K–12 engineering education in Massachusetts in which there are a variety of goals, many efforts and resources, and engagement of key stakeholders. Data also suggest there are opportunities and challenges that can serve as catalysts for future work and collaborations. The sections below provide a review of data synthesized across data collection methods and around each of the study’s main foci related to engineering education: goals; activities, organizations and resources; collaborations; and opportunities and challenges.40

FIGURE 1.
Survey respondents and interviewees represent stakeholder groups from a variety of sectors.*

* Duplicate counts are possible if an interviewee also took the survey. Survey respondents self-designated their stakeholder group affiliations; interviewees were assigned groups represented by the survey categories.
Goals for Engineering Education and Factors Needed to Achieve Those Goals

KEY FINDING:

Stakeholders generally agree on what the goals for K–12 engineering education should be, even though those goals don’t necessarily match the goals of current efforts, and there is no common definition of engineering education.

What should the goals for K–12 engineering education be? What are the goals of the engineering education efforts in which stakeholders are currently engaged?

When interviewing stakeholders, it became clear that they had differing definitions of engineering education that have implications for how, when, and with whom it would be taught and the kinds of learning experiences that students should have. For example, some argued that K–12 engineering education does not fit with science; some think that it should include computer science; some think that it should include Making and tinkering.

This lack of clarity around a definition of engineering education limits buy-in across stakeholders. Many respondents shared concerns that parents, and even some administrators, may have trouble supporting engineering education if they aren’t clear about what it is. The lack of a common definition might be related, in part, to expectations about what engineering can and cannot be with respect to other traditional ways of teaching and engaging with mathematics and science. But this lack of clarity is an opportunity for the stakeholders in Massachusetts to be strategic and lead the nation by coming to a consensus about how best to define and articulate the role of engineering in K–12 education.

Even though stakeholders differed in their definition of K–12 engineering education, they generally agreed about the goals for it. We asked survey respondents to choose what they consider to be the three main goals of K–12 engineering education. The goals selected most frequently include (1) to “help students see how science and engineering are instrumental in addressing major challenges that confront society today” (42%); (2) to prepare children to be STEM-literate citizens (41%); and (3) to help students learn a systematic process for defining and solving problems (40%). Generally, there was agreement about these goals; however, NSF awardees (42%) placed a higher importance on including students who may have been traditionally marginalized in the science classroom than did other respondents (24%), while non-NSF awardee respondents (43%) placed a higher importance on helping students learn skills like communication, teamwork, and creativity than did NSF awardees (27%). These goals can be thought of as suggestions for what to do. Many respondents also addressed how to do this—referencing the need for better alignment of courses and providing more resources (especially equipment) to teachers.

The top five goals of current efforts in which stakeholders are engaged were the same goals respondents chose as priorities for K–12 engineering education in general, yet surprisingly, in a different order (see Figure 2). In other words, the goals for engineering education chosen by respondents are not necessarily the same goals of the efforts in which they are currently engaged. For instance, while the goal “to motivate students to engage with STEM content” is the most frequent choice for efforts currently known, it is lower on the list of goals respondents believe should be the priority of K–12 engineering education. And, while the goal “to help students see how science and engineering are instrumental in addressing major challenges that confront society today” is high on the list of goals respondents believe should be the priority of K–12 engineering education, it is lower on the list of goals addressed by efforts in which respondents have been engaged.
FIGURE 2.
How do the goals for K–12 engineering education differ from the goals of existing named efforts?

GOALS OF CURRENT INITIATIVES

1. To motivate students to engage with STEM content
2. To help students learn skills like communication, teamwork, and creativity
3. To help students learn a systematic process for defining and solving problems
4. To prepare children to be STEM-literate citizens
5. To help students see how science and engineering are instrumental in addressing major challenges that confront society today

GOALS FOR K–12 ENGINEERING EDUCATION

1. To help students see how science and engineering are instrumental in addressing major challenges that confront society today
2. To prepare children to be STEM-literate citizens
3. To help students learn a systematic process for defining and solving problems
4. To help students learn skills like communication, teamwork, and creativity
5. To motivate students to engage with STEM content
KEY FINDING:

Most of those who are engaged in K–12 engineering education in the Greater Boston region do not expect to work on assessments in the next year, even though they recognize them as the greatest area of need.

To be able to achieve desired goals, we theorized that certain contextual factors would need to be in place. Therefore, we asked survey respondents to indicate the degree to which a number of factors currently exist at the level necessary to achieve the main goals they selected as priorities. These factors included allotted time to engage in and/or implement engineering activities; access to curriculum; money for materials; educator training; effective assessments; awareness of existing resources and initiatives; coordination among schools and nonprofits, universities, and companies; coordination between initiatives by nonprofits, universities, and companies; coordination of out-of-school time/afterschool programs and in-school/school day programs; and state policy and standards.

The majority of respondents were in agreement that access to curriculum and the awareness of existing resources and initiatives exists “somewhat” in the current state of K–12 engineering education (see Table 1). One key finding from this analysis was that many respondents, including the NSF awardees, did not believe that effective assessments exist at all. And while the state policies and standards appear to be at a sufficient level, some stakeholders expressed concerns about whether too many standards and a focus on testing might constrain learning opportunities. This is somewhat of a peculiar set of circumstances—on one hand, stakeholders see a huge gap in the availability of effective assessments; on the other hand, there was no evidence in our findings that suggests any one group of stakeholders was eager to take on developing these types of resources.

We also found that, with the possible exception of standards and policies, stakeholders did not indicate that we have reached saturation or that there are redundancies in the factors and resources that support K–12 engineering education, at least to the degree that they are aware. Rather, there is room for growth, and inter-stakeholder- and intra-stakeholder-group (e.g., between companies or between nonprofits) collaboration would ensure coordination of more comprehensive solutions to districts’ needs for funding, curriculum, professional development, and program implementation.

TABLE 1.

To what degree do the following contributing factors exist in the current state of K–12 engineering education?

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>EFFECTIVE ASSESSMENTS</th>
<th>ACCESS TO CURRICULUM</th>
<th>AWARENESS OF EXISTING RESOURCES AND INITIATIVES</th>
<th>STATE POLICY AND STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOES IT EXIST?</td>
<td>NOT AT ALL</td>
<td>SOMEWHAT</td>
<td>SOMEWHAT</td>
<td>JUST RIGHT AND MORE THAN NEEDED</td>
</tr>
</tbody>
</table>
When and Where Engineering Should Be Offered

KEY FINDING:

Many stakeholders believe that engineering education should take place in school for elementary and high school students but out of school for middle school students.

Where should K–12 engineering education “fit” into K–12 education in Massachusetts?

We gave stakeholders the following choices: as a stand-alone course, embedded in a STEM subject, integrated with many subjects, as a vocational course, during informal/out-of-school time activities, not at all, and other. Key responses are outlined in Figure 3. Stakeholders believe engineering education should take place during out-of-school time slightly more than during in-school time for middle school students, and just slightly less than in-school time for high schoolers.

Interestingly, stakeholders also indicated there is less collaboration (existing and planned) with out-of-school educators than with their in-school counterparts, and that there is less than the necessary level of coordination between out-of-school time programs and in-school programs needed to reach the respondents’ desired goals. In fact, NSF awardees gave this lack-of-coordination factor the highest “not at all” rating. These findings point to an area of need and potential future focus of improvement efforts. Interviewees also noted that tension arises when the possibility that new engineering courses might displace existing science or mathematics courses at the high school level, as teachers fear losing their course load.

FIGURE 3.
Where does engineering education “fit”?  

K–5/Elementary School
Integrated with many subjects (74%)
Embedded in a STEM subject (70%)
During informal/out-of-school time activities (69%)

6–8/Middle School
During informal/out-of-school time activities (78%)
Embedded in a STEM subject (75%)
Integrated with many subjects (71%)

9–12/High School
As a stand-alone course (79%)
During informal/out-of-school time activities (73%)
As a vocational course (64%)
Who is the audience of the efforts named?

<table>
<thead>
<tr>
<th>Audience</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>67%</td>
</tr>
<tr>
<td>Educators</td>
<td>53%</td>
</tr>
<tr>
<td>Formal/In-School</td>
<td>44%</td>
</tr>
<tr>
<td>Parents</td>
<td>27%</td>
</tr>
<tr>
<td>Industry/Company</td>
<td>19%</td>
</tr>
<tr>
<td>Administrators</td>
<td>19%</td>
</tr>
<tr>
<td>Funders</td>
<td>20%</td>
</tr>
<tr>
<td>Researchers</td>
<td>17%</td>
</tr>
<tr>
<td>Policy makers</td>
<td>14%</td>
</tr>
<tr>
<td>Counselors</td>
<td>12%</td>
</tr>
<tr>
<td>Others</td>
<td>4%</td>
</tr>
</tbody>
</table>

Engineering Education Activities, Organizations, and Resources

KEY FINDING:

Multiple stakeholders mentioned the Museum of Science, Future Cities, FIRST programs, Project Lead the Way, and Tufts University’s Center for Engineering Education and Outreach as being active in engineering education.

What are the programs, initiatives, and activities in which stakeholders engage? What additional efforts are they aware of?

We asked stakeholders about the Massachusetts K–12 engineering education effort or activity they had been most engaged with during the past year. In response, interviewees and survey respondents provided the names of 97 efforts and activities, over 400 organizations, and over 200 individuals, some of which were mentioned more than once across respondents. A list of named organizations with websites is available in Appendix C. Those named multiple times include Boston’s Museum of Science, Future Cities, FIRST programs, Project Lead the Way, and Tufts University’s Center for Engineering Education and Outreach.

Interviewees representing institutions of higher education named the most organizations, followed by interviewees from K–12 education. Generally, stakeholders named organizations and efforts with which they are directly engaged, and had less knowledge about organizations and efforts that fall outside of the realm of their stakeholder group. For instance, company representatives tended to know about the schools where they hold competitions and some of the other competitions that exist; likewise, informal and out-of-school time stakeholders tended to name more of their contributors, colleagues, and competitors than those who serve different audiences. Therefore, building awareness at the intersection of stakeholder groups and their associated efforts could lead to new collaborations, opportunities, and innovative contributions to K–12 engineering education.

Stakeholders also consistently named several individuals who stand out as leaders in the local and, in some cases, national landscape of K–12 engineering education. The leaders represent different stakeholder groups, but their leadership has crossed sectors and engaged a variety of stakeholder groups, ultimately supporting more collaboration toward common goals (e.g., engineering education standards). Stakeholders also named a number of individuals more than once, those who rally the attention of pockets of stakeholders and have influence within a single sector, such as industry. Leveraging these individuals can help to bring stakeholder groups across sectors together.
When asked about the impacts of the engineering education efforts in which they are engaged, interviewees said that their efforts are having an impact by increasing awareness of engineering education, creating a positive shift in students' identification with STEM, and motivating student engagement in STEM. At the same time, most interviewees were reticent to talk about impacts, mentioning the limitations of current assessments, student exposure to engineering education (especially through a specific effort), and research on what impacts we might expect or want to have. However, stakeholders could talk about numbers of students, teachers, etc., served, and what types of experiences were offered to those audiences.

KEY FINDING:
More NSF awardees’ efforts target underrepresented students.

What audiences are served by the efforts named?
Most of the named efforts by survey respondents have a student audience, specifically “any student” (see Figures 4 and 5), meaning the effort does not target a specific subgroup of a larger group of students who could otherwise participate. However, the target audience isn’t necessarily
the same as the demographics of the actual participants, which may be constrained or supported by factors that affect student attitudes, engagement, and participation. NSF awardees are more likely engaged in efforts targeting special populations, including students of groups traditionally underrepresented in science and engineering, and students of color.

Overall, survey respondents know the most about efforts intended for middle school students. Forty percent of the named initiatives were intended for elementary (K–5) students, compared with 59% for middle school (6–8) and 50% for high school (9–12). Generally, stakeholders in our study tended to be aware of local efforts, many of which are small scale. Paradoxically, an interviewee stated that districts want large-scale and/or comprehensive solutions.

Stakeholders want engineering for all students; they mostly named efforts that are targeted at general student audiences, but, by their own admission, those efforts aren’t providing engineering education to all students. For instance, stakeholders named more initiatives at the middle-grades level, and more stakeholders indicated that engineering education at the middle-grades level should occur during out-of-school time; however, there isn’t currently an infrastructure for out-of-school time that includes all students. Therefore, the landscape is populated with many small programs serving their local communities. It may be easier to target specific populations in that landscape, but it is harder to ensure that all students have engineering education experiences, especially when there isn’t coordination between in-school and out-of-school time efforts.

**KEY FINDING:**

Stakeholders most want to work on building awareness, but they think that awareness isn’t enough. In addition, there needs to be a mechanism that matches resources with those who need them.

When asked about their knowledge of K–12 engineering education resources in Massachusetts—allowing them to define resource as they chose—interviewees discussed resources specific to funding, industry, programming expenses, standards, awareness, measurement, partnerships, and tools for teachers. Interviewees described the resources
that they and/or their organizations provide as research and evaluation services, professional development, and capacity to bring stakeholders together to share their tools. Respondents tended to know about resources that aligned with their own work.

Teachers, parents, and others searching on the Internet for information on engineering education may encounter a challenge. Organizations vary considerably in the focus, language, and level of detail that they use on their websites. We found that large for-profit companies often do not provide detail about their STEM education outreach efforts. Groups with a broad STEM focus may have related engineering efforts and resources, but they do not always provide much specificity about those opportunities on their websites. Public schools and districts typically have few details on their websites about STEM instruction at the elementary level. And organizations of different types use different terms for the age levels that they serve, if they give that information at all.

Although there are many available resources, individuals in our study indicated that the challenge is in finding what is relevant in the sea of what is available. Specifically, respondents felt a centralized system to access resources, a matchmaking service to connect interested stakeholders with efforts, and more effort in raising awareness of programs and marketing of materials would help inform interested stakeholders.

### Collaboration Among and Between Stakeholders

**KEY FINDING:**

Stakeholders collaborate much more regularly with K–12 STEM teachers than with community college faculty or policymakers.

**How are stakeholders currently collaborating? What future collaborations interest them?**

With the goal of understanding who has been working with whom in relation to engineering education and what the nature of those collaborations have been, we asked survey respondents how often and for how long they have collaborated with various stakeholder groups around K–12 engineering education efforts in Massachusetts in the past 5 years. We purposely did not define “collaboration” in our interviews or survey so that we would elicit the interviewees’ and respondents’ orientation to the concept.

Stakeholders are most frequently collaborating with K–12 STEM teachers (56%), and all respondents said that they had collaborated at a frequency of more than 4 times per year with all other stakeholder groups, except for community college faculty and policymakers. The NSF awardees responding to the survey frequently named faculty from BA-, MA-, or PhD-granting institutions as those with whom they collaborate with more often, though NSF-awardee interviewees did not indicate that they were regularly collaborating with other local awardees. (Incidentally, most NSF awardee survey respondents identified themselves as faculty from a BA-, MA-, or PhD-granting institution.) This connection is in line with a general interest of stakeholders in collaborating with those from their own sectors. In addition, there is an interest in multiple-year collaboration across many stakeholder groups. Only 12% of survey respondents indicated that they currently collaborate with faculty at community colleges more than 4 times per year, and only 26% indicated that they would be most likely to collaborate with faculty at community colleges in the future. Only 19% of survey respondents indicated that they currently collaborate with guidance counselors more than 4 times per year, and only 16% of survey respondents indicated they would be
most likely to collaborate with K–12 counselors around engineering education issues in the future.

When describing the emphases of potential future collaborations, respondents reported an interest in promoting awareness of K–12 engineering education opportunities in Massachusetts during the next 5 years most frequently (50%). Developing and/or testing assessment tools was the effort least likely to be engaged in among all respondents, even though they indicated this is a need when choosing factors needed to reach the goals for engineering education. NSF awardees, more frequently than non-NSF awardees, named participating in research on K–12 engineering education as an effort they would likely engage in during the next 5 years.

Stakeholders reported collaborating on programs for teachers (e.g., professional development), students (e.g., summer camps), or specific events (e.g., STEM fairs). Many responded that it would benefit schools if they collaborated more with community organizations, local businesses, and universities and colleges. Some noted the challenges of working in school systems and the level of support needed from school leadership to make collaborations possible and beneficial.

The response to industry was a bit more complicated. Those in our study mentioned both opportunities and challenges related to industry professionals' involvement in K–12 engineering education efforts. Industry is seen as being able to offer real-world experience to students and as having resources. However, the perception is that industry uses those resources in limited ways—often for short-term career exposure, role modeling, or staffing competitions—suggesting a desire for longer partnerships with industry. In addition, some mentioned that competition and branding by companies limits the degree to which they contribute.

And all stakeholders we interviewed mentioned the limits of time and the need for clear purposes and benefits for collaborating. When asked what kind of collaboration NSF awardees might want to engage in, they responded with comments such as these:

“One of the things that I would be interested in collaborating, for example, ... is pulling together a statewide conference.”

“We can have...a summer school, or summer institute, or summit at <named institution> that organized all these people who are interested in K–12.”

“If there was a Massachusetts collaborative that helped us get in front of more teachers. That’s the part that being at a university is really hard to do. ... It would be great to think of a collaboration where we can bring things together to help get our stuff in front of more teachers, and ... we could think about ways of making it more cohesive for the schools and districts.”

“Maybe you would create an entity that somehow should be funded and should be basically really a full-time operation, because when you do it on an ad hoc basis ... you just cannot really sustain it for a long time.”

In summary, there is an existing interest in collaboration with other stakeholders to advance engineering education, yet there are some perceived barriers that stand in the way, including a lack of leadership and the amount of time needed to work on efforts. This suggests there could be a need for a champion to motivate collaborators and sustain efforts.
Additional Opportunities and Challenges

We specifically asked stakeholders to consider opportunities for and challenges to improving engineering education. In addition to some of the perceptions mentioned above, stakeholders outlined those that follow. Many of the opportunities mentioned by some were considered by others as challenges to be overcome, and many of the challenges were also seen as opportunities.

**Hands-on and Authentic Learning:** Many stakeholders see value for all students in hands-on learning, such as the kind that engineering education can offer, but they acknowledge the challenge of outfitting classrooms with the supplies and equipment required by these kinds of experiences. Others mentioned that real-world and authentic learning experiences, such as those that industry can offer, can increase student engagement and better prepare them for careers in engineering.

**Funding:** Interviewees described available funding from their organizations, industry partners, and grant awards. Funding was often mentioned both as an opportunity—in terms of monies allocated toward expanding programs—and as a challenge, specifically around the competition for funds and their intermittent nature. Respondents noted that they seek diversified funding, in part, to ensure ongoing support.

“‘I believe that many teachers do not know how to educate their students about engineering topics because engineering remains a mystery to the general public, and teachers themselves need a greater background in the field to be able to teach it.”

—Survey respondent

**Teacher Professional Development:** Interviewees portrayed teacher professional development as an opportunity and the lack of teacher training as a challenge. That is, they feel that teachers haven’t had enough training in engineering education and do not feel confident about implementing it. Stakeholders see an opportunity to develop and deliver more professional development. “Supporting teacher professional development” was the second-highest (48%) effort selected by respondents when asked what they might like to collaborate on in the future.

**Comprehensive Solutions:** Although the landscape is populated with many small-scale efforts, they do not provide comprehensive opportunities, even in combination with some of the larger efforts (e.g., Science from Scientists). Districts are searching for these more comprehensive solutions (i.e., those that cover all or many of the grades and provide curriculum and professional development).
Recommendations

Recommendation #1: Focus on the Goal of “Engineering for All”

KEY FINDING:

Engineering education is included in the standards for all students in Massachusetts; therefore, all students should have equal access to high-quality engineering education.

The Massachusetts STEM Plan 2.0 “provides policymakers, educators, businesses, and parents with a common vision on how to move forward together to create a STEM-literate citizenry that is informed and prepared to fill the needs of a new and ever-changing innovative economy.” This goal implies that every student needs literacy rather than a few needing, for instance, career preparation. Only 12% of our survey respondents chose “to prepare students for a career in engineering” as one of the top three goals for K–12 engineering education. Most stakeholders in this study indicated STEM literacy as a primary goal for engineering education and named efforts that target all students (versus particular subgroups). NSF awardees identified inclusion of traditionally marginalized students as a priority goal. However, this study indicates that the stakeholders who participated recognize gaps in the opportunities available to students. These gaps appear to exist in some locations more than others (e.g., Brockton or Mattapan have fewer opportunities for students in engineering education than do Cambridge or Somerville, where advocates; institutions, organizations, and companies; and programs and resources are concentrated).

Efforts to align along a single goal, such as STEM literacy for all students, or a limited set of goals driven by leadership and supported by basic infrastructure, could promote continued improvement of engineering education in Massachusetts. This would be consistent with what has already been accomplished to formally align engineering education within the state standards. Furthermore, coordination around a set of goals would not have to be at odds with innovation if various efforts and stakeholder groups could work towards a broad goal, such as STEM literacy for all, but by means best matched to stakeholder groups’ (providers’ and users’) resources, interests, and needs.

While this study focuses on K–12 engineering education, there is an opportunity to leverage learning experiences across in-school and out-of-school time contexts to expand engineering education for all students. Stakeholders recognize that there needs to be more coordination across these contexts.

Literacy focuses on breadth of understanding... while competence is concerned with depth of understanding and skills in a specific ... area(s).

Source: Technical Competency. (2002). In G. Pearson & A. T. Young (Eds.), Technically speaking: Why all Americans need to know more about technology (p. 22).
Recommendation #2: Increase Strategic Awareness Building Through Matchmaking

**KEY FINDING:**

Individuals and organizations want some way of matching the resources that are available to those resources that meet their needs so funders, program providers, and others can more strategically address the gaps that exist and so users can better find services to meet their needs.

Most of those who responded to our survey expect to engage in a collaboration in the near future to raise awareness about engineering education. While there are many resources and opportunities available, not everyone is currently aware of them. There are some solutions in place, such as websites that provide information about people, organizations, and programs related to engineering education. They include national repositories (e.g., NAE’s LinkEngineering and NSDL’s TeachEngineering websites), and local repositories (e.g., the City of Boston and Boston After School and Beyond’s Boston Navigator). However, they do not include matching services.

District-based, regional, and state conferences and meetings, such as the Massachusetts STEM Summit, are important for raising awareness and developing crucial relationships for ongoing collaborations in which win-win agendas are built by the partners. However, these efforts typically reach only a portion of the population, and rarely parents, many of whom do not understand what engineering education is or why we should have it. This calls for more concerted efforts and synergy between industry, K–12 counselors, and K–12 educators to work together to help frame the conversations about the relevancy of engineering as a form of learning, as well as the potential career paths to which it can lead.

Recommendation #3: Support Collaborations To Develop and Effectively Implement Formative and Interim Assessments

**KEY FINDING:**

Assessments need to measure engineering-related outcomes.

The MCAS science and technology/engineering test is administered to fifth and eighth graders and to high school students. The National Assessment of Educational Progress (NAEP) technology and engineering literacy (TEL) assessment was taken by eighth-grade students across the nation in 2014. However, stakeholders in our study believe that we do not have the assessments that we need, while paradoxically stating that there is too much emphasis on high-stakes testing, which can limit the focus on good engineering education and may impact which students have access to these learning opportunities. This contradiction may indicate a need for assessments that are first specifically designed for the types of learning that engineering education affords and then are used to support students’ learning.

“There are a ton of resources out there but sometimes it’s hard to sort through them all and find the ones that are relevant to what I’m trying to do and how I want to do it. I wish there was a better way to sort through all the information so I could better target the resources that are interesting and relevant to me.”

—Survey respondent
We believe that formative and interim assessments can be leveraged to support teaching practice, which in turn can support students’ opportunities to learn. Teachers need professional development to effectively implement these types of assessments in addition to having the assessments they need.

**Recommendation #4:**
**Leverage NSF Awardees**

**KEY FINDING:**

NSF awardees may be an underutilized asset in the local landscape.

Many of the region’s signature K–12 engineering education efforts have benefited from NSF funding (e.g., Boston’s Museum of Science’s *Engineering is Elementary* and WGBH’s *Design Squad*), and many K–12 engineering education awards have been made to local institutions through NSF’s Education and Human Resources directorate alone. In addition, many NSF awardees have built extensive networks with practitioners that can be leveraged (e.g., UMass-Boston and Northeastern University’s work with Boston Public Schools through the Boston Science Partnership, WPI’s STEM Education Centers’ support of schools implementing Project Lead the Way, and Tufts CEEO’s STOMP, which matches undergraduate mentors with teachers interested in integrating engineering into their curricula). NSF awardees bring lines of inquiry about engineering education through their research into the local conversation. They contribute expertise, and develop and test curricula, professional development, and/or tools at school sites and informal settings. Their target audience is often underrepresented populations.

However, there is room for more local engagement and opportunity to leverage these assets for the benefit of the local community, while also informing national research and development through collaborations with local stakeholders. The leads of NSF-funded projects whom we interviewed reported that they did not regularly meet with other local awardees. Since the average duration of NSF funding is typically 2.9 years for research grants, engagement of awardees over time in a manner that fosters relationship building with local populations, ongoing collaboration to respond to local needs that can be addressed by research and development activities, and intra-awardee coordination will require innovative solutions and/or additional sources of funding to maintain coordinated and collaborative engagement. In addition, it will be important to identify the ways and purposes for collaborating that interest NSF awardees and those with whom they might collaborate.
Conclusion

Massachusetts has a rich history in terms of how K–12 engineering education evolved to be recognized as a component of formal teaching and learning within its articulated framework. Participation from the state’s institutions of higher education, private and nonprofit businesses, educators, and NSF researchers have all made significant contributions that foster a robust platform for K–12 engineering education in both formal and informal learning contexts. An ecosystem is forming with support at the state level from the Governor’s STEM Advisory Council and the STEM Pipeline Fund, which provides resources to help replicate and scale promising efforts that align with the goals and objectives of the STEM 2.0 plan.

With these supports in place, Massachusetts has the infrastructure to shepherd the innovation and dissemination of resources, models, and tools to further enhance K–12 engineering education within the state and at the national level. In this regard, Massachusetts is a model for other states as they consider the design and implementation of a K–12 engineering education ecosystem by identifying their key stakeholder groups across sectors related to policy, industry, education, and informal contexts.

The current landscape for Massachusetts indicates that while there is an established foundation in engineering education, there are clear gaps related to how the various stakeholder groups define engineering in the context of K–12, a central focus and concentrated effort placed on developing appropriate assessments, and a need to tailor resources to match the specific needs of the representative stakeholder groups. For Massachusetts to continue to make progress and stay ahead, these issues will need to be tackled in a purposeful and coordinated way that addresses the system as a whole. In addition, there are also gaps related to the development and dissemination of innovations that often concentrate in particular areas/regions (e.g., Greater Boston, Worcester).

As we bring engineering into the K–12 setting, teacher training (both in-service and pre-service), curricular models, and even parent education are required for system reform.

and do not always have broad reach and participation with respect to students from underserved communities. The current silos that exist within and between stakeholder groups limit the full potential of K–12 engineering education. Many resources and opportunities already exist, but folks are not always aware of them or accessing them to capacity. In this context, it is critically important that there be more synergy between key stakeholder groups to further enable greater reach of resources to broader audiences of students and teachers across the state. This may include engaging existing and new stakeholders in awareness-building efforts—increasing awareness is key. Since stakeholders expressed interest in more collaboration, stakeholders could work together to build on their interests to target specific needs, such as increasing access to engineering for all students and providing quality professional development for teachers.

One group of stakeholders, NSF awardees with engineering education projects, are key contributors to a national engineering education innovation effort. They could work with local stakeholders to find innovative solutions to address local needs that have national relevance, as well as disseminate their past and current innovations. However, this type of inter-sector collaboration would require altering an existing infrastructure or creating a new one, and funding an organizing entity to support the collaboration.
Endnotes


2 Ibid.


10 National Science Foundation Advanced Search. Retrieved February 27, 2016, from https://www.nsf.gov/awardsearch/advancedSearchResult?PlId=78565&PIFirstName=Christine&MILastName=Cunningham&PIOrganization=11000000&PIState=MA&PIZip=02110&PICountry=US&PropOrganization=11000000&PropElieCode=46&BooleanElement=And&AwardNumberOperator=Eq&AwardAmount=&AwardInstrument=&ActiveAwards=true&ExpiredAwards=true&OriginalAwardDate=20160227&StartDateOperator=Eq&ExpDateOperator=Eq


19 Ibid.


27 Ibid.


30 Ibid.

The project team would like to acknowledge the contributions of Carissa Brownnoter, Jonathan Dietz, Linda Hirsch, the interviewees and survey respondents who gave us their time and shared their thoughts. In addition, we thank the Massachusetts STEM Summit for the opportunity to convene a panel of thought leaders in K–12 engineering education research and practice, as well as the participants who represented the various key stakeholder groups.
Appendix A: Stakeholder Interviews
Massachusetts Engineering Innovation and Dissemination Community (MEIDC)

This report presents findings from stakeholder interviews conducted for the MEIDC1 K–12 Engineering Education in the Greater Boston region project from February 2015 through October 2015.

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1 This project is funded by the National Science Foundation, grant #DRL-1450532.
1. Overview

Interview Protocol Development
In October 2014, during the visioning of this landscape study, the project team developed example questions to frame the stakeholder interviews. The team revised the interview protocol (see page 14) slightly in March 2015, after field testing. The team designed interview questions to learn about what identified stakeholders knew about the following broad topics:

- Key organizations involved in advancing engineering education in Massachusetts, specifically the Greater Boston region
- Key individuals involved in advancing engineering education in Massachusetts, specifically the Greater Boston region
- Resources committed to efforts to improve engineering education
- Opportunities and challenges around K–12 engineering education in Massachusetts
- Interest in collaboration with other stakeholders to advance engineering education

Interview Data Collection
Over the course of nine months, the project leads interviewed 45 individuals representing various stakeholder groups related to K–12 engineering education in Massachusetts. Based on these interviews, we assigned interviewees to a primary stakeholder group. Table 1 provides a breakdown of interviewees by primary stakeholder group. In addition, some stakeholders have affiliations with a secondary stakeholder group. For instance, some of the faculty at institutions of higher education and staff at informal and nonprofit organizations are also NSF awardees.

Interviewees

Table 1: MEIDC interviewees by primary stakeholder group

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Number of Interviewees</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions of higher education faculty or administrator</td>
<td>12</td>
<td>12</td>
<td>27%</td>
</tr>
<tr>
<td>Industry/company employee</td>
<td>8</td>
<td>8</td>
<td>18%</td>
</tr>
<tr>
<td>K–12 teacher or administrator</td>
<td>8</td>
<td>8</td>
<td>18%</td>
</tr>
<tr>
<td>Informal/out-of-school time educator or administrator</td>
<td>6</td>
<td>6</td>
<td>13%</td>
</tr>
<tr>
<td>Government employee</td>
<td>5</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>Nonprofit organization employee</td>
<td>5</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>Funder</td>
<td>1</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>45</td>
<td>100%</td>
</tr>
</tbody>
</table>

As shown in Table 2, when primary and secondary status were combined, the interviewees represented nine stakeholder groups. The groups represented most were higher education faculty and/or administrators (12 interviewees) and NSF awardees (10).
Table 2: MEIDC interviewees combined stakeholder group representations, from most to least

<table>
<thead>
<tr>
<th>Combined Primary and Secondary Stakeholder Groups</th>
<th>Stakeholder Representation</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutions of higher education faculty or administrator</td>
<td></td>
<td>12</td>
<td>19%</td>
</tr>
<tr>
<td>NSF grantee</td>
<td></td>
<td>10</td>
<td>16%</td>
</tr>
<tr>
<td>Informal/out-of-school time educator or administrator</td>
<td></td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>K–12 teacher or administrator</td>
<td></td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>Non-profit organization employee</td>
<td></td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>Industry/company employee</td>
<td></td>
<td>8</td>
<td>13%</td>
</tr>
<tr>
<td>Government employee</td>
<td></td>
<td>5</td>
<td>8%</td>
</tr>
<tr>
<td>Funder</td>
<td></td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Media</td>
<td></td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>64</td>
<td>100%</td>
</tr>
</tbody>
</table>

Interview Analysis

The interviews were audio-recorded and sent to an external service for transcription. During the collection of interviews, the project team utilized a database software, FileMaker Pro, to organize the data. Specifically, the team used the database to quickly identify named organizations and individuals for the purposes of enhancing a Web search and selecting additional interviewees. In addition to forty-five interview transcriptions, the team coded two documents containing interview notes and one document with a listing of local school collaborators, for a total of 48 documents.

The project team coded interview transcripts using both predetermined code categories based on the interview protocol and additional codes that were constructed around emergent themes. Initial coding occurred within the FileMaker Pro database until August 2015, when the project team gained access to qualitative data analysis software, Atlas.ti-v7. The initial codes from the database were transferred to Atlas and all forthcoming interviews were coded in Atlas alone.

After interviews were completed by October 1, 2015, the project team used the qualitative data analysis software to sort and code the data into additional categories and themes. Throughout analyses, categories and themes were merged and refined as needed.

Results

Results from analysis of the interview data are organized around the following six interview topic areas and are provided in the following sections.

In March 2015, the interview questions were revised to include the following:

1. Key organizations involved in advancing engineering education in Massachusetts/Greater Boston region
2. Key individuals involved in advancing engineering education in Massachusetts/Greater Boston region
3. Resources committed to the effort to improve engineering education
4. Compelling opportunities around K–12 engineering education in Massachusetts
5. Challenges facing those who would like to influence K–12 engineering education in Massachusetts
6. Involvement in future efforts
2. Key Organizations

Interviewees were asked to discuss the organizations they feel are key to advancing K–12 engineering education in Massachusetts.

- Interviewees named and discussed 421 distinct\(^2\) key organizations.
- The most frequently named organizations included museums, universities, K–12 schools, and government, specifically, the Museum of Science, Boston; Governor’s STEM Advisory Council; Massachusetts Institute of Technology (MIT); Northeastern University; Boston Public Schools; STEM Regional Networks; University of Massachusetts–Boston; and Tufts University.
- Interviewees representing institutions of higher education named the most key organizations (194) and those who represent K–12 education named 77 key organizations.

Programs

In addition to naming organizations, interviewees discussed how they have worked with organizations and the outcomes of their work. The majority of these examples of working together described particular programming efforts for teachers (i.e., professional development) and students (i.e., summer camps), or specific events (i.e., STEM fairs).

Specific Efforts

Interviewees discussed efforts specific to curricula, competitions, mentoring, courses for students, and professional development for teachers. Examples of each are provided in Table 3 below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curricula</td>
<td>Project Lead the Way</td>
</tr>
<tr>
<td>Competitions</td>
<td>An online bridge contest at engineeringyourfuture.org</td>
</tr>
<tr>
<td>Courses/field of study</td>
<td>Shops and courses at Minuteman Technical High School</td>
</tr>
<tr>
<td>Professional development</td>
<td>University of Massachusetts and Worcester Polytechnic Institute’s STEM Education Resource Center</td>
</tr>
</tbody>
</table>

3. Individuals

Interviewees were asked to discuss the people they feel are key to advancing K–12 engineering education in Massachusetts.

- Interviewees named over 200 individuals.
- The most frequently named individuals were Yvonne Spicer, Jake Foster, and Martha Cyr.
- Interviewees named a high number of key people (113) representing institutions of higher education and 40 key people representing K–12 education.

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\(^2\) This number could be slightly inflated. For the purposes of this report, a distinction was made between an institution with multiple campuses (i.e., UMass Amherst and UMass Boston), an institution that hosts a center (i.e., Tufts University and the CEEO), or an organization that has an associated center (i.e., Museum of Science, Boston, and the National Center for Technological Literacy).
4. Resources

When asked about their knowledge of K–12 engineering education resources in Massachusetts, interviewees discussed resources specific to funding, industry, programming expenses, standards, awareness, measurement, partnerships, and tools for teachers. Selected quotations of each example are provided below.

Funding Resources

• Organizational Funding. One interviewee described the amount of their organization’s budget dedicated specifically to STEM: “…our entire organizational budget is about $3 million a year …what funding is earmarked for STEM is significantly lower, unfortunately…right now, I would say probably about $200,000 a year is earmarked specifically for STEM.”

• Industry Funding. An interviewee explained the monetary commitment that industry partners have made to schools across the United States: “[Two industry partners] have each earmarked $6 million over a three-year time frame... and focus in on a high-needs area, to put [our program] into as many middle schools, high schools, and elementary schools as possible.”

• Grant Funding. Another interviewee shared how they used grant funding from Mass Life Sciences to test their program activities: “We got funding from [granter] a few years ago to test engineering/Maker activities and develop workshops focused on making and engineering, and that project got us thinking about the skill set that is necessary for kids to be able to make and engineer.”

Other Resources

• Standards. An interviewee discussed Massachusetts’ early supportive role of K–12 engineering education standards: “Massachusetts is one of the—it was the first Department of Education to develop K–12 engineering standards.” Another interviewee described their opinion of the importance of connecting the standards in K–12 engineering curricula: “Everything has to be based on the frameworks and the standards. So, yes, it’s fun to bring a fun robot into the classroom, but if it doesn’t tie back to the standards then, you know, I’m less interested.”

• Public Policy. Another interviewee identified K–12 engineering education as the top priority in their organization’s public policy agenda: “So, when you ask about resources, I don’t know how to quantify that except to tell you that it is the top agenda item—public policy agenda….”

• Measurement. An interviewee discussed their organization’s capacity for education research and evaluation, as well as bringing stakeholders together to share their tools: “We have a big focus on measurement and evaluation, [such as] common validated measurement tools to assess program outcomes … for students as well as overall program quality and implementation, for instance, design, and instruction, and all of those different pieces. So by bringing that all together, we have a pretty powerful engine for continuous improvement in the out-of-school time learning sector in Boston. We bring research and evaluation partners [from Massachusetts] … their researchers, and their evaluation tools together to provide a very comprehensive view of program quality for each program that’s involved with us, and then [we develop] a visually appealing, concise report that pulls all of those different tools together into something that’s meaningful and meant to start a conversation on how to improve with programs. And we also provide a comparison point for all programs in the city. The beautiful thing about using standard measurement tools is that everybody speaks the same language and can compare their outcomes with the outcomes of other programs in the city. So we provide that.”

• Research and Evaluation Support. One interviewee shared the types of resources their organization provides, including research and professional development resources: “So the kinds of resources that we provide are—so a lot of measurement and evaluation services, and then professional development based on that.”

• Partnerships. One interviewee discussed partnerships their members have with local companies: “[A local company], for example, will partner with [our school], develop curriculum, and then hire the kids coming right out of college—out of the school. It’s their own workforce pipeline. But we do hear more and more that individual companies are partnering with schools….”

• Teacher Tools. An interviewee named some of the organizations that are developing curricula and tools for teachers: “MassCAN is the Massachusetts Computer Attainment Network, and they are helping us develop the next AP Computer Science course here.”
5. Opportunities

Interviewees discussed efforts specific to learning and teaching, curriculum resources, leadership, engagement and motivation, technology resources, workforce opportunities, and standards and assessments. Selected examples of each are provided below.

- **Authentic and Hands-on Learning Opportunities.** One interviewee discussed the opportunities engineering education provides for authentic learning: “There’s the opportunity to get students interested in STEM because engineering is play. It is purposeful, intentional, creative, iterative play at the end of the day.” Another interviewee discussed experiential learning: “If the state decides to adopt the new version of STE standards, and teachers can really think about the integration of engineering with content, then we are moving toward that more hands-on experiential learning that we know works for children.”

- **Workforce Development.** An interviewee described results from a survey they administered to industry stakeholders, which found a need for hands-on learning to prepare students for the workforce: “I think business folks generally think education’s good, but when it comes to preparing kids for the workforce, companies are kind of doing it themselves to the extent that they can. When we drilled down a little bit on that, what we found was that they feel like—particularly in engineering and STEM—that hands-on experiential learning is the best way to get students the competencies they need to be hired....” Another interviewee expressed their opinion about the importance of engineering skills for careers: “Any student that gains that in K–12 education, it’s going to obviously make them a better prepared adult for the workforce.”

- **School Leadership.** One interviewee mentioned the leadership at [school district] and their hope that it will bring more opportunities for working with community organizations and local businesses: “In [my city], I think the new superintendent is very interested in career-focused learning pathways and subject-area-focused learning pathways. And he sees schools as the hub of information for a community or neighborhood, so I know that he is a big proponent of school community partnerships, and I think that under his leadership, there’s a really big opportunity for more STEM-focused organization with companies, etc., to work with students in school directly. And hopefully, it will reduce the barriers that many community organizations have found in the past to working directly with schools. I think that that presents a huge opportunity for STEM learning in [my city].”

- **Industry Mentors.** One interviewee discussed how they believe working with professionals can engage students: “One of the things, when I taught at the middle school level, a number of students got interested in engineering at the middle school level, and we offered a whole day of meeting people in the field of engineering, different people in engineering within the school, so students had a chance to find out what the different careers were like....”

- **Awareness.** Another interviewee shared their opinion about opportunities with local institutions of higher education: “I feel like the university, in some ways, is an untapped resource. And that there’s just so much wonderful engineering education going on... So it’s just—it seems like sometimes there’s not enough awareness, necessarily, of all the opportunities that are there to have K–12 work with university.... So there’s—we have such amazing, unique engineering resources here in Massachusetts that we don’t always take advantage of.”

- **Standards.** One interviewee discussed how Massachusetts has the opportunity to be a continued leader in moving forward through standards: “I think NGSS framework is a great opportunity for the state, but also nationally. Massachusetts has always been a leader in that.” Another interviewee concurred: “I really do believe Massachusetts is (A) so lucky to have engineering standards and (B) so lucky to have so many resources... to be uniquely poised to be a real leader in this work.”
6. Challenges

Interviewees discussed efforts specific to where engineering education should fit in the K–12 curriculum, and how engineering education is defined. Selected examples of each are provided below.

Fit

Interviewees had a lot to say about the challenge of determining how and where engineering education should “fit” into the K–12 curriculum. Some support engineering being integrated within currently taught subjects, and others argue for stand-alone courses. Additionally, some describe engineering learning at different grade levels.

• Integrated. One interviewee explains how the need for K–12 engineering education has been identified, but where and how it should be taught are still unknowns: “I don’t know which way is the right way to do it. I don’t know if you integrate it into every subject area or if you just have kids learn it when they learn it. I don’t know any of those answers. But I do know that … an increase in the number of jobs [is] going to need some type of computer literacy and fluency skills. And that we’re not going to be able to maintain our strong economy in Massachusetts unless we’re able to produce people with those skills.” One interviewee describes the resistance around including engineering within the science curriculum: “Some people have resisted, for lots of different reasons, bringing engineering into the science standards or into the science umbrella, and I think—I don’t think we’re going to get every kid in this country to take an engineering class or have an engineering experience unless we find a way to fit it into what we call the “fab five” here in [our school]: math, English, science, history, world language.” Another interviewee described how they fit engineering into their teaching: “Physics teachers tend to have the easiest time, I think, with finding places to put the engineering in, but I also think it was really important for me to take advantage of the professional development for my department.”

• Stand-Alone. One interviewee shared the challenge of finding a way to fit engineering into other courses: “I haven’t yet really found what I think is a relevant, scalable way of doing this with the time constraints that you have during school. And the reality is, you know, this week they’re learning about engineering, but two weeks from now they’re learning about butterflies. And either you learn how to insert the engineering into the butterfly topic, or you have to, you know, create a lesson on butterflies…. So every lesson almost needs to stand alone. And, you know, you have to tackle a different topic, and I think this is one of the big challenges that the system faces in general.”

• Career Technology Education. An interviewee described how engineering is being taught at their school: “You know, [our school] also has similar cross-pollination with career vo-tech advisors, the science department has there. They have engineering courses that are offered within science, but then they also have engineering courses within their career, vocational, technical education program over there.”

• Replacement. An interviewee raised the concern that if engineering were added to the curriculum, it would need to replace something else because of time constraints: “Now, at the same time, there’s not enough time in the day, so they also expect the students to have a world language, English, math, social studies, so there’s really not enough time in the day. So, if you were to add engineering to the mix, what would come out?” Another interviewee shared a similar view of having to make tradeoffs to include engineering in K–12 education: “It’s a tradeoff. When you have made one of those tradeoffs, so, that’s another situation where individual schools have to make up their minds about what will be taken away…. If we build our engineering program up, what gets diminished?”

• Introductory Course. One interviewee discussed the need for engineering to have its own introductory course: “If you look at a college, there is no singular entry course that is widely accepted as the intro engineering course…. I think that [university] might call it unified engineering, but it’s not unified—it’s unified for them, but it’s not unified for the country, but I think that colleges and universities haven’t really decided for themselves what an entry engineering program looks like. There are plenty of folks that know what physics, chemistry, and biology look like and that’s why you have AP courses the way they are.”
Definition
Interviewees also had a lot to say about the how to define engineering education and its purpose at the K–12 level. Some argue it is not a science, others note that there is a lack of a common definition and understanding, and some discuss how parents can need support in understanding what it means.

- **Not a Science.** One interviewee expressed their opinion that engineering is not a science: “It’s also, I think, helping to define that engineering is not science. … I think sometimes there’s some confusion out there in the education field. This is part of the problem, I think, sometimes is we have people who are in charge not having a clear concept of what we’re talking about.”

- **High School.** Another interviewee shared the concern that there is no common way to define engineering education at the high school level: “I think that there’s no set of uniform understanding of what engineering looks like in the high school. I think it just comes down to that.”

- **Engineering for All.** One interviewee shared their opinion of the purpose of engineering education: “There’s a little bit of tension about what that means, in terms of, are we driving the STEM pipeline? Are we pushing towards technical literacy, or are we just trying to get kids to do cool stuff in the school? So, even there, that’s a piece where there’s different purviews. I’m driving the center towards this, you know, this engineering for all.”

- **Parents’ Understanding.** An interviewee described their challenge of defining engineering education to parents: “One of the big challenges with our youth—and, in fact, I just had to talk to a parent because the parent didn’t understand why it was really important for her daughter… because a lot of our families, when they think about engineering, when they think about technology, they think about the dangers of it, they think about Facebook. They think about texting. They think about things that are actually dangers in their kid’s life. They really don’t know what the creative possibilities of engineering and technology are.”

Other
- **Assessments.** One interviewee discussed their opinion of educational assessments: “Another challenge is a macro challenge. It affects all education. It’s the assessments, right? State assessments. Right now I would argue we’re in a pendulum swing towards the momentum of really hyper-focusing on state assessments and teaching to the test. That is really impacting students and teachers and administrators on so many levels, especially in urban schools and rural schools where they might not be performing at proficiency level, and therefore have to be really attentive to that need.”

- **Informal.** Another interviewee noted the challenges to bringing engineering education to the informal space: “I think some challenges that—I mean, sort of in terms of out-of-school time programs, we have—a very small percentage of all of the youth development opportunities in Boston are STEM-focused. So I think that one challenge is convincing other out-of-school time education or program providers … of their ability and confidence in delivering STEM programming, and that it’s not so different from what they’re already doing. And so that’s an initiative that we’re taking on there this summer. I think that’s a challenge, providing the professional development and training and sort of confidence-building for staff that might not necessarily have a background in the STEM field, but they are—that they are capable of facilitating students in learning those skills in that content area. I think that that’s a challenge.”

7. Opportunities and Challenges

Interviewees also discussed many opportunities that were also seen as challenges, particularly around funding, industry involvement, and teacher professional development. Selected examples of each are provided below.

- **Funding.** Throughout the interview sessions, funding was often discussed as both an opportunity—in terms of monies allocated to expanding programs—but also as a challenge, specifically around the competition for funds among many subjects. Below, comments from two interviewees shed light on this dichotomy.
Opportunity: “So the good news is we’ve got a couple of federal grants, NSF grants, .... We’re looking to expand our source of support beyond the [contribution] from the state and the matching funds to foundations. We want to build capacity [with] partners so that we’ll all [be] about getting engaged in this.”

Challenge: “I think that science education and, especially engineering education, kind of falls to the side in a lot of cases. It’s not a priority. So I think that that is a challenge, and that most federal grants really only depend on math and ELA scores in terms of support and turnaround and that sort of thing. So I think until the accountability structure changes in terms of what schools have to report, that is going to continue to be a challenge.”

Industry Support. Industry was mentioned frequently during interviews, both as a way to provide funding and resource support, and as a way to include their employees in K–12 engineering education. In regards to resources, one interviewee discussed how opportunities exist for future collaborations; however, another interviewee shared how not all stakeholders are interested in working together, as illuminated in selected comments below.

Opportunity: “There’s really an opportunity for engineering industries to provide resources, and support, and connections. Maybe that could be done through the STEM network or other coordination bodies like that.”

Challenge: “We don’t want to be the flavor of the month, but sometimes that’s what happens with private industry…. You want to count on private industry, but it may be that they’re only investing in it when the time is right for them … they’re trying to use these things, sometimes, for their own advancement and their own advertising and, when it’s not in their best interest, sometimes they fade out.”

Industry Involvement. Interviewees also discussed the opportunities and challenges for having industry professionals involved in K–12 engineering education efforts. Selected examples of each are provided below.

Opportunity: “When it comes to industry in particular, most of them choose to partner with K–12 school districts in a very philanthropic way. And so, they often will send their employees in to do, like, a one-day drop-in thing, or maybe volunteer after school on a more regular basis, which would be fantastic.”

Challenge: “You pick a biotech company, ... I mean, these guys all have internal programs, not engineering-wise, but, you know, you could argue bioengineering is engineering, as well. But, they try to send volunteers out into the community to get kids to understand what the different career opportunities are. At least in my opinion, you also have to be very careful who you’re sending, because people with great intentions aren’t always the right people to be role models. So you kind of, at least from what we do—we’re very careful about picking and training and making sure that the folks that we’re sending are charismatic and fun and lively enough to engage a ten year old.”

Teacher Professional Development. Interviewees also discussed some of the training available to teachers, yet others noted there are challenges to implementing teacher development resources, as shown in comments below.

Opportunity: “All of our vocational teachers [must] have industry experience, both training and have worked in industry for at least three years minimum.”

Challenges: “I think a lot of teachers, they don’t understand the academic content so sometimes the translation to how that’s implied in the real world is not fully realized. There might be some lack of knowledge or gaps.”

Teacher Capacity. Along with the opportunities and challenges for teacher professional development, interviewees perceived some concerns around teachers’ level of comfort in teaching K–12 engineering curriculum. One interviewee sees this as a missed opportunity, while another interviewee finds it a real challenge, as described in comments below.

Opportunity: “We just don’t often have the time or teachers comfortable enough or administrators supportive enough to let students really authentically engage in engineering design. So, I think that’s a missed opportunity that somehow we need to work on.”
Challenge: “It [would] be nice to be able to train teachers better upfront so that if you’re going to become a science teacher, you actually have taken some engineering class. … And maybe … and trying to help teachers at least to become a little bit more comfortable with the material. But I think that’s challenging, because if you’ve never seen a science or engineering class, it’s very, very difficult … to [quickly] become comfortable enough with the material to be able to design lessons to teach.”

8. Collaboration

Interviewees discussed the K–12 engineering education collaboration efforts they would like to be involved with in the future. Many shared what they feel would need to happen before collaboration could begin.

Types of Collaboration

One interviewee suggested having less-formal meetings for initial collaboration efforts: “I could see, kind of, one-day opportunities for people to come together and collaborate in some quasi-structured way. Like, you’re interested in expanding your engineering program, here’s an opportunity to get together with other people. Does that make sense? Not necessarily a formal presentation, but an opportunity—we use a lot of protocols for meetings here—so opportunities for structured conversations around a topic as opposed to somebody necessarily presenting material, and an opportunity to collaborate.”

Needs for Collaboration

To collaborate well in the future, NSF awardees, in particular, reported the need for both better leadership and more time.

In regard to leadership, one interviewee shared, “We need a charismatic leader. Rep. Kennedy already committed to STEM. [My colleague] would always say, look around you. What would it look like if there were no engineers? Someone would say we would all be naked on the ground. [My colleague] got people to appreciate the importance of engineering.”

And in regard to time, another was interested in collaboration, but noted time is an issue: “Time is always the issue. I firmly believe this is a collaborative process. No one person is going out and solving this by themselves. And if we’re not sharing best practices with each other and just support that you’re not the only one fighting this battle and coming together as a community, that’s an important thing. That’s why I’m part of it because I feel that they can support me and I can also contribute ideas and brainstorming things with them.”

9. Summary

• Interviews confirmed there are many key organizations and individuals involved in advancing engineering education in Massachusetts/Greater Boston region.

Interviewees provided multiple programming efforts—some previously known to the study and some not—resulting in over 400 organizations mentioned altogether that are involved in advanced engineering education. These additions allowed the study to include efforts not already discovered in the Web search analyses, which created a more robust view of the current landscape. In addition to naming organizations, interviewees discussed their experiences working with the organizations and the outcomes of their work. The majority of examples of organizational collaborations included teacher professional development, summer camps and other out-of-school time experience for students, or specific events like STEM fairs.

• Interviews provided a means to discuss the varied resources committed to efforts to improve K–12 engineering education in Massachusetts.

When asked about their knowledge of K–12 engineering education resources in Massachusetts, interviewees discussed resources specific to funding, industry, programming expenses, standards, awareness, measurement, partnerships, and tools for teachers. In regards to funding resources, interviewees described organizational budgets dedicated specifically to STEM,
funding from industry partners, and grant funding to test their program activities. Interviewees mentioned the importance of connecting to the standards in K–12 engineering curricula; the types of resources their organizations provide, including research and professional development resources; and their organizations’ capacity for education research and evaluation, as well as bringing stakeholders together to share their tools.

• Both opportunities and challenges exist around K–12 engineering education in Massachusetts; some issues are discussed as both an opportunity and a challenge.

Interviewees illuminated many of the opportunities and challenges to implementing K–12 engineering education in the state, and especially provided insight to those issues that can be seen as both opportunities and challenges.

Opportunities. Interviewees discussed efforts specific to learning and teaching, curriculum resources, leadership, engagement and motivation, technology resources, workforce opportunities, and standards and assessments. They discussed the opportunities engineering education provides for authentic learning; results from a survey they administered to industry stakeholders, which found a need for hands-on learning to prepare students for the workforce; the leadership at their school districts and their hope that it will bring more opportunities for working with community organizations and local businesses; how they believe working with professionals can engage students; their opinions about opportunities with local institutions of higher education; and how Massachusetts has the opportunity to be a continued leader in moving forward through standards.

Challenges. Interviewees discussed efforts specific to where engineering education should fit in the K–12 curriculum, and how engineering education is defined. Interviewees had a lot to say about the challenges of determining how and where engineering education should “fit” into the K–12 curriculum. Some support engineering being integrated within currently taught subjects while others argue for stand-alone courses. Additionally, some describe engineering learning at different grade levels. Interviewees also had a lot to say about how to define engineering education and its purpose at the K–12 level. Some argue that it is not a science; others note that there is a lack of a common definition and understanding; and some discuss how parents can need support in understanding what it means. Future research may further explore the challenges to defining the goals of K–12 engineering education without a common definition, and the challenge of implementing programming when there are differing views on where and how it should fit in the K–12 curriculum.

Both Opportunities and Challenges. Interviewees also discussed many opportunities that were also seen as challenges, particularly around funding, industry involvement, and teacher professional development. Throughout the interview sessions, funding was often discussed as both an opportunity—in terms of monies allocated to expanding programs—but also as a challenge, specifically around the competition for funds among many disciplines (i.e., science, math, engineering). Industry was mentioned frequently during interviews, both as a way to provide funding and resource support, and as a way to include their employees in K–12 engineering education. In regards to resources, one interviewee discussed that opportunities exist for future collaborations; however, another interviewee shared how not all stakeholders are interested in working together. Interviewees also discussed the opportunities and challenges for having industry professionals involved in K–12 engineering education efforts. Interviewees discussed some of the training available to teachers, yet others noted there are challenges to implementing teacher development resources. Along with the opportunities and challenges for teacher professional development, interviewees perceived some concerns around teachers’ level of comfort in teaching K–12 engineering in the classroom.

• There is an existing interest in collaboration with other stakeholders to advance engineering education.

Interviewees discussed the K–12 engineering education collaboration efforts they would like to be involved with in the future. Many shared what they feel were challenges to collaboration, including a lack of leadership and the amount of time needed to work on efforts. Future studies may focus on the different models of collaborations that could be implemented and the resources needed to develop and sustain them.
Interview Protocol

In October 2014, during the visioning of this landscape study, the project team developed example questions to frame the stakeholder interviews. These initial interview questions included:

- What are the key organizations involved in advancing engineering education in Massachusetts, and especially the Greater Boston region? Have you worked with them? When and how? What were the outcomes of that work?
- Who do you think are key individuals involved in advancing engineering education in Massachusetts, and especially the Greater Boston region? Have you worked with them? When and how? What were the outcomes of that work?
- What resources have you or your organization committed to the effort to improve engineering education?
- What are a few of the most compelling opportunities and challenges around K–12 engineering education that you think we need to address in Massachusetts?
- Which organizations in Massachusetts would you like to collaborate with to advance engineering education? Which individuals?

In March 2015, the interview questions were revised to include the following:

1. [no change] What are the key organizations involved in advancing engineering education in Massachusetts, and especially the Greater Boston region?
   a. Have you worked with them?
   b. When and how?
   c. What were the outcomes of that work?

2. [no change] Who do you think are key individuals involved in advancing engineering education in Massachusetts, and especially the Greater Boston region?
   a. Have you worked with them?
   b. When and how?
   c. What were the outcomes of that work?

3. [no change] What resources have you or your organization committed to the effort to improve engineering education?

4. [reworded] What are a few of the most compelling opportunities around K–12 engineering education in Massachusetts?

5. [new question] What are a few of the challenges facing those who would like to influence K–12 engineering education in Massachusetts?

6. [reworded] What efforts would you like to be involved with in the future?
   a. Are you interested in collaborating with others (e.g., people, organizations) to advance engineering education in Massachusetts?
   b. If so, which ones? Who?
   c. Describe the characteristics of that collaboration?
Appendix B: Stakeholder Surveys

Massachusetts Engineering Innovation and Dissemination Community (MEIDC)

This report presents findings from the MEIDC1 K–12 Engineering Education in the Greater Boston Area survey administered to multiple stakeholder groups during fall 2015.

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1. Overview
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   - Survey Administration
   - Respondents
   - Results

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   - Existing Support for K–12 Engineering Education Goals
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   - Goals
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5. Collaboration
   - Current and Past Collaboration Experiences
   - Future Engagement in K–12 Engineering

6. Summary

7. MEIDC Survey Instrument

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1 This project is funded by the National Science Foundation, grant #DRL-1450532.
1. Overview

Survey Development
During fall 2015, the project team developed the MEIDC survey based on stated research questions and informed by emergent data from stakeholder interviews. The stated purpose of the survey was to gather data about who is engaged in engineering education and in what ways, and what they see as the goal(s) of K–12 engineering education and the factors related to reaching that goal (e.g., where things are now, what the priorities should be moving forward).

Recipients were told that Tufts University, in partnership with Education Development Center, Inc. (EDC), was conducting an NSF-funded landscape analysis of K–12 engineering education in Massachusetts to highlight the opportunities, gaps, and resources, and determine areas of overlapping interest among stakeholders that may translate into a focus for purposeful activities. They were also told that the information they could provide would help to build a picture of K–12 engineering in the Greater Boston area and offer insight to areas of engineering education that may benefit from more focus in the future. It was noted to recipients that responses would be kept confidential and results only reported at the aggregate level.

Survey Administration
The MEIDC survey was administered online through Qualtrics Survey Software on September 30, 2015, and remained open through October 9, 2015. Project staff emailed the survey link to a total of 946 stakeholders. Of these, 846 received the survey and 137 completed the survey, for a response rate of 16.2%. Table 1 below shows the distribution of survey recipients and respondents.

Table 1. MEIDC survey recipients and respondents

<table>
<thead>
<tr>
<th></th>
<th>Emails Sent</th>
<th>Emails Bounced</th>
<th>Emails Received</th>
<th>Surveys Finished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-NSF awardees</td>
<td>712</td>
<td>87</td>
<td>625</td>
<td>104</td>
</tr>
<tr>
<td>NSF awardees</td>
<td>235</td>
<td>14</td>
<td>221</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>947</td>
<td>101</td>
<td>846</td>
<td>137</td>
</tr>
</tbody>
</table>

There were also 15 recipients who opted out of the survey. Of the known reasons for opting out, most were because the recipient did not feel their work was relevant (e.g., not K–12 engineering education, outside of Massachusetts) or because they were no longer involved in the work.

Respondents
As noted in the table above, respondents included 137 identified stakeholders (33 NSF awardees and 104 non-NSF awardees) located in Massachusetts. Respondents’ names, professional titles, and affiliated organizations were collected through the survey for tracking purposes and are not reported here.

Results
Results from analysis of the survey data are provided in the following sections.
2. Stakeholder Groups

Survey respondents were asked to identify the stakeholder groups that represent their current role(s) in K–12 engineering education.

- As shown in Table 2, many identified with multiple groups, but the majority selected one stakeholder category.
- As shown in Table 2a, most respondents represented faculty from BA-, MA-, or PhD-granting institutions (25%), researchers (23%) and K–12 STEM teachers (20%).
- Of the 33 NSF awardees, most identified as faculty from BA-, MA-, or PhD-granting institutions (58%).
- Of the 104 non-NSF awardee stakeholders, most identified as K–12 STEM teachers (27%).
- Thirty-five respondents selected the category “other” and a categorization of their responses is provided in Table 2b below.

Table 2. Respondents by number of stakeholder groups

<table>
<thead>
<tr>
<th>Number of Stakeholder Groups</th>
<th>Total (n=137)</th>
<th>NSF Awardee (n=33)</th>
<th>Non-NSF Awardee (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>% of Total</td>
<td>Count</td>
</tr>
<tr>
<td>More than 1</td>
<td>53</td>
<td>39%</td>
<td>14</td>
</tr>
<tr>
<td>Only 1</td>
<td>84</td>
<td>61%</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 2a. What stakeholder groups represent your current role(s) in K–12 engineering education?

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Total (n=137)</th>
<th>% of Total</th>
<th>NSF Awardee (n=33)</th>
<th>% of NSF Awardees</th>
<th>Non-NSF Awardee (n=104)</th>
<th>% of non-NSF Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty: BA-, MA-, or PhD-granting institution</td>
<td>34</td>
<td>25%</td>
<td>19</td>
<td>58%</td>
<td>15</td>
<td>14%</td>
</tr>
<tr>
<td>Faculty: Community college</td>
<td>3</td>
<td>2%</td>
<td>3</td>
<td>9%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Institution of higher education administrator</td>
<td>15</td>
<td>11%</td>
<td>5</td>
<td>15%</td>
<td>10</td>
<td>10%</td>
</tr>
<tr>
<td>K–12 teacher—STEM</td>
<td>28</td>
<td>20%</td>
<td>0</td>
<td>0%</td>
<td>28</td>
<td>27%</td>
</tr>
<tr>
<td>K–12 teacher—non-STEM</td>
<td>6</td>
<td>4%</td>
<td>0</td>
<td>0%</td>
<td>6</td>
<td>6%</td>
</tr>
<tr>
<td>K–12 administrator</td>
<td>8</td>
<td>6%</td>
<td>0</td>
<td>0%</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>K–12 counselor</td>
<td>3</td>
<td>2%</td>
<td>0</td>
<td>0%</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Informal/out-of-school time educator</td>
<td>19</td>
<td>14%</td>
<td>1</td>
<td>3%</td>
<td>18</td>
<td>17%</td>
</tr>
<tr>
<td>Informal/out-of-school time administrator</td>
<td>15</td>
<td>11%</td>
<td>2</td>
<td>6%</td>
<td>13</td>
<td>13%</td>
</tr>
<tr>
<td>Researcher</td>
<td>32</td>
<td>23%</td>
<td>16</td>
<td>48%</td>
<td>16</td>
<td>15%</td>
</tr>
<tr>
<td>Industry/company employee</td>
<td>13</td>
<td>9%</td>
<td>0</td>
<td>0%</td>
<td>13</td>
<td>13%</td>
</tr>
<tr>
<td>Policymaker</td>
<td>4</td>
<td>3%</td>
<td>0</td>
<td>0%</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Funder</td>
<td>4</td>
<td>3%</td>
<td>0</td>
<td>0%</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Parent</td>
<td>14</td>
<td>10%</td>
<td>3</td>
<td>9%</td>
<td>11</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
<td>35</td>
<td>26%</td>
<td>5</td>
<td>15%</td>
<td>30</td>
<td>29%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.
3. Experience with and Beliefs about K–12 Engineering Education

Respondents were asked a series of questions to identify their experiences with and beliefs about K–12 engineering education in Massachusetts.

Goals of K–12 Engineering Education

Respondents were asked to choose what they consider to be the three main goal(s) of K–12 engineering education.

- As shown in Table 3, the goals selected most frequently overall included:
  - To help students see how science and engineering are instrumental in addressing major challenges that confront society today
  - To prepare children to be STEM-literate citizens
  - To help students learn a systematic process for defining and solving problems
  - To help students learn skills like communication, teamwork, and creativity
  - To motivate students to engage with STEM content

- These most selected goals represent more than just learning an engineering curriculum; they include student engagement and motivation, learning 21st century skills, preparing to be a knowledgeable citizen, and understanding the relevance and significance of engineering.

- Considering only the responses from NSF awardees, the configuration of the top five goals most frequently selected changes to prioritize a goal around equity: “To include students who may have been traditionally marginalized in the science classroom”; the “21st century skills” goal drops out.

- When considering only the responses from non-NSF awardees, the configuration includes the same five goals, but in a different order, prioritizing “21st century skills.”

Table 3. Main goals of K–12 engineering education*

<table>
<thead>
<tr>
<th>Goals of K–12 Engineering Education</th>
<th>Total (n=137)</th>
<th>% of total*</th>
<th>NSF Awardee (n=33)</th>
<th>% of NSF awardees*</th>
<th>Non-NSF Awardee (n=104)</th>
<th>% of non-NSF awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td>To help students see how science and engineering are instrumental in addressing major challenges that confront society today</td>
<td>57</td>
<td>42%</td>
<td>14</td>
<td>42%</td>
<td>43</td>
<td>41%</td>
</tr>
<tr>
<td>To prepare children to be STEM-literate citizens</td>
<td>56</td>
<td>41%</td>
<td>12</td>
<td>36%</td>
<td>44</td>
<td>42%</td>
</tr>
<tr>
<td>To help students learn a systematic process for defining and solving problems</td>
<td>55</td>
<td>40%</td>
<td>12</td>
<td>36%</td>
<td>43</td>
<td>41%</td>
</tr>
<tr>
<td>To help students learn skills like communication, teamwork, and creativity</td>
<td>54</td>
<td>39%</td>
<td>9</td>
<td>27%</td>
<td>45</td>
<td>43%</td>
</tr>
<tr>
<td>To motivate students to engage with STEM content</td>
<td>50</td>
<td>36%</td>
<td>13</td>
<td>39%</td>
<td>37</td>
<td>36%</td>
</tr>
<tr>
<td>To apply science and math concepts to solve problems through engineering activities</td>
<td>43</td>
<td>31%</td>
<td>10</td>
<td>30%</td>
<td>33</td>
<td>32%</td>
</tr>
<tr>
<td>To include students who may have been traditionally marginalized in the science classroom</td>
<td>39</td>
<td>28%</td>
<td>14</td>
<td>42%</td>
<td>25</td>
<td>24%</td>
</tr>
<tr>
<td>To help students view engineering as relevant to their lives</td>
<td>37</td>
<td>27%</td>
<td>10</td>
<td>30%</td>
<td>27</td>
<td>26%</td>
</tr>
<tr>
<td>To integrate science, mathematics, and technology</td>
<td>26</td>
<td>19%</td>
<td>4</td>
<td>12%</td>
<td>22</td>
<td>21%</td>
</tr>
<tr>
<td>To prepare students for a career in engineering</td>
<td>17</td>
<td>12%</td>
<td>5</td>
<td>15%</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>7%</td>
<td>2</td>
<td>6%</td>
<td>7</td>
<td>7%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.
Existing Support for K–12 Engineering Education Goals

Respondents were also asked to indicate the degree to which a number of factors currently exist at the level necessary to achieve the main goals they selected.

- As shown in Table 4, the majority of respondents indicated that each factor currently exists “somewhat” at the level necessary to achieve the goals.
- Overall, this may indicate that there is room for more work to be done to get the factors up to “just right” or “more than needed.”

Table 4. Existence of supporting factors for K–12 engineering goals—**Total respondents** (n=137)*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Just right</th>
<th>More than needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allotted time to engage in/implement engineering activities</td>
<td>19%</td>
<td>63%</td>
<td>11%</td>
<td>4%</td>
</tr>
<tr>
<td>Access to curriculum</td>
<td>9%</td>
<td>73%</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>Money for materials</td>
<td>24%</td>
<td>65%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Educator training</td>
<td>22%</td>
<td>66%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Effective assessments</td>
<td>36%</td>
<td>49%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Awareness of existing resources and initiatives</td>
<td>15%</td>
<td>72%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Coordination among schools and nonprofits, universities, and companies</td>
<td>28%</td>
<td>61%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Coordination between initiatives by nonprofits, universities, and companies</td>
<td>31%</td>
<td>60%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Coordination of out-of-school time/afterschool programs and in-school/school-day programs</td>
<td>34%</td>
<td>53%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>State policy and standards</td>
<td>19%</td>
<td>55%</td>
<td>15%</td>
<td>8%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 4a, of the 33 NSF awardees who took the survey, 64% felt there was no existence of effective assessments needed to support K–12 engineering goals.
- Of the 33 NSF awardees, 15% felt there were more state policy and standards than needed.

Table 4a. Existence of supporting factors for K–12 engineering goals—**NSF awardees** (n=33)*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Just right</th>
<th>More than needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allotted time to engage in/implement engineering activities</td>
<td>24%</td>
<td>64%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>Access to curriculum</td>
<td>18%</td>
<td>70%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Money for materials</td>
<td>27%</td>
<td>58%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>Educator training</td>
<td>36%</td>
<td>52%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Effective assessments</td>
<td><strong>64%</strong></td>
<td>24%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>Awareness of existing resources and initiatives</td>
<td>15%</td>
<td>73%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Coordination among schools and nonprofits, universities, and companies</td>
<td>27%</td>
<td>64%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Coordination between initiatives by nonprofits, universities, and companies</td>
<td>39%</td>
<td>52%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Coordination of out-of-school time/afterschool programs and in-school/school-day programs</td>
<td>33%</td>
<td>55%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>State policy and standards</td>
<td>18%</td>
<td>55%</td>
<td>9%</td>
<td><strong>15%</strong></td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.
As shown in Table 4b, of the 104 non-NSF awardees who took the survey, 35% felt there was no existence of coordination of out-of-school time/afterschool programs and in-school/school-day programs needed to support K–12 engineering goals. Of the 104 non-NSF awardees, 17% felt the existence of state policy and standards was “just right.”

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Just right</th>
<th>More than needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allotted time to engage in/implement engineering activities</td>
<td>17%</td>
<td>63%</td>
<td>13%</td>
<td>4%</td>
</tr>
<tr>
<td>Access to curriculum</td>
<td>7%</td>
<td>74%</td>
<td>13%</td>
<td>3%</td>
</tr>
<tr>
<td>Money for materials</td>
<td>23%</td>
<td>67%</td>
<td>5%</td>
<td>1%</td>
</tr>
<tr>
<td>Educator training</td>
<td>17%</td>
<td>71%</td>
<td>7%</td>
<td>1%</td>
</tr>
<tr>
<td>Effective assessments</td>
<td>27%</td>
<td>57%</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Awareness of existing resources and initiatives</td>
<td>15%</td>
<td>71%</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>Coordination among schools and nonprofits, universities, and companies</td>
<td>29%</td>
<td>61%</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>Coordination between initiatives by nonprofits, universities, and companies</td>
<td>29%</td>
<td>63%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Coordination of out-of-school time/afterschool programs and in-school/school-day programs</td>
<td>35%</td>
<td>53%</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>State policy and standards</td>
<td>19%</td>
<td>55%</td>
<td>17%</td>
<td>6%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

**Understanding These Factors**

In addition to asking respondents to rate the existence of factors to achieve goals, respondents were also asked to provide any additional information that might help to understand the relationship between the factors and the goals they selected. Many responses indicated that there may be many resources available, including program materials, research, and evaluation efforts, but there is a need for a way to sift through what is out there to find what is relevant. Respondents also noted the lack of funding available for resources.

Many additional comments provided by respondents indicate the need to help teachers think about teaching engineering differently. Some respondents noted that the goals of engineering education at the K–12 level should be to help students develop more 21st century skills and prepare for careers. These can be thought of as suggestions for what to do. Alternatively, many discuss how to do this—referencing the need for better alignment of courses and providing more resources to teachers. Many responses supported this idea of “what to do” to change the culture and illuminated the need to connect engineering education to careers and jobs, and the need to develop skills like problem solving. In terms of “how to change” the culture, responses indicated the need for better sequencing of the curriculum and the need for collaboration to help teachers. More specifically, respondents indicated a need to adjust schedules to allow time for this. Additionally, respondents identified a lack of knowledge about and comfort with engineering.

Issues of changing the culture of engineering education also came up in reference to comments about education policy. Particularly, issues of standards, testing, and access for all were discussed. For example, some respondents felt that too much emphasis on testing can limit the focus on good engineering education and that this can impact which students have access to this material. Others argued for more recognition for the teaching profession. And some described needing to begin changing the culture of education at the school level to include more engineering.
K–12 Engineering Education “Fit”

Respondents were asked to select all of the levels and ways they think engineering education should fit into K–12 education in Massachusetts.

- As shown in Table 5, at the K–5/elementary school level, the majority of respondents selected “integrated with many subjects,” “embedded in a STEM subject,” and “during informal/out-of-school time activities.
- NSF awardees generally did not differ from other stakeholders in responses to this item, although there was a higher percentage of non-NSF awardees than NSF awardees who felt a “stand-alone course” should be at the K–5 level.

Table 5. Engineering education fit in K–12 education in Massachusetts: K–5/elementary school

<table>
<thead>
<tr>
<th>Type</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a stand-alone course</td>
<td>18%</td>
<td>9%</td>
<td>20%</td>
</tr>
<tr>
<td>Embedded in a STEM subject</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Integrated with many subjects</td>
<td>74%</td>
<td>76%</td>
<td>73%</td>
</tr>
<tr>
<td>As a vocational course</td>
<td>5%</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>During informal/out-of-school time activities</td>
<td>69%</td>
<td>73%</td>
<td>67%</td>
</tr>
<tr>
<td>Not at all</td>
<td>1%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 5a, at the 6–8/middle school level, the majority of respondents also selected “integrated with many subjects,” “embedded in a STEM subject,” and “during informal/out-of-school time activities.
- Again, NSF awardees generally did not differ from non-NSF awardees in responses to this item, although there was a higher percentage of non-NSF awardees than NSF awardees who felt a “stand-alone course” should be at the 6–8 level.
- Additionally, many more respondents (48%) felt a stand-alone course should be at the 6–8 level than at the K–5 level (18%).

Table 5a. Engineering education fit in K–12 education in Massachusetts: 6–8/middle school

<table>
<thead>
<tr>
<th>Type</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a stand-alone course</td>
<td>48%</td>
<td>39%</td>
<td>51%</td>
</tr>
<tr>
<td>Embedded in a STEM subject</td>
<td>75%</td>
<td>73%</td>
<td>76%</td>
</tr>
<tr>
<td>Integrated with many subjects</td>
<td>71%</td>
<td>76%</td>
<td>69%</td>
</tr>
<tr>
<td>As a vocational course</td>
<td>20%</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>During informal/out-of-school time activities</td>
<td>78%</td>
<td>79%</td>
<td>78%</td>
</tr>
<tr>
<td>Not at all</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 5b, at the 9–12/high school level, the majority of respondents selected “as a stand-alone course” and “during informal/out-of-school time activities.
- Again, NSF awardees generally did not differ from non-NSF awardees in responses to this item, although there was a higher percentage of NSF awardees than non-NSF awardees who felt a “stand-alone course” should be at the 9–12 level.
- Additionally, many more respondents (79%) felt a stand-alone course should be at the 9–12 level than at the 6–8 level (48%) or the K–5 level (18%).
### Table 5b. Engineering education fit in K–12 education in Massachusetts: 9–12/high school*

<table>
<thead>
<tr>
<th>Type</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a stand-alone course</td>
<td>79%</td>
<td>85%</td>
<td>77%</td>
</tr>
<tr>
<td>Embedded in a STEM subject</td>
<td>53%</td>
<td>55%</td>
<td>53%</td>
</tr>
<tr>
<td>Integrated with many subjects</td>
<td>58%</td>
<td>58%</td>
<td>58%</td>
</tr>
<tr>
<td>As a vocational course</td>
<td>64%</td>
<td>52%</td>
<td>68%</td>
</tr>
<tr>
<td>During informal/out-of-school time activities</td>
<td>73%</td>
<td>73%</td>
<td>72%</td>
</tr>
<tr>
<td>Not at all</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
<td>3%</td>
<td>4%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

### 4. Current Engagement in K–12 Engineering Education

Respondents were asked a series of questions about the Massachusetts K–12 engineering education effort or activity they had been the most engaged in during the past year. For this item, an effort or activity was defined as something related to, for instance, curriculum development or testing, competitions, career awareness, teacher professional development, assessments.

#### K–12 Engineering Education Efforts and Activities

Respondents provided the names of specific efforts or activities with their corresponding lead or sponsoring institution(s) or organization(s). They also provided information about many K–12 engineering education efforts and activities in Massachusetts. Some efforts mentioned more than once included Boston’s Museum of Science, Future Cities, FIRST Programs, Project Lead the Way, and Tufts University’s Center for Engineering Education and Outreach.

#### Characteristics of K–12 Engineering Education Efforts and Activities in Massachusetts

In addition to naming specific K–12 engineering education efforts and activities and the institutions/organizations that lead them, respondents were asked a series of questions about the effort/activity they are engaged in including location of target audience, goals of effort/activity, intended audience, grade level, and student characteristics. Results from these questions are provided below.

##### Location

- As shown in Table 6, a higher percentage of NSF awardees are aware of efforts across Massachusetts and nationally than are non-NSF awardees.

- Correspondingly, a higher percentage of non-NSF awardees are aware of efforts more locally—in a particular town or city or in the Greater Boston area—than are NSF awardees.

- An analysis of open-ended responses indicates that Boston and Cambridge were the majority of particular towns or cities named.
Table 6. Location of target audience for named efforts/activities*

<table>
<thead>
<tr>
<th>Location</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A particular town/city (please name)</td>
<td>21%</td>
<td>15%</td>
<td>22%</td>
</tr>
<tr>
<td>The Greater Boston area</td>
<td>19%</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Across Massachusetts</td>
<td>21%</td>
<td>26%</td>
<td>19%</td>
</tr>
<tr>
<td>The Northeast</td>
<td>6%</td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>Nationally</td>
<td>21%</td>
<td>30%</td>
<td>18%</td>
</tr>
<tr>
<td>Other</td>
<td>13%</td>
<td>11%</td>
<td>14%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

Goals

- As shown in Table 7, the majority of respondents knew of efforts with the goals “to motivate students to engage with STEM content” (64%) and “to help students learn skills like communication, teamwork, and creativity” (57%).
- A high percentage of NSF awardees also knew of efforts designed to address the goals “to include students who may have been traditionally marginalized in the science classroom” (55%) and “to prepare children to be STEM-literate citizens” (52%)
- Other responses are provided in Table 7.

Table 7. Goals addressed by effort/activity*

<table>
<thead>
<tr>
<th>Goals</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To motivate students to engage with STEM content</td>
<td>64%</td>
<td>58%</td>
<td>65%</td>
</tr>
<tr>
<td>To help students learn skills like communication, teamwork, and creativity</td>
<td>57%</td>
<td>39%</td>
<td>63%</td>
</tr>
<tr>
<td>To help students learn a systematic process for solving problems</td>
<td>51%</td>
<td>46%</td>
<td>53%</td>
</tr>
<tr>
<td>To help students see how science and engineering are instrumental in addressing major challenges that confront society today</td>
<td>49%</td>
<td>39%</td>
<td>52%</td>
</tr>
<tr>
<td>To help students view engineering as relevant to their lives</td>
<td>49%</td>
<td>49%</td>
<td>49%</td>
</tr>
<tr>
<td>To prepare children to be STEM-literate citizens</td>
<td>49%</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>To include students who may have been traditionally marginalized in the science classroom</td>
<td>48%</td>
<td>55%</td>
<td>46%</td>
</tr>
<tr>
<td>To integrate science, mathematics, and technology</td>
<td>47%</td>
<td>39%</td>
<td>50%</td>
</tr>
<tr>
<td>To apply science and math concepts through engineering activities</td>
<td>46%</td>
<td>36%</td>
<td>49%</td>
</tr>
<tr>
<td>To prepare students for a career in engineering</td>
<td>31%</td>
<td>33%</td>
<td>31%</td>
</tr>
<tr>
<td>Other</td>
<td>9%</td>
<td>12%</td>
<td>8%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 7a, the same five main goals that respondents chose as priorities for K–12 engineering education (see Table 3) appear most frequently as the goals addressed by efforts respondents know about; however, they are in a different order.
- While the goal “to motivate students to engage with STEM content” is the most frequent choice for efforts currently known, it is lower on the list of goals respondents believe should be the main focus of K–12 engineering education.
- While the goal “to help students see how science and engineering are instrumental in addressing major challenges that confront society today” is high on the list of goals respondents believe should be the main focus of K–12 engineering education, it is lower on the list of goals addressed by efforts respondents know about.

49
Table 7a. Order of respondents’ choice of main goals vs. goals addressed by efforts respondents know about

<table>
<thead>
<tr>
<th>Goal</th>
<th>Respondents’ choice of main goals</th>
<th>Goals addressed by efforts respondents know about</th>
</tr>
</thead>
<tbody>
<tr>
<td>To motivate students to engage with STEM content</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>To help students learn skills like communication, teamwork, and creativity</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>To help students learn a systematic process for solving problems</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>To help students see how science and engineering are instrumental in addressing major challenges that confront society today</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>To help students view engineering as relevant to their lives</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>To prepare children to be STEM-literate citizens</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>To include students who may have been traditionally marginalized in the science</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>To integrate science, mathematics, and technology</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>To apply science and math concepts through engineering activities</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>To prepare students for a career in engineering</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

- As shown in Table 8, “students” and “educators” are the most frequently selected audiences for efforts respondents know about.
- NSF awardees more frequently named efforts targeting “researchers” and those related to “formal/in-school time” than non-NSF awardees.
- Non-NSF awardees more frequently named efforts targeting “industry,” “administrators,” and “funders” than NSF awardees.

Intended Audience

Table 8. Intended audience for effort/activity*

<table>
<thead>
<tr>
<th>Intended Audience</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>67%</td>
<td>67%</td>
<td>67%</td>
</tr>
<tr>
<td>Educators</td>
<td>53%</td>
<td>55%</td>
<td>52%</td>
</tr>
<tr>
<td>Formal/in-school time</td>
<td>44%</td>
<td>52%</td>
<td>41%</td>
</tr>
<tr>
<td>Parents</td>
<td>27%</td>
<td>33%</td>
<td>25%</td>
</tr>
<tr>
<td>Industry/company employees</td>
<td>23%</td>
<td>18%</td>
<td>24%</td>
</tr>
<tr>
<td>Administrators</td>
<td>19%</td>
<td>18%</td>
<td>19%</td>
</tr>
<tr>
<td>Funders</td>
<td>20%</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>Researchers</td>
<td>17%</td>
<td>30%</td>
<td>13%</td>
</tr>
<tr>
<td>Policymakers</td>
<td>14%</td>
<td>6%</td>
<td>16%</td>
</tr>
<tr>
<td>Counselors</td>
<td>12%</td>
<td>6%</td>
<td>14%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
<td>0%</td>
<td>5%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.
**Grade Level**
- As shown in Table 9, “high school” was the most frequently selected grade level for efforts that respondents know about.
- However, NSF awardees most frequently named efforts targeting “elementary students.”
- Other responses are provided in Table 10.

**Table 9. Intended grade level for effort/activity***

<table>
<thead>
<tr>
<th>Intended Grade Level</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9–12/High</td>
<td>59%</td>
<td>48%</td>
<td>63%</td>
</tr>
<tr>
<td>K–5/Elementary</td>
<td>50%</td>
<td>55%</td>
<td>48%</td>
</tr>
<tr>
<td>6–8/Middle</td>
<td>40%</td>
<td>36%</td>
<td>41%</td>
</tr>
<tr>
<td>Other</td>
<td>9%</td>
<td>12%</td>
<td>8%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

**Characteristics of Target Audience**
- As shown in Table 10, “any student” was the most frequently selected target group for efforts respondents know about.
- NSF awardees more frequently named efforts targeting “students of color” (58%) than did non-NSF awardees (37%).

**Table 10. Characteristics of students targeted for effort/activity***

<table>
<thead>
<tr>
<th>Students Targeted</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any student</td>
<td>62%</td>
<td>55%</td>
<td>64%</td>
</tr>
<tr>
<td>Students of color</td>
<td>42%</td>
<td>58%</td>
<td>37%</td>
</tr>
<tr>
<td>Students from families with low socio-economic status</td>
<td>41%</td>
<td>52%</td>
<td>38%</td>
</tr>
<tr>
<td>Female students</td>
<td>38%</td>
<td>52%</td>
<td>34%</td>
</tr>
<tr>
<td>Students with limited English/ELL</td>
<td>31%</td>
<td>39%</td>
<td>28%</td>
</tr>
<tr>
<td>Students with special needs</td>
<td>20%</td>
<td>24%</td>
<td>19%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
<td>0%</td>
<td>2%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

**Descriptions of Efforts and Activities**
In addition to asking respondents to provide details about the specific K–12 engineering education efforts and activities they named, we also asked them to tell us anything else that is important to describe the effort or activity. While most provided additional details about their organizations’ programming efforts or curriculum-related activities and resources, some described specific elements such as programs that are student-centered, focus on equity and access, involve research and evaluation, or have a policy focus.
5. Collaboration

Current and Past Collaboration Experiences
Respondents were asked to think about the stakeholder group(s) they have collaborated with on any K–12 engineering education efforts in Massachusetts in the past 5 years, and to indicate how often and for how long they have been involved with each of these groups.

- As shown in Table 11, many respondents reported collaborating with “K–12 STEM teachers” for a frequency of “more than 4 times a year” (56%).
- NSF awardees more frequently named “Faculty: BA-, MA-, or PhD-granting institution” (58%) as collaborators “more than four times a year” than did non-NSF awardees (37%).
- Non-NSF awardees more frequently named “K–12 teachers non-STEM” (39%) as collaborators “more than 4 times a year” than did NSF awardees (18%).
- Total respondents selected a collaboration experience frequency of “more than 4 times a year” more frequently than “less than 4 times a year” for all stakeholder groups, except for “community college faculty” and “policymakers.”

Table 11. Frequency of collaboration experiences, by stakeholder group*

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>less than 4 times a year</th>
<th>more than 4 times a year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n=137)</td>
<td>NSF-awardees (n=33)</td>
</tr>
<tr>
<td>Faculty: BA-, MA-, or PhD-granting institution</td>
<td>22%</td>
<td>24%</td>
</tr>
<tr>
<td>Faculty: community college</td>
<td>21%</td>
<td>33%</td>
</tr>
<tr>
<td>Institution of higher education administrators</td>
<td>12%</td>
<td>18%</td>
</tr>
<tr>
<td>K–12 teachers—STEM</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>K–12 teachers—non-STEM</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>K–12 administrators</td>
<td>14%</td>
<td>24%</td>
</tr>
<tr>
<td>K–12 counselors</td>
<td>10%</td>
<td>12%</td>
</tr>
<tr>
<td>Informal/out-of-school time educators</td>
<td>23%</td>
<td>24%</td>
</tr>
<tr>
<td>Informal/out-of-school time administrators</td>
<td>12%</td>
<td>9%</td>
</tr>
<tr>
<td>Researchers</td>
<td>20%</td>
<td>21%</td>
</tr>
<tr>
<td>Industry/company employees</td>
<td>23%</td>
<td>27%</td>
</tr>
<tr>
<td>Policymakers</td>
<td>17%</td>
<td>21%</td>
</tr>
<tr>
<td>Funders</td>
<td>16%</td>
<td>24%</td>
</tr>
<tr>
<td>Parents</td>
<td>20%</td>
<td>24%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 11a, many respondents reported collaborating with “K–12 STEM teachers” for a length of “more than 1 year” (58%).
- NSF awardees more frequently named “Faculty: BA-, MA-, or PhD-granting institution” (64%) and “Researchers” (70%) as collaborators for “more than 1 year” than did non-NSF awardees (46% and 35%, respectively).
• Non-NSF awardees more frequently named “K–12 non-STEM teachers” (39%) and “K–12 counselors” (27%) as collaborators for “more than 1 year” than did NSF awardees (21% and 12%, respectively).

• Total respondents selected a collaboration experience length of “more than 1 year” more frequently than “1 year or less” for all stakeholder groups.

Table 11a. Length of collaboration experiences, by stakeholder group*

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>1 year or less</th>
<th>more than 1 year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n=137)</td>
<td>NSF awardees (n=33)</td>
</tr>
<tr>
<td>Faculty: BA-, MA-, or PhD-granting institution</td>
<td>7%</td>
<td>9%</td>
</tr>
<tr>
<td>Faculty: community college</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Institution of higher education administrators</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>K–12 teachers—STEM</td>
<td>6%</td>
<td>9%</td>
</tr>
<tr>
<td>K–12 teachers—non-STEM</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>K–12 administrators</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>K–12 counselors</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Informal/out-of-school time educators</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Informal/out-of-school time administrators</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Researchers</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Industry/company employees</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Policymakers</td>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>Funders</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Parents</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

Future Engagement in K–12 Engineering

Respondents were asked two questions about their interest in future K–12 engineering education efforts and activities.

- As shown in Table 12, half of the respondents reported an interest in “Promoting awareness of K–12 engineering education opportunities in Massachusetts” during the next 5 years.
- NSF awardees more frequently named “Participating in research on K–12 engineering education” (70%) as an effort they would likely engage in during the next 5 years than non-NSF awardees (31%).
- “Developing and/or testing assessment tools” was the effort least likely to be engaged in for both NSF awardees (42%) and non-NSF awardees (18%).
Table 12. Which kind of K–12 engineering education efforts and activities are you most likely to engage in during the next 5 years?*

<table>
<thead>
<tr>
<th>K–12 Engineering Education Efforts and Activities</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoting awareness of K–12 engineering education opportunities in Massachusetts</td>
<td>50%</td>
<td>48%</td>
<td>50%</td>
</tr>
<tr>
<td>Supporting teacher professional development</td>
<td>48%</td>
<td>67%</td>
<td>42%</td>
</tr>
<tr>
<td>Supporting efforts to increase involvement from industry</td>
<td>46%</td>
<td>55%</td>
<td>43%</td>
</tr>
<tr>
<td>Supporting efforts to increase involvement between in-school and out-of-school or community-based efforts</td>
<td>42%</td>
<td>39%</td>
<td>42%</td>
</tr>
<tr>
<td>Participating in research on K–12 engineering education (i.e., on best practices or the effectiveness of curricula)</td>
<td>40%</td>
<td>70%</td>
<td>31%</td>
</tr>
<tr>
<td>Supporting advocacy initiatives</td>
<td>35%</td>
<td>33%</td>
<td>36%</td>
</tr>
<tr>
<td>Implementing engineering curricula in classrooms</td>
<td>59%</td>
<td>82%</td>
<td>52%</td>
</tr>
<tr>
<td>Collecting data on engineering education</td>
<td>34%</td>
<td>67%</td>
<td>23%</td>
</tr>
<tr>
<td>Developing and/or testing assessment tools</td>
<td>24%</td>
<td>42%</td>
<td>18%</td>
</tr>
<tr>
<td>Other</td>
<td>11%</td>
<td>9%</td>
<td>12%</td>
</tr>
<tr>
<td>None</td>
<td>1%</td>
<td>0%</td>
<td>2%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.

- As shown in Table 13, 69% of the respondents reported an interest in collaborating with “K–12 Teachers—STEM.”
- Non-NSF awardees more frequently reported “K–12 Teachers—non-STEM” (38%) as stakeholders they would be likely to collaborate with than did NSF awardees (24%).

Table 13. Which stakeholder group(s) are you most likely to collaborate with around the efforts and activities you selected above? *

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Total (n=137)</th>
<th>NSF awardees (n=33)</th>
<th>Non-NSF awardees (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K–12 teachers—STEM</td>
<td>69%</td>
<td>76%</td>
<td>66%</td>
</tr>
<tr>
<td>Faculty: BA-, MA-, or PhD-granting institution</td>
<td>59%</td>
<td>82%</td>
<td>52%</td>
</tr>
<tr>
<td>K–12 administrators</td>
<td>44%</td>
<td>58%</td>
<td>39%</td>
</tr>
<tr>
<td>Researchers</td>
<td>42%</td>
<td>67%</td>
<td>35%</td>
</tr>
<tr>
<td>Informal/out-of-school time educator</td>
<td>41%</td>
<td>39%</td>
<td>41%</td>
</tr>
<tr>
<td>Industry/company employees</td>
<td>40%</td>
<td>45%</td>
<td>38%</td>
</tr>
<tr>
<td>Funders</td>
<td>36%</td>
<td>48%</td>
<td>32%</td>
</tr>
<tr>
<td>K–12 Teachers—non-STEM</td>
<td>34%</td>
<td>24%</td>
<td>38%</td>
</tr>
<tr>
<td>Parents</td>
<td>31%</td>
<td>27%</td>
<td>32%</td>
</tr>
<tr>
<td>Policymakers</td>
<td>26%</td>
<td>21%</td>
<td>28%</td>
</tr>
<tr>
<td>Faculty: community college</td>
<td>26%</td>
<td>24%</td>
<td>26%</td>
</tr>
<tr>
<td>Informal/out-of-school time administrators</td>
<td>24%</td>
<td>30%</td>
<td>22%</td>
</tr>
<tr>
<td>Institution of higher education administrators</td>
<td>21%</td>
<td>27%</td>
<td>19%</td>
</tr>
<tr>
<td>K–12 counselors</td>
<td>16%</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>Other</td>
<td>4%</td>
<td>3%</td>
<td>5%</td>
</tr>
</tbody>
</table>

* Percentages total more than 100% because respondents could select more than one group.
6. Summary

The results of the MEIDC survey validated many of the assumptions we had prior to administration, including evidence of the key players in K–12 engineering education in Massachusetts (like the Museum of Science, Boston) and where the greatest level of activity was occurring (Boston and Cambridge).

The survey did indicate some new thinking including the following.

1. There are many engineering education efforts underway in Massachusetts, but there is no centralized system to access them.
2. There is a need for a match-making service to connect interested stakeholders with efforts.
3. More can be done in regards to awareness of programs and marketing of materials.
4. There is room for improvement in regards to the existence of factors needed to achieve the main goals of K–12 engineering education in Massachusetts.
5. There is a need for effective assessments, but few are interested in working on them.

In addition, we found that NSF awardees:

1. Tend to know more about statewide and national efforts than local ones.
2. Have more interest in efforts that have goals regarding equity in K–12 engineering education.

Specifically, this survey contributed to the following findings:

Goals
- Many goals focused on 21st century skills and equity issues did not appear in the top five.
- The goals desired by respondents are not necessarily the goals that current efforts are addressing.
- There is a need for a centralized system to help match people to particular efforts.

Collaboration
- NSF awardees are interested in equity issues around K–12 engineering education in Massachusetts.
- NSF awardees were more likely to know of efforts targeting “students of color.”
- There is an interest in multiple-year collaboration across many stakeholder groups.
- Few respondents were interested in developing assessments even though they indicated this is a need.

Additional potential takeaways that may help steer future inquiry are provided in Appendix A: Stakeholder Interviews.
7. MEIDC Survey Instrument

Massachusetts Engineering Innovation and Dissemination Community (MEIDC)
K–12 Engineering Education in the Greater Boston Area Survey

Tufts University, in partnership with Education Development Center, Inc. (EDC), is conducting an NSF-funded landscape analysis of K–12 engineering education in Massachusetts to highlight the opportunities, gaps, and resources, and determine areas of overlapping interest among stakeholders that may translate into a focus for purposeful activities.

The purpose of this survey is to gather data about who is engaged in engineering education and in what ways, what they see as the goal(s) of K–12 engineering education and the factors related to reaching that goal (e.g., where things are now, what the priorities should be moving forward, etc.). We estimate this survey will take ~20 minutes.

The information you provide will help us build a picture of K–12 engineering in the Greater Boston area, and offer insight to areas of engineering education that may benefit from more focus in the future. Your responses will be kept confidential and we will only report data at the aggregate level.

This project is funded by the National Science Foundation, grant #DRL-1450532. Any opinions, findings, and conclusions or recommendations expressed in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Questions about You

Please tell us about yourself:

First Name________________________________________________________
Last Name________________________________________________________
Professional Title_________________________________________________
Organization Name__________________________________________________

What stakeholder groups represent your current role(s) in K–12 engineering education?
(Check all that apply)

☐ Faculty: BA-, MA-, or PhD-granting institution
☐ Faculty: community college
☐ Institution of higher education administrator
☐ K–12 teacher—STEM
☐ K–12 teacher—non-STEM
☐ K–12 administrator
☐ K–12 counselor
☐ Informal/out-of-school time educator
☐ Informal/out-of-school time administrator
☐ Researcher
☐ Industry/company employee
☐ Policymaker
☐ Funder
☐ Parent
☐ Other, please describe __________________________
# Your Experience with and Beliefs about K–12 Engineering Education

Please think about the stakeholder group(s) you have collaborated with on any K–12 engineering education efforts in Massachusetts during the past 5 years. Indicate how often and for how long you have been involved with each of these groups.

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>How often</th>
<th>How long</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty: BA-, MA-, or PhD-granting institution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty: community college</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution of higher education administrators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K–12 teachers—STEM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K–12 teachers—non–STEM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K–12 administrators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K–12 counselors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informal/out-of-school time educators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informal/out-of-school time administrators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researchers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry/company employees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policymakers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other, please describe</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please choose what you consider to be the three main goal(s) of K–12 engineering education?

❑ To prepare children to be STEM-literate citizens
❑ To prepare students for a career in engineering
❑ To apply science and math concepts to solve problems through engineering activities
❑ To motivate students to engage with STEM content
❑ To integrate science, mathematics, and technology
❑ To help students learn skills like communication, teamwork, and creativity
❑ To help students learn a systematic process for defining and solving problems
❑ To help students see how science and engineering are instrumental in addressing major challenges that confront society today
❑ To include students who may have traditionally been marginalized in the science classroom
❑ To help students view engineering as relevant to their lives
❑ Other, please describe ____________________

Given the three goals you chose above, please indicate the degree to which each of the following factors currently exist at the level necessary to achieve these goals.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Just right</th>
<th>More than needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allotted time to engage in/implement engineering activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to curriculum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money for materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educator training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective assessments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State policy and standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness of existing resources and initiatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination among schools and nonprofits, universities, and companies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination between initiatives by nonprofits, universities, and companies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination of out-of-school time/afterschool programs and in-school/school-day programs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What additional information might we need to know to understand the relationship between these or other factors and the goals you selected?

At which levels and how do you think engineering education should fit into K–12 education in Massachusetts? (Select all that apply)

<table>
<thead>
<tr>
<th></th>
<th>K–5/ Elementary School</th>
<th>6–8/ Middle School</th>
<th>9–12/ High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a stand-alone course</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Embedded in a STEM subject</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Integrated with many subjects</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>As a vocational course</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>During informal/out-of-school time activities</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Not at all</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Other, please describe</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Current Engagement in K–12 Engineering Education**

Please name the K–12 engineering education effort or activity* with which you have been the MOST engaged during the last year in Massachusetts. *An effort or activity could be related to curriculum development or testing; competitions, career awareness, teacher professional development, assessments, etc.

Name of specific K–12 engineering education effort or activity
Name the lead(s) and/or sponsoring institutions/organizations of the effort/activity

Indicate the location of the target audience(s) for this effort/activity. (Select all that apply)

☐ A particular town/city (please name) ____________________
☐ The Greater Boston region
☐ Across Massachusetts
☐ The Northeast
☐ Nationally
☐ Other, please describe ____________________

Indicate the goal(s) you believe are being addressed by this effort/activity. (Select all that apply)

☐ To prepare children to be STEM–literate citizens
☐ To prepare students for a career in engineering
☐ To apply science and math concepts through engineering activities
☐ To motivate students to engage with STEM content
☐ To integrate science, mathematics, and technology
☐ To help students learn skills like communication, teamwork, and creativity
☐ To help students learn a systematic process for solving problems
☐ To help students see how science and engineering are instrumental in addressing major challenges that confront society today
☐ To include students who may have traditionally been marginalized in the science classroom
☐ To help students view engineering as relevant to their lives
☐ Other, please describe ____________________
Indicate the intended audience for this effort/activity. (Select all that apply)

☐ Formal/in-school time
☐ Informal/out-of-school time
☐ Students
☐ Educators
☐ Counselors
☐ Administrators
☐ Policymakers
☐ Researchers
☐ Industry/company employees
☐ Funders
☐ Parents
☐ Other, please describe ____________________

Indicate the grade level(s) of the intended audience for this effort/activity. (Select all that apply)

☐ K–5/Elementary
☐ 6–8/Middle
☐ 9–12/High
☐ Other, please describe ____________________

Indicate the characteristics of students targeted for this effort/activity. (Select all that apply)

☐ Female students
☐ Students of color
☐ Students with limited English/ELL
☐ Students with special needs
☐ Students from families with low socio-economic status
☐ Any student
☐ Other, please describe ____________________

What else is important to describe about this effort or activity?
Future Engagement in K–12 Engineering Education

Which kind of K–12 engineering education efforts and activities are you most likely to engage in during the next five years? (Select all that apply)

- Promoting awareness of K–12 engineering education opportunities in Massachusetts
- Implementing engineering curricula in classrooms
- Supporting teacher professional development
- Collecting data on engineering education
- Participating in research on K–12 engineering education (i.e., on best practices or the effectiveness of curricula)
- Supporting advocacy initiatives
- Developing and/or testing assessment tools
- Supporting efforts to increase involvement from industry
- Supporting efforts to increase involvement between in-school and out-of-school or community-based efforts
- Other, please describe ____________________
- None

Which stakeholder group(s) are you most likely to collaborate with around the efforts and activities you selected above? (Select all that apply)

- Faculty: BA-, MA- or PhD-granting institution
- Faculty: community college
- Institution of higher education administrators
- K–12 teachers—STEM
- K–12 teachers—non-STEM
- K–12 administrators
- K–12 counselors
- Informal/out-of-school time educator
- Informal/out-of-school time administrators
- Researchers
- Industry/company employees
- Policymakers
- Funders
- Parents
- Other, please describe ____________________

You have completed the survey. You can go back and review any questions/responses by using the arrow buttons at the bottom of the page. Your survey will be submitted once you advance to the next page. Thank you!
Appendix C: K–12 Engineering Education-related Organizations*

Massachusetts Engineering Innovation and Dissemination Community (MEIDC)

(*including national organizations with Massachusetts affiliates*)

This list comprises organizations with URLs named by interviewees and survey respondents, or identified through a literature and website search as part of the MEIDC landscape analysis.

—#—
100Kin10 – http://www.100kin10.org/

—A—
AccuRounds – http://www.accurounds.com/
Acera School – http://acerschool.org/
Acton-Boxborough Parent Involvement Project – http://www.actonpip.org/welcome-to-abpip-stem
Adafruit Industries – https://www.adafruit.com/
Advotq – http://advocatetg.com/
AECOM – www.aecom.com
  ○ URS – http://www.urs.com
Agawam Public Schools – http://www.agawampublicschools.org/pages/Agawam_PS
  ○ Rosie Robotics – http://www.agawampublicschools.org/pages/Agawam_PS/Parent_Support_Services/Robotics_Summer_Camp
Amazon.com Robotics – https://www.amazonrobotics.com/
American Association of Woodturners – http://www.woodturner.org/
American Association for the Advancement of Science – http://www.aaas.org/
American Association of Physics Teachers – http://www.aapt.org/
  ○ American Association of Physics Teachers, New England Section – http://aapt-nes.org/
American Council of Engineering Companies – http://www.acec.org/
  ○ American Council of Engineering Companies of Massachusetts – http://www.acecma.org/
American Society for Engineering Education – http://www.asee.org/
American Society of Civil Engineers – http://www.asce.org/
  ○ Boston Society of Civil Engineers Section/ASCE – http://www.bsces.org/
American Society of Mechanical Engineers – https://www.asme.org/career-education/K–12-students
Amesbury Public Schools – http://schools.amesburyma.gov/
Amherst Public Schools – http://www.arps.org/
Analogic Corporation – http://www.analogic.com/
Arlington Education Foundation – http://www.arlingtoneducationfoundationma.org/wp/
Arlington Public Schools – http://www.arlington.k12.ma.us/
  - Ottoson Middle School – https://sites.google.com/a/arlington.k12.ma.us/ottoson_middle_school/
Artisan's Asylum – https://artisansaasylum.com/
Artists for Humanity – http://afhbooston.org/
  - 3D Design Studio – http://www.custommade.com/by/artistsforhumanity/
Assebet Valley Regional Technical High School – http://www.assabettech.com/pages/AssabetValley
Attleboro Public Schools – http://www.attleboroschools.com/schools/attleboro_high_schools/index.php
Auburn Public Schools – https://www.auburn.k12.ma.us/site.php?page_id=830
Avon Public Schools – http://www.apps.avon.k12.ma.us/

---B---

BAE Systems, Inc. – http://www.baesystems.com/
Bay Cove Human Services – http://www.baycove.org/bcexternal/index.cfm
  - Bay Cove Academy – http://www.baycove.org/academy
Beaver Country Day School – http://www.bcdschool.org/
Belmont Day School – http://www.belmontday.org/
Belmont Public Schools – http://www.belmont.k12.ma.us/bps/bhs/
  - Belmont-Chenery Middle School – http://www.belmont.k12.ma.us/cms/
  - Belmont High School – http://www.belmont.k12.ma.us/bps/bhs/
Benjamin Franklin Institute of Technology – http://www.bfit.edu/
Bentley University – http://www.bentley.edu/
Berklee College of Music, Music Production and Engineering Department – https://www.berklee.edu/mpe
Berkshire Museum – http://berkshiremuseum.org/
Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems – http://www.censsis.neu.edu/
  - High-Tech Tools and Toys Laboratory – http://www.censsis.neu.edu/education/HTTTL/
Beyond Benign – http://www.beyondbenign.org/
Bill & Melinda Gates Foundation – http://www.gatesfoundation.org/
Blue Bunny Books & Toys – http://www.bluebunnybooks.com/
Boeing – http://www.boeing.com/
Boston After School & Beyond – http://bostonbeyond.org
Boston Centers for Youth and Families – http://www.cityofboston.gov/BCYF/centers/Menino.asp
  - Beyond the Chalkboard – http://www.beyondthechalkboard.com/
Boston College – www.bc.edu
  - Lynch School of Education – http://www.bc.edu/schools/lsoe.html
Boston Collegiate Charter School – http://www.bostoncollegiate.org/home/
Boston Public Schools – http://bostonpublicschools.org
  - Boston Arts Academy – http://bostonartsacademy.org/
    - Center for Arts Education, STEM Lab – http://bostonartsacademy.org/home-news/steam-lab
  - Boston Latin Academy – http://latinacademy.org/
  - Brighton High School – http://www.brightonhigh.org/
  - Dearborn STEM Academy – http://www.bostonpublicschools.org/school/dearborn-middle-school
  - Jeremiah E. Burke High School – http://www.jebhs.org/
  - John D. O’Bryant School of Mathematics and Science – http://obryant.us/
- McKinley Middle School – [http://www.bostonpublicschools.org/school/mckinley-middle-school](http://www.bostonpublicschools.org/school/mckinley-middle-school)


- Boston University, School of Education – [http://www.bu.edu/sed/](http://www.bu.edu/sed/)

Boston University Academy – [http://www.buacademy.org/home](http://www.buacademy.org/home)


Brandeis University – [http://www.brandeis.edu/mrsec/index.html](http://www.brandeis.edu/mrsec/index.html)

Bridgewater State University – [http://www.bridgew.edu/](http://www.bridgew.edu/)
- Center for PreK–12 Educational Outreach – [https://microsites.bridgew.edu/centerofeducationaloutreach](https://microsites.bridgew.edu/centerofeducationaloutreach)
- Center for the Advancement of STEM Education – [http://www.bridgew.edu/content/centers](http://www.bridgew.edu/content/centers)


Brookwood School – [http://www.brookwood.edu/](http://www.brookwood.edu/)


Bunker Hill Community College – [http://bhcc.mass.edu/](http://bhcc.mass.edu/)


—C—


Cambridge College – [https://www.cambridgecollege.edu/](https://www.cambridgecollege.edu/)


Cape Cod Community College – [http://www.capecod.edu/](http://www.capecod.edu/)


Clark University – [www.clarku.edu](http://www.clarku.edu)

Code.org – [https://code.org/](https://code.org/)


College Board – [https://www.collegeboard.org/](https://www.collegeboard.org/)


Community Boating of Boston – http://www.community-boating.org/
Community Group, The – http://www.thecommunitygroupinc.org/
Concord Academy – http://www.concordacademy.org/
Concord Consortium – http://concord.org/
Concord Public Schools – http://www.concordpublicschools.net/
CONNECT Partnership – http://www.connectsemass.org
C-Town Tech Program – http://www.charlestowntech.com/
Custom Group, Inc. – http://customgroupusa.com/
  ▪ Center for Manufacturing Technology – http://www.customtrainingcenter.com/
  ▪ Custom Machine, LLC – http://www.custommachineinc.com/

Dassault Systemes – http://www.3ds.com/
Davis Educational Foundation – http://www.davisfoundations.org/site/educational.asp
  ▪ Dennis-Yarmouth Regional High School – http://www.dy-regional.k12.ma.us/dennis-yarmouth-regional-high-school
Derby Academy – http://www.derbyacademy.org/
  ▪ Dighton-Rehoboth Regional High School – http://www.drregional.org/dighton-dohobothhigh
Digital Literacy Project – http://dlp.io/
DIGITS – http://digits.us.com/
DiscoverE – http://www.discovere.org/
Doyle Engineering, Inc. – http://www.doyleeng.com/
DuPont – http://www.dupont.com/
Dynamy – http://www.dynamy.org/

Earthwatch Institute – http://earthwatch.org/
EcoTarium – http://www.ecotarium.org/
EDCO Collaborative – http://www.edcollab.org/
Education Development Center, Inc. – www.edc.org
Einstein’s Workshop – https://www.einsteinworkshop.com/
EMC Corporation – http://www.emc.com/
Endicott College – http://www.endicott.edu/
Engineer Your Future – http://engineeryourfuture.org/
Engineering Center Education Trust, The – http://www.engineers.org/
Engineering Lens – http://www.integratingengineering.org/
Engineers Dedicated to a Better Tomorrow – http://www.dedicatedengineers.org/Resources/eng_societies.htm
Eugene Wright Science and Technology Academy – http://www.chelseaschools.com/cps/schools/wright.htm
Everett Public Schools – http://www.everettpublicschools.org/
Excel Academy Charter Schools – http://www.excelacademy.org/
Exploration Summer Programs – http://www.explo.org/360/wellesley
  ▪ EXPLO 360 at Wellesley College – http://www.explo.org/360/wellesley
Exploratorium – http://www.exploratorium.edu/
ExploraVision – http://www.exploravision.org/

FABLabs for America – http://www.fablabs4america.org/
Fall River Public Schools – http://www.fallriverschools.org/
I2 Camp – http://i2camp.org/
ID Tech – https://www.idtech.com/
IEEE – https://www.ieee.org/
  - IEEE Boston Section – http://ieeeboston.org
IKZ Advisors, LLC – http://www.ikzadvisors.com/
Inly School – http://www.inlyschool.org/
International Society for Technology in Education – http://www.iste.org/
  - STEM Center for Teaching and Learning – http://www.iteea.org/EbD/CATTS/catts.htm
Invent Now, Inc. – http://inventnow.org/
Ipswich Public Schools – http://www.ipsk12.net/
  - Ipswich High School – http://www.edlinesites.net/pages/Ipswich_High_School

JASON Learning – http://www.jason.org/
JogNog – https://www.jognog.com/
Johns Hopkins University – https://www.jhu.edu/
Jr. Tech, Inc. – http://www.juniortech.org/

KinderSteam – http://jcdsri.org/school-news/video-highlights-kindersteam/
KnowAtom – http://www.knowatom.com/

Latino STEM Alliance – http://www.latinostem.org
Lawrence Family Development Charter School – http://www.lfdcs.org/
Lawrence Public Schools – https://www.lawrence.k12.ma.us/lhs-campus-events
  - Lawrence High School Campus – http://www.lawrence.k12.ma.us/mst
Learning Resources Network – www.bu.edu/lemet/artemis/
Lemelson Foundation – http://www.lemelson.org/
Leominster Public Schools – http://www.leominster.mec.edu/pages/Leominster_Public_Schools
Center for Technical Education Innovation – http://www.edlinesites.net/pages/Center_Technical_Ed
Lesley University, Graduate School of Education – http://www.lesley.edu/
Lexington Public Schools – http://lps.lexingtonma.org/
Lincoln-Sudbury Regional School District – http://www.lsrhs.net/
ton-area-grants.html
LinkEngineering – http://linkengineering.org/
Lockheed Martin – http://www.lockheedmartin.com/
Lowell Public Schools – http://www.lowell.k12.ma.us/
Lucid Technologies – http://www.lucidtechninc.com/
Lynn Public Schools – http://www.lynnschools.org/
  - Lynn Vocational Technical Institute – http://www.lynnschools.org/ourschools_lyti.shtml#gpm1_1
Maimonides School – http://www.maimonides.org/
Makey Makey – http://makeymakey.com/
Malden Public Schools – http://www.maldenps.org/
  - Linden STEAM Academy – http://www.maldenps.org/LindenSchool.cfm?subpage=597860
Marlborough Public Schools – http://www.mps-edu.org/
Martha’s Vineyard Public Schools – http://www.mvyps.org/
Mass Insight Education – http://www.massinsight.org/
Massachusetts AFL-CIO – http://www.massaflcio.org/
Massachusetts Afterschool Partnership – http://www.massafterschool.org/
Massachusetts Biotechnology Education Foundation – https://www.massbioed.org/
Massachusetts Business Alliance for Education – http://www.mbae.org/
Massachusetts Business Roundtable – http://maroundtable.com
Massachusetts College of Liberal Arts – http://www.mcla.edu/
  - Regional Science Resource Center – http://www.mcla.edu/About_MCLA/area/Community-Collaborations/stempipeline/scienceresourcecenter/index
Massachusetts Community Colleges Executive Office – http://www.masscc.org/
  - Statewide Articulation Task Force – http://www.masscc.org/articulation/
Massachusetts Competitive Partnership – http://masscompetes.org/
Massachusetts Computer Using Educators – http://www.masscue.org
Massachusetts Computing Attainment Network – www.masscan.net
Massachusetts Construction Career Day – http://www.engineers.org/index.cfm/pid/10502
Massachusetts Department of Elementary and Secondary Education, Office of Science, Technology, Engineering, and Mathematics – http://www.doe.mass.edu/steam/
Massachusetts Department of Higher Education – http://www.mass.edu/
  - @Scale Grant Program – http://www.mass.edu/stem/initiatives/pipelinescaleprojects.asp
  - Governor’s STEM Advisory Council – http://www.mass.edu/stem/home/council.asp
  - STEM Pipeline Fund – http://www.mass.edu/stem/initiatives/pipeline.asp
  - Massachusetts Department of Higher Education STEM Nexus – http://www.mass.edu/steam/home.asp
Massachusetts Division of Fisheries and Wildlife – http://www.mass.gov/eea/agencies/dfg/dfw/
Massachusetts General Hospital – http://www.massgeneral.org/
Massachusetts High Technology Council – http://www.mhtc.org/
Massachusetts Institute of Technology – http://www.mit.edu/
  - BioBuilder Educational Foundation – http://biobuilder.org/
  - Center for Bits and Atoms – http://cba.mit.edu/
  - D-Lab Youth and Educator Engagement – https://d-lab.mit.edu/youth-outreach
  - Edgerton Center – http://edgerton.mit.edu/
  - Koch Institute – http://ki.mit.edu/approach/outreach
  - MIT Lincoln Laboratory – http://www.ll.mit.edu/
    - MIT Lincoln Laboratory Radar Introduction for Student Engineers – http://www.ll.mit.edu/outreach/LLrise.html
  - MIT Media Lab – http://media.mit.edu/
- Massachusetts Maritime Academy – [http://www.maritime.edu/](http://www.maritime.edu/)
- Massachusetts Science Education Leadership Association – [http://www.msel.org](http://www.msel.org)
- MATHCOUNTS Foundation – [https://www.mathcounts.org/](https://www.mathcounts.org/)
- MCPHS University – [http://www.mcphs.edu/](http://www.mcphs.edu/)
  - Medford High School – [http://www.medfordpublicschools.org/schools/medford-high-school](http://www.medfordpublicschools.org/schools/medford-high-school)
  - Medway Middle School – [http://www.medwayschools.org/medway-middle-school](http://www.medwayschools.org/medway-middle-school)
  - Merrimack College STEM Center – [http://www.merrimack.edu/academics/science_engineering/STEM_Center/](http://www.merrimack.edu/academics/science_engineering/STEM_Center/)
  - Millis High School – [http://www.millis.k12.ma.us/highschool](http://www.millis.k12.ma.us/highschool)
Museum of Science, Boston – http://www.mos.org/
  - Gateway to Engineering and Technology Education – http://www.mos.org/gateway-project
  - National Center for Technological Literacy – http://www.mos.org/engineering-curriculum

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Nashoba Regional School District – http://nrhs.nrsd.net/
Natick Educational Foundation – http://www.natickedfoundation.org/
National Academy of Engineering – http://www.nae.edu/
National Aeronautics & Space Administration – https://www.nasa.gov/
National Association of Black Engineers – http://www.nasbeboston.org/
National Center for Technological Literacy – http://www.eie.org/
National Council of Textile Organizations – http://www.eie.org/
National Grid – http://nationalgrid.com/
  - National Grid Foundation – http://nationalgridfoundation.com/
National Science Foundation – http://www.nsf.gov/
National Science Teachers Association – https://www.nsta.org
  - Massachusetts Association of Science Teachers – http://www.massscienceteach.org
National Society of Black Engineers – http://www.nsbbe.org
  - NSBE Jr. – http://www.nsbbe.org/Membership/Membership-Types/NSBE-Jr.aspx#VZq-l6HD-Uk
National Society of Land Surveyors – http://www.malsce.org/
Needham Public Schools – http://www.needham.k12.ma.us/
  - Needham High School – http://nhs.needham.k12.ma.us/main
Network for Sciences, Engineering, Arts, & Design – http://sead.viz.tamu.edu/
NetZero – http://www.netzero.net/
Newburyport Public Schools – http://www.newburyport.k12.ma.us/
  - Newburyport High School – http://nhs.newburyport.k12.ma.us/
Newton Public Schools – http://www.newton.k12.ma.us/
  - Newton Innovation Lab – http://newtons-lab.wikispaces.com/
NewtonSTEM – http://newtonstem.org/
Nitsch Engineering – http://www.nitscheng.com/
Noble & Greenough School – http://www.nobles.edu/
Northampton Public Schools – http://www.northampton-k12.us/
Northeastern University – http://www.neu.edu/
  - CAPSULE – http://capsulenu.weebly.com
  - Center for STEM Education – http://www.stem.neu.edu/
Northern Essex Community College – http://www.necc.mass.edu/
Norton Public Schools – http://www.norton.k12.ma.us/pages/Norton_Public_Schools
Noyce Foundation – http://www.noycefdn.org/
NUTRONS – http://www.nutrons.com/
NuVu Innovation School – https://cambridge.nuvustudio.com/studios/about#tab-studio-model

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Olin College of Engineering – http://www.olin.edu/
Olin SEER Program – http://www.olin.edu/seer/olin-seer-program/
ONEOK, Inc. – http://www.oneok.com/
Orange County Community Foundation – http://www.oc-cf.org/
Outward Bound – http://www.outwardbound.org/

Parts and Crafts Center for Semiconducted Learning – http://www.partsandcrafts.org/scl/
Pearson Education – http://www.pearsoned.com/
Plymouth Public Schools – http://www.plymouth.k12.ma.us/
Posse Foundation – https://www.possefoundation.org/
  - Posse Boston – https://www.possefoundation.org/news-events/boston
Program in Education, Afterschool and Resiliency – www.pearweb.org
Project Lead the Way, Inc. – https://www.pltw.org
PTC, Inc. – http://www.ptc.com/
Purdue University – http://www.purdue.edu/
  - Institute for P-12 Engineering Research and Learning – http://www.inspire-purdue.org/

Quincy Public Schools – http://quincypublicschools.com/
  - Quincy High School – http://quincypublicschools.com/qhs/
Quinsagamond Community College – http://www.qcc.edu/

Raytheon – http://www.raytheon.com/
  - Raytheon College/Pre-College Engineering Mentoring Program – http://grantome.com/grant/NSF/DUE-0227593
Real World Design Challenge – http://www.realworlddesignchallenge.org/
Regional PreK-16 STEM Networks:
  - Berkshire STEM Pipeline – http://www.mcla.edu/About_MCLA/area/Community-Collaborations/stem-pipeline/
  - Boston STEM Network – http://bostonstemnetwork.org/
  - Cape Cod Regional PreK-16 STEM Network – http://www.capecodstemnetwork.org/
  - Central Massachusetts STEM Pipeline Network – http://www.umassmed.edu/rsrccentramastem/pipelineNetwork
  - Metro North STEM Network – http://mnreb.org/STEM.php
  - MetroWest STEM Education Network – http://www.framingham.edu/stem/
  - Northeast STEM Network – http://nestemnet.info/
  - Regional PreK-16 STEM Networks – http://www.mass.edu/step/getinvolved/pipelinetworks.asp
  - Southeastern Massachusetts STEM Network – http://www.connectsemass.org/stem

Regis College – http://www.regiscollege.edu/
Revere Public Schools – http://www.revere.ma.edu/

Sandwich Public Schools – http://www.sandwichk12.org/pages/Sandwich_Public_Schools
Sandwich STEM Parents’ Group – https://www.facebook.com/SandwichStemParentsGroup
Savage Soccer – http://users.wpi.edu/~savage/
Science Club for Girls – http://www.scienceclubforgirls.org/contact-us
Science from Scientists – http://www.sciencefromscientists.org/
Scituate Public Schools – http://www.scituate.k12.ma.us/
Shady Hill School – http://www.shs.org
SheGives – http://shegivesboston.org/
Shell – http://www.shell.com/
  ○ Silver Lake Regional High School – http://www.edline.net/pages/slrhs
SkillsUSA – http://www.skillsusa.org/
  ○ SkillsUSA Massachusetts – http://www.sersd.org/Students/Clubs-Activities/SkillsUSA
Smith College – http://www.smith.edu/
Sociedad Latina – http://www.sociedadlatina.org/
Society of Hispanic Professional Engineers – http://www.shpe.org/
  ○ Society of Hispanic Professional Engineers, Boston Chapter – http://www.shpeboston.org/
Society of Women Engineers – http://societyofwomenengineers.swe.org/
  ○ Society of Women Engineers, Boston – http://www.sweboston.org/
Somerville Public Schools – http://www.somerville.k12.ma.us/
  ○ Somerville High School – http://www.somerville.k12.ma.us/education/components/scrapbook/default
.php?sectionid=96
Somerville STEAM Academy – http://www.somerville.org/
Somerville, City of – http://www.somerville.org/
South End Technology Center – http://www.tech-center--enlightentcity.tv
Sparhawk School – http://www.sparhawkschool.com/
SparkFun Electronics – https://www.sparkfun.com/
Springfield Technical Community College – http://www.stcc.edu/
  ○ STEM Starter Academy – http://www.stcc.edu/STEMAcademy/
Stoneham Public Schools – http://www.stonehamschools.org/pages/Stoneham_Public_Schools
  ○ Stoneham High School – http://www.edlinesites.net/pages/Stoneham_High
Stow Public Schools – http://www.stow-ma.gov/pages/stowma_schools/index
Suffolk University – http://www.suffolk.edu/
Swampscott Public Schools – http://www.swampscott.k12.ma.us/
  ○ Swampscott High School – http://highschool.swampscott.k12.ma.us/pages/index
  ○ Swampscott Middle School – http://middle.school.swampscott.k12.ma.us/pages/index
  ○ Synopsys Silicon Valley Science and Technology Outreach Foundation –
    https://www.outreach-foundation.org/

Tabor Academy – http://www.taboracademy.org/
TeachEngineering – www.teachengineering.org/
Team Through My Window – http://teamthroughmywindow.org/
Technocopia – http://technocopia.org/
TERC – https://www.terc.edu/display/HOME/Home
Toshiba – http://www.toshiba.com/
  ○ TOMODACHI Toshiba Science & Technology Leadership Academy – http://www.toshiba.com/csr/educa-
    tion_tomodachi_stem.jsp
  ○ Triton High School – http://www.tritonschools.org/high/
Tsongas Industrial History Center – http://www.uml.edu/Tsongas/default.aspx
—W—

Wachusett Regional School District – http://www.wrsd.net/
  ◦ Wachusett Regional High School – http://www.wrsd.net/wrhs/

Walmart – http://www.walmart.com/

Walpole Public Schools – http://www.walpole.k12.ma.us/
  ◦ Walpole High School STEM Academy – http://walpoleows.h5.sharpchool.com/academics/w_h_s_s_t_e_m_academy


Wayland Public Schools – http://www.wayland.k12.ma.us/
  ◦ Wayland High School – http://whs.wayland.k12.ma.us/


Wellesley College – http://www.wellesley.edu/

Wellesley Education Foundation – http://www.wellesleyeducationfoundation.org/

Wellesley Public Schools – http://www.wellesley.k12.ma.us/
  ◦ Wellesley Middle School – http://www.wellesley.k12.ma.us/wellesley-middle-school
  ◦ Wellesley High School – http://www.wellesley.k12.ma.us/wellesley-high-school

Wentworth Institute of Technology – http://wit.edu/

West Springfield Public Schools – http://www.wssps.org/

Westborough Public Schools – http://www.westboroughk12.org/

Westford Public Schools – http://westfordk12.us/Pages/index
  ◦ Westford Academy – http://wa.westfordk12.us/Pages/index

Weston Public Schools – http://www.westonschools.org/
  ◦ Weston High School – http://westonschools.org/index.cfm?pid=10301
  ◦ Weston Middle School – http://westonschools.org/index.cfm?pid=10302

Westwood Public Schools – http://www.westwood.k12.ma.us/
  ◦ Westwood High School – http://www.westwood.k12.ma.us/westwood-high-school/

Weymouth Public Schools – http://www.woamhs.org/
  ◦ Weymouth High School – http://www.woamhs.org/neyouthschool

WGBH Educational Foundation – http://www.wgbh.org/
  ◦ Design Squad – http://pbskids.org/designsquad/parentseducators/
  ◦ Nova Labs – http://www.pbs.org/wgbh/nova/nova/labs/
  ◦ WGBH National Center for Accessible Media – http://ncam.wgbh.org/experience_learn/educational_media/steam/intro

Wheelock College – http://www.wheelock.edu/
  ◦ Aspire Institute – http://www.wheelock.edu/about/centers-and-institutes/aspire-institute

Whitman-Hanson Regional High School – http://www.whrsd.org/

Williamsburg Public Schools – http://www.burgy.org/pages/williamsburgma_schools/index

Winchester Public Schools – http://www.winchester.k12.ma.us/Pages/Winchester_Public_Schools
  ◦ Winchester High School – http://www.edline.net/pages/Winchester_High_School


Worcester Polytechnic Institute – http://www.wpi.edu/
  ◦ Advanced Robotics – https://www.wpi.edu/academics/k12/advanced-robotics.html
  ◦ STEM Education Center – http://www.wpi.edu/academics/stem.html

Worcester Public Schools – http://worcesterschools.org/
  ◦ Worcester Technical High School – http://portal.techhigh.us/Administration/Pages/default.aspx

Worcester State University – http://www.worcester.edu/

Worcester Think Tank – http://www.worcesterthinktank.com/

Wyzant Tutoring – https://www.wyzant.com/

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Youth Development Organization – http://www.ydolawrence.org/
  ◦ STEM Design Lab – http://www.ydolawrence.org/STEM

* The organizations and programs included in this list were named by interviewees and survey respondents, or identified through a literature or Internet search. We are providing the links as a convenience and for informational purposes only. By providing links to these sites, the authors of this report do not guarantee, approve, or endorse the information or products available on these sites.