



STEMTECH ALLIANCE

**A Partnership of Five Massachusetts Technology Associations
To Increase Middle School Student Interest in STEM Careers**

RESEARCH REPORT

Understanding Middle School Students' Perceptions of Careers in Science, Technology, Engineering and Math (STEM)

September 2008

**Massachusetts Technology Leadership Council * Massachusetts BioEd Foundation *
Massachusetts Medical Device Industry Council * Massachusetts Networks
Communications Council * The Engineering Center * New England Clean Energy Council**

Project Overview

Background

The Massachusetts economy is dominated by and dependent upon the growth and success of technology-based businesses. Companies working in software and Internet, telecommunications, IT, biotechnology, medical device and engineering are highly dependent on the State's ability to produce a workforce that is skilled in science, technology, engineering and math (STEM). An educated and available STEM workforce is the very lifeblood of these companies, now and in the future.

But these companies are increasingly concerned that the supply of future STEM employees will not be available to them. Research concludes that their sense of urgency about this looming problem is warranted.

In response to this compelling issue, the five major Massachusetts technology-based trade associations have come together, for the first time ever, and formed the **STEMTech Alliance** to seek innovative ways to address this challenge. Working together these five associations, representing over 3700 Massachusetts-based technology companies with approximately 300,000 employees, will reach out to their constituent companies to harness the energy of the private sector in a major program of STEM awareness for Massachusetts middle schools.

Goal

The goal of this effort is to develop and implement a three-year program to provide STEM awareness programs to **middle school** students, teachers and administrators across the Commonwealth. STEMTech Alliance includes the direct participation of the five leading technology industry trade associations: the *Massachusetts Technology Leadership Council* (lead organization), the *Massachusetts Biotechnology Education Foundation* a part of the Massachusetts Biotechnology Council, the *Massachusetts Medical Device Council* (MassMEDIC), the *Massachusetts Network Communications Council* (MassNetComms) and *The Engineering Center* (TEC)

Over the next three years the STEMTech Alliance will undertake four major activities both to encourage interest in and to increase awareness and understanding of STEM careers for middle school students and teachers:

First, commission a research effort to look at the existing literature on STEM learning and awareness and build the connections between middle school curricula and STEM careers;

Second, work with an advertising agency to develop a key communications platform and strategy that provides a theme and messages to serve as a common connection between all STEMTech Alliance activities;

Third develop a STEM Guidebook available on-line (and in hard copy) with a set of guidelines and best practices on how companies and middle schools can best work together.

Finally, bring STEM professionals into the classroom to better illustrate the range and excitement of STEM careers, as well as the diversity of STEM employees. Working with STEM Ambassadors (STEM professionals who volunteer for school visits) this effort will give students and educators a personal understanding of the importance and variety of STEM careers and the way in which STEM professionals are "changing the world."

I. Research Report Introduction

The purposes of this report are threefold:

- To educate project leadership, staff and other important constituencies;
- To provide the foundation for the branding and messaging campaign of STEMTech Alliance; and
- To enable STEM volunteers to quickly understand the problems and opportunities, as they prepare to go into middle school classrooms to motivate students about the tremendous opportunities STEM fields offer.

National research reports continue to find that U.S. students, at all levels of schooling, are showing a decreasing interest in pursuing education – and careers – in technical fields including science, technology, engineering and math, commonly referred to as STEM. The number of engineering degrees awarded in the U.S. is down 20% from its peak in 1985 and by 2010, if current trends continue, the estimate is that 90% of all scientists and engineers will live in Asia. (1) U.S. business leaders believe the U.S. needs to double the number of STEM graduates by 2015. (1)

In a 2005 assessment of problem-solving skills, U.S. students had the smallest percentage of the top performers and the largest percentage of low performers. (1) In Massachusetts, these same trends are visible: in 2002, 22% of Massachusetts SAT test takers expressed an interest in pursuing STEM subjects in college; this number dropped to 19% in 2004, and only recently began to creep back up, reaching 20.4% in 2007.(2)

The questions that are being asked over and over again are “Why?” and “What can educators and the business community do to reverse these trends?”

The Massachusetts Department of Higher Education is deeply concerned about this problem. In 2008, as part of its effort to increase STEM awareness among middle school students, the Department awarded a grant to five Massachusetts technology associations to undertake a three-year effort to increase STEM awareness for middle school students across the Commonwealth. This project, entitled *STEMTech Alliance*, is working to understand the problem and the opportunity. And then to identify STEM professionals who will go into middle school classrooms and try to inspire students to consider STEM careers.

As part of this project, the *STEMTech Alliance* has looked at the existing research on student learning, to understand what middle school students already know about STEM careers, and to ascertain how best to increase their knowledge. Our findings are included in this report. It is not an academic research report; instead it is a summary of key principles, concepts, and facts that we have gathered through our formal and informal learning.

In trying to answer the questions “What do students know about STEM careers?” and “How can we increase student awareness of STEM?” we have turned to the following sources to inform our understanding and the preparation of this report:

First, we have done our own field research. In June 2008, we held three focus groups and spoke with 18 teachers and nine students. While this sample is small, the comments and observations we received reflect what is in the literature.

Second, we have reviewed the information and findings prepared by several highly respected organizations and individuals; each has done their own research and has based their own program offerings on the research results. These resources include the **Boston Museum of Science, WGBH Television, Tufts University Center for Engineering Outreach, and Sally Ride**, former astronaut and President of Sally Ride Science. These organizations are dedicated to changing perceptions and student learning about STEM fields and are working effectively and creatively to address the STEM issue. They have each launched a series of programs for students and provided materials for teachers that are creating considerable interest and excitement. Individually and collectively, these efforts are helping to grow interest in STEM fields.

Third, we have reviewed a number of relevant articles published in research journals over the past several years. We are attaching two literature reviews –by career specialist Dr. Thomas Harrington from Northeastern University and Jean Supel from the Donahue Institute at the University of Massachusetts.

In summarizing the information we have gathered, we have organized this report to provide general answers to five basic questions:

- What do Middle School Students know about STEM Careers?
- How do they describe a ‘Good Job’?
- How do Middle School Students learn?
- What do Middle School Students think of STEM courses?
- How can classroom visitors maximize classroom presentations to increase awareness of STEM Careers?

We hope this document provides a useful overview of the problem and opportunity and helps the business community better understand the critical role it can play working with middle school teachers and students in the years to come.

II. Middle School Student Understanding of STEM

1. What do Middle School Students know about STEM Careers?

Middle School students – in grades 6, 7 and 8 – know very little about careers in general and even less about STEM careers.

Their concept of “jobs”, “work,” or “careers” comes from two sources: first, the popular culture that they see all around them which includes both traditional (TV, movies, magazines) and on-line media (Internet, on-line social network). Secondly, students learn about careers from the adults in their lives, specifically parents and teachers. Despite these two influences, students have a very limited understanding of careers. Television shows them what a lawyer or doctor does and they understand how these professionals spend their days, but they don’t know or learn what a scientist or chemical engineer does. And, when it comes to describing what their parents do in their jobs, most middle school students know very little. They say their parents “go to the office and are in meetings a lot” but show little understanding beyond that. (3)

When students are asked to describe either STEM professionals or STEM jobs, their responses are often not positive and are based on common stereotypes. (3)

Science often means “medicine” to middle school students. They have a general concept of what doctors and nurses do, but being a “scientist” is a far more abstract concept to them. They cannot make an easy connection between what scientists “know” do and how they spend their days ‘doing science’.

Technology generally means computers to middle school students. If pressed, they understand that cell phones, iPods, the Internet, YouTube, and My Space, represent technology, but their general understanding of what technology is and how it is used in a career is very limited.

Engineering means designing and building things – bridges, roads, buildings, water systems etc. Middle school students understand the process of “building things” and it intrigues them.

Math, and its relationship to careers, means nothing to them. In fact, students generally cannot think of any careers where math is used.

In addition to their limited understanding of STEM careers, students often have negative perceptions of what it means to work in science, technology, engineering and math which provides a reason for them not to pursue STEM careers. Students say STEM careers are “hard”, are only for “very smart” people, and require a lot of education. Society somehow communicates that STEM professionals work ‘alone,’ which students at this age do not like. Middle school students internalize these various messages and turn away from STEM careers. (4)

Finally, when asked to draw a picture of a STEM professional, they draw the stereotype of an aging white male, often with glasses, sitting at a desk doing math problems. They don’t generally have positive role models for STEM careers and this creates yet another barrier to their interests because students want to know that STEM people are “normal” and “look like them”. (3)

2. What is a Good Job?

While middle school students have little understanding of general careers and specific jobs, the research data is clearer on what students think is a “good” job and the social characteristics that are important to them as they think about their future.

The research shows that a career’s perceived value is comprised of both intrinsic factors (i.e. does the student have a personal interest in the job) and extrinsic factors (how much does the job pay, how many years of school do you have to have to get the job, etc.)

Money is a motivating factor for all middle school students; they are curious about what jobs pay and want to find a job where they can earn a lot. They know that sports figures and TV stars earn good money and that factor, plus the star quality of these individuals, puts these careers high on their list. But middle school students have no idea that STEM professionals can also earn a good deal of money.

Beyond money, students are looking for certain social characteristics in a job. Various surveys have shown that middle school girls, in particular, are looking to find jobs where they can (a) work with people they like (b) be creative (c) have flexibility in their work (d) earn a good income and (e) travel. Both boys and girls want to work in a job where they can “do good”, make the world a better place, and be part of a “team” of people. (4)

Exposure to jobs has a big impact on middle school students. Those who have gone on field trips to see what happens in a court room, a hospital or a technology company show an increased interest in all three. But many students have had extremely limited exposure to STEM careers and, as a result, show little interest in them. It should be noted that, as students think about careers, they “add” professions through grade 6; but start “subtracting” professions after that. Early exposure to jobs and careers is therefore critically important to forming their opinions. (5)

Finally, when students think of “good jobs” they want to see people who “look like them”. They often perceive that successful people, in general, are old, or male, or both. This perception is even stronger in STEM careers and students don’t think that women or minorities or younger workers of any race work in these fields. As such, it is hard for them to relate to these jobs or see themselves in them. (6)

3. How do Middle School Students learn?

Middle school students have specific learning styles, which differ from how elementary and high school students learn. (7)

In elementary school, students pay attention to the teacher’s norms and follow them closely; in high school, students are increasingly self-motivated and able to make their own decisions, beyond what the adults in their lives tell them to do.

But middle school students are different. They have a clear understanding of their abilities in school and know, early on, which subjects they are ‘good at’ and ‘bad at’. And, this can become a self-fulfilling prophesy: if they “succeed” in a subject, they think it is because they are “good at it”. If they do poorly in a subject, they ascribe this to the fact that they are “not good at it” rather than

understanding that if they worked harder they could, in fact, succeed. Middle school students move towards subjects (and careers) that require abilities they think either have or can develop and move away from subjects (and careers) that require abilities they think don't have or about which they have self doubts. (3)

Even though middle schoolers have the ability to judge their own competencies, they have not yet developed the ability to think abstractly. They learn much better by “doing”, by working in groups or teams and by being rewarded for their success. Middle school students need concrete examples of things and not theoretical abstracts. They learn better by doing and making something, rather than just listening to someone talk to them. Too often they learn math, science, technology and engineering by reading a book, or doing work sheets or talking about the subject. Many of them have almost no chance to “do” these very same subjects which would bring them to life and increase their interest. (3) (6)

And there is one other overriding factor that is particular to middle school students and affects their learning. In middle school, students become increasingly focused on their social standing among their peers. They want to “fit in” and “be cool” and judge their ability to meet these two goals on a daily basis. They are very concerned with “self awareness” and therefore move towards subjects and friends that make them “cool” and turn away from things that make them stand out and appear different. (8)

This is where the clash with STEM subjects starts to occur. In middle school, many students become aware of the concept of a “Nerd.” Nerds are seen as being academically strong in science and math, the very basics of the STEM field, but they also are presumed to have many bad attributes, including being unattractive, unathletic, not sexy, and not fun– the very qualities that early adolescents are looking to avoid at all costs. (8)

One of the major goals of STEMTech Alliance is to introduce middle school students to a group of STEM professionals who counteract the stereotypes associated with academic strengths, who are engaging, fun and socially acceptable, and who happen to work in and are good at STEM subjects.

4. What do Middle School student think of STEM courses?

Middle School students in Massachusetts are required to take STEM courses in grades 6, 7 and 8 which include courses in biology, physical sciences (chemistry and physics), technology/engineering and math. The content for each grade is prescribed by the State Department of Education and middle school teachers must cover specific subject matter in these four topics in each of the three years of middle school.

The general rule of thumb appears to be that if students are good in a subject they like it but if they do poorly in the particular subject then they don't like it. But the overriding message students share is that STEM courses are somehow “hard” and only for “very smart students” and they feel that even if they do well in the subject now, it will become more difficult in the future and they will fail. (3)

Students like engineering (technology) because they get to do hands on activities, work together and build things. They like the visual and tactile impact of being able to create something that they can see and touch and move. Boys, in particular, like the competition of building something better than their classmates. (3)

The physical sciences also hold interest to them as do the life sciences (biology). Actual science achievement is related to expected achievement, motivation, “field experiences, quantity of courses taken, science-related experiences outside of school, mentors and role models, often tracking socioeconomic status, parental education, social and cultural “capital” and learning behaviors.” (3)

Math is a more complicated subject. Many students like math because they can get the “right” answer – math is either right or wrong and they like the finality of that. And if they get the ‘right’ answer then they consider themselves good at the subject and ‘like it’. However, even students who know they are good at math say they do not want to work in a career that has math in it because it is also viewed as “hard” and is perceived as something only for “smart” students. Their perceptions about liking or disliking math tend to solidify at about 7th grade and it is difficult to change their perceptions, motivations and success after that. (3) (5)

5. How can classroom visitors present info on STEM Careers?

Given all this information, the question to be answered now is how can individuals who work in STEM careers – in the life sciences, technology, software and IT, and engineering – communicate the excitement and variety of the work they do? How can they overcome the perceptions and misperceptions that middle school students have about STEM fields, increase awareness of STEM careers and make a difference in the classroom?

The conversations we have had with students, teachers and the research itself suggest that STEM visitors to a middle school classroom should keep the following approach in mind: (3) (6) (9)

1. Students want to hear **personal stories** and see people who look like them. The most useful thing an industry visitor can do is to relate well to children and find an exciting way to talk about how they got into their work, what they do and why they truly like it. They should also be prepared to answer the “how much money do you make?” and explain that STEM careers pay well. They should talk about the kind of normal lives they lead, the nice homes they have, the good cars they drive, that they have children, etc. The bottom line is that STEM professionals should help students understand that doing well in STEM fields can provide a very good life.
2. Students need to hear that **STEM professionals are not always geniuses**, did not have perfect school records, have tried different careers, have had some successes and failures but have now found work they are truly excited about and good at.
3. STEM professionals should try to **relate what they do to the world around them**. If they are working in drug discovery, they can talk about the disease they are looking to cure and see if the students know anyone suffering from this disease; if they work in IT, they can talk about developing products and applications that impact the way people live, work and play. If they are engineers, they can talk about designing and building such things as cars and toys.
4. STEM professionals need to **be enthusiastic**, “become a 12 year old again”, and show why they are excited about the work they are doing.

5. Coming into classrooms and being a “talking head” will lose a student’s attention immediately. Instead STEM professionals should come to class with a problem they are working on that can engage students and **bring some props or tools** that they use in their jobs to create some interest and generate the “wow” factor that middle school students like. Scientists may be able to bring a lab coat and goggles with them; engineers can bring models or measuring equipment; professionals in the software and IT industry might bring in a programmable robot.
6. Middle school students learn best by “doing” and **hands-on activities** will get and keep their attention. In some classroom visits, STEM professionals asked students to build a satellite out of simple materials and brought some mylar and a flashlight and then asked students to measure the amount of light generated and figure out the cost of materials needed to build the object. This activity had the double advantage of connecting science and math or technology and engineering AND providing students with an activity to do. Middle school students often see these subjects as unrelated and are intrigued when they see connections being made between them.
7. STEM professionals should **begin their classroom presentations with an interactive exercise** to get students’ attention and follow that with an explanation and description of opportunities in their field. If students get to work on a problem or activity that excites them they are more likely to remember the activity favorably and can then connect that “favorability factor” to an interest in the subject matter and a possible career.
8. Middle school students **need to understand why they are learning something** and STEM visitors can use this as a jumping off point. An example would be “You are currently doing fractions – let me tell you how I use fractions in the experiments I am doing. “ One school reported that a football player once talked about the football being thrown and how he used the Pythagorean Theorem in estimating where he needed to be to catch the ball.
9. Middle school students like the “**icky and gross**” factors. In environmental science, they always want to know where the toilet water goes and a discussion of this can involve engineering, technology, science and math.
10. Finally, STEM visitors should stress the **broad variety of careers** in their field and, if possible, talk about how STEM careers can **help make the world a better place**.

We hope this brief review has provided a greater understanding of the issues and possibilities around STEM careers and can prepare and guide industry visitors as they enter classrooms and work with students. The need is critical and STEMTech Alliance is committed to the work that lies ahead.

BIBLIOGRAPHY

This report is based on conversations and input received from a number of individuals, in the Greater Boston area, who are working in STEM education and whose experience, knowledge and perspective have been critical to informing the work of the STEMTech Alliance. We are grateful for their input and would like to acknowledge the information we have learned from them:

1 Tapping America's Potential: The Education for Innovation Initiative: Business Roundtable, July 2005

2 Massachusetts STEM Talent Overview, John Hodgman, U Mass Lowell, March 2008

Focus Groups:

3 Middle School Teachers

Wood Hill School, Andover MA (6.4.08)

Pollard Middle School, Needham MA (6.11.08)

5 Middle School Students

Boys and Girls Club of South Boston (6.16.08)

4 Dr. Sally Ride, former Astronaut and President *Sally Ride Science*, (3.27.08)

6 Yvonne Spicer, *Boston Museum of Science*, Vice President for Advocacy and Educational Partnerships, for the Museum's National Center for Technological Literacy

7 Thea Sahr, *WGBH*, Associate Director, Educational Outreach.

Marisa Wolsky, *WGBH*, Executive Producer, PBS Design Squad (4.22.08)

8 Dr. David Anderegg, Professor, *Bennington College*, Author *Nerds: Who They Are and Why We Need More of Them* Presentation Before the Massachusetts Goddard Council (7.2.08)

Christine Cunningham, *Boston Museum of Science*, VP for Research and Director of the Museum's 'Engineering is Elementary'

9 Chris Rogers, *Tufts University*, Center for Engineering Education (9.10.08)