Addressing the STEM Challenge by Expanding Specialty Math and Science High Schools

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In June 2006, several NCSSSMST executive committee members and past presidents were invited by Dr. Rob Atkinson, President of the Information Technology and Innovation Foundation (ITIF.org), to contribute to a paper on the need for specialized STEM high schools. The paper was presented on Capitol Hill by Dr. Atkinson and Dr. Jay Thomas, NCSSSMST Vice President, in March 2007. With the endorsement from several Congressmen, David Price (D-NC) and Brad Miller (D-NC), this paper informed a section of HR 2272, which was signed into law in August 2007 as the America COMPETES Act. The act increases federal funding for education and research and development in science, mathematics,engineering and technology education in the next three years, including increasing funding of specialized high schools. This article is reprinted with permission from ITIF.

If America is to succeed in the innovation-powered global economy, boosting math and science skills will be critical. This is why a wide array of task forces and organizations has recently raised the clarion call for more and better scientists and engineers. While the policy proposals offered are wide ranging, one key policy innovation has surprisingly been largely ignored: the role of specialty math and science high schools. Today, there are well over 100 of these high schools throughout the nation. And evidence shows that these schools are a powerful tool for producing high school graduates with a deep knowledge and strong passion for science and math that translates into much higher rates of college attendance and graduation in scientific fields.

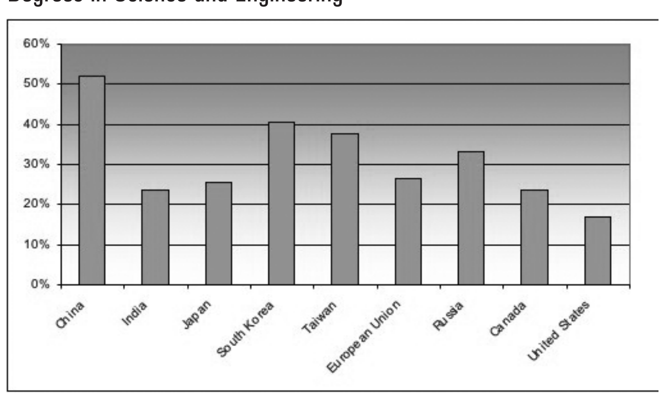
As a result, any solution to the scientist, technician, engineer, and mathematician (STEM) shortage must include a national commitment to expand the number of specialty math and science high schools. To do this, Congress should allocate $180 million a year for five years to the National Science Foundation to be matched by states and local school districts and industry with the goal of tripling enrollment in math and science high schools to around 140,000 by 2012.

The STEM challenge

The United States faces a new and pressing competitiveness challenge as a growing number of nations seek to gain global market share in technology-based economic activities. While the national policy response must be multi-faceted,[1] ensuring an adequate supply of talented scientists and engineers is one key step.

However, on a host of science, math, and engineering metrics, America is falling behind. The United States now lags behind much of the world in the share of its college graduates majoring in science and technology. As a result, the United States ranks just 29th of 109 countries in the percentage of 24 year olds with a math or science degree (See Figure 1).

Figure 1: Percentage of First Degree University Students Receiving Degrees in Science and Engineering[2]



As the economy is becoming more science and technology-based, fewer American students are studying science, technology, engineering and math (STEM). For example, while total U.S. citizen non-science and engineering graduate degrees increased 64 percent between 1985 and 2002, the graduate degrees in STEM fields awarded to U.S. citizens increased by just 14 percent, while degrees in STEM fields awarded to foreign-born students more than doubled (See Figure 2).

In some fields there has been a marked decline. For example, there are fewer non-biological science and engineering doctorate degrees being awarded to U.S. citizens today than in 1996 (See Figure 3). Likewise, bachelors degrees in engineering granted to Americans peaked in 1985 and are now 23 percent below that level.

So far the United States has been able to rely on foreign students studying and working here to make up the shortfall of domestic talent. In 2000, over half of all Ph.D. scientists under the age of 45 were foreign born, up from 27 percent in 1990 (See Table 1). But it's not clear that we will be able to rely on foreign scientists and engineers to fill the gap in the future. Fewer foreign students are coming to the United States for their degrees and fewer are staying after they graduate.[4]

Even in the face of these statistics some argue that today's worries about a STEM shortage will prove as illusive as past worries. It's true that well publicized warnings about shortages of STEM talent made in the 1980s and early 1990s did not come to pass. But it's important to recognize two key factors. First, those predictions did not, and could not, have taken into account the significant decline in funding for research in the 1990s, prompted in part by defense downsizing and federal fiscal shortfalls. Had funding not been cut, shortages could very well have appeared. Second, and more importantly, the United States made up for shortfalls in American-born STEM graduates by expanding immigration of STEM talent.

Figure 2: Percent Change in U.S. Graduate Degrees: 1985-2002[3]

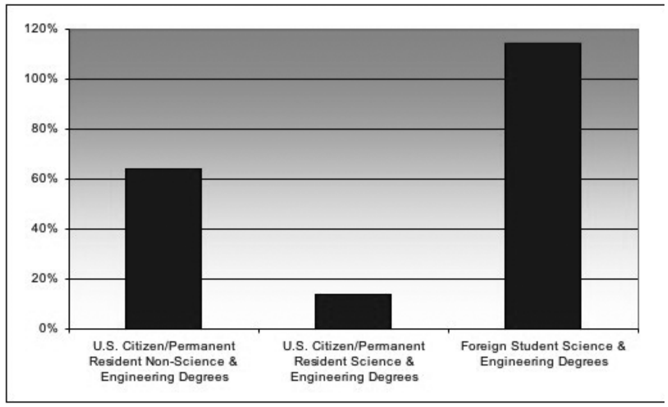


Figure 3: Non-Biological Sciences Science and Engineering Doctoral Degrees Awarded to U.S. Citizens[5]

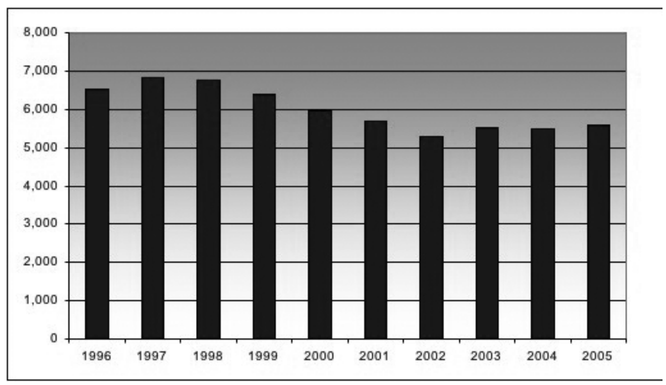


Table 1: Foreign-born Share of Scientist and Engineers Employment[6]

	1990	2000
Bachelors	11%	17%
Masters	19%	29%
All PhD	24%	38%
PhDs $<$ 45	27%	52%
Post-Doc	51%	60%

Proposed Solutions to the STEM Challenge

There is no lack of proposals to address the STEM challenge. Proposals fall into two major categories: easing immigration and boosting domestic supply. With regard to the former, there is considerable focus on easing immigration rules to make it easier for foreign-born scientists and engineers to work in the United States. While such steps are important in the short run, over-reliance on foreign-born STEM personnel involves considerable risk. As we saw after 9-11, numbers of STEM immigrants can decline suddenly. Moreover, other nations, particularly Canada, Australia and Great Britain, have increased their recruitment of STEM talent.[7] As other nations get richer and STEM employment opportunities there become more plentiful it will be harder to attract and retain foreign STEM talent.

The second major policy focus centers on boosting the supply of U.S. STEM talent. Some proposals have focused on boosting incentives to encourage college graduates to obtain graduate degrees in STEM. For example, Congressional legislation would expand NSF doctoral fellowships. Other proposals focus on increasing the retention rate of undergraduates in STEM fields, in part by expanding NSF's Science, Technology, Engineering and Mathematics Talent Expansion Program and by encouraging development of Professional Science Masters programs.[8] Still other proposals focus on making it easier for students interested in STEM, especially underrepresented minorities and women, to go to college and study STEM fields, through programs such as NASA's Science and Technology Scholarship Program and NSF's Robert Noyce Scholarships.[9]

Finally, and most relevant to this policy brief, a wide array of proposals would seek to intervene farther back in the STEM pipeline at the K-12 level. These include expanding professional development programs for science teachers;[10] enhancing science enrichment programs; using No Child Left Behind to judge scientific educational outcomes; and boosting science teacher quality, either through stricter requirements, providing incentives to attract higher quality teachers to science,[11] and/or making it easier for scientists and engineers to become teachers.

To solve the STEM problem, policy makers should focus on all the areas above. Surprisingly, however, virtually all the reports on this issue and the legislation addressing it largely ignore one of the most potentially successful policy interventions in this area: specialized math and science technology high schools. One report that did mention specialty math and science high schools was the National Academy's *Gathering Storm* report, but it did not contain specific policy recommendations towards implementing them.[12] Moreover, the PACE-Energy Act (S. 2197), based on report, contains a small program to let energy national laboratory staff assist in teaching at such high schools.[13]

By creating an environment focused more intensely on science and technology, these schools have been able to successfully enable students to study science and math, often at levels far beyond what students in conventional high schools are at; they can then go on to degrees in math and science at relatively high levels. It's time to build upon this successful model and significantly expand the number and scope of our nation's math and science specialty high schools.

What are Mathematics, Science and Technology High Schools?

There are close to 100 math and science high schools (MSHS) across the nation, members of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology, with pull-out programs with 125 students, to full day programs and dedicated high schools of over 4,000 students, to state sponsored residential schools, enrolling over 47,000 students in total. Approximately three-quarters of these schools are full-day schools, 25 percent are half-day programs, and 18 percent are residential schools.[14]

While a few MSHSs date back to the early 1900s,[15] many were developed after 1980 in response to a growing concern about the competitive position of the U.S. economy. In response, several states established new public high schools with an emphasis on mathematics, science and technology such as Thomas Jefferson High School for Science and Mathematics in Northern Virginia, The North Carolina School for Science and Mathematics (NCSSM) in Durham, The Illinois Mathematics and Science Academy (IMSA) in Aurora, and the Eleanor Roosevelt High School in Greenbelt, Maryland. Congress allocated funding for magnet schools of mathematics and science to assist school districts under supervision of the courts with desegregation plans in the late 1980s. Many of the science and technology magnet schools were placed on the high school campuses with disproportionately high numbers of African American students in order to bring non-black students into these schools. The magnet programs were developed using a school-within-a-school concept. The Center for Advanced Technologies in St. Petersburg, Florida, The Blair Science, Mathematics, Computer Science Magnet Program in Silver Spring, Maryland, and the Conroe Academy of Science and Technology in Conroe, Texas are examples of the school-within-a-school concept.[16]

Mathematics, Science, and Technology High Schools differ from the general education found in comprehensive high schools in key ways. First, as the name implies, MSHSs focus much more extensively on STEM curricula. For example, in addition to the three years of lab science and three years of mathematics required by the state for high school graduation, Florida's Center for Advanced Technologies offers students an opportunity to declare a mathematics-science major by taking four additional courses in mathematics and science, often Advanced Placement Courses.[17]

Second, students don't just take more STEM courses; they take more advanced courses and do more advanced work.[18] Indeed, the coursework and integrated curricula of MSHSs go over and above the normal graduation requirements for general education students. For example, students at the Arkansas School for Mathematics, Sciences, and the Arts can take courses in Biomedical Physics, Immunology, Micro-biology, Multivariable Calculus, Number Theory, Differential Equations, Math Modeling, Computer Programming III, and Web Application Development. The focus at these schools is not on the College Board's Advanced Placement offerings, but on courses beyond AP. Students are expected to work at a college level of instruction and learning.

The majority of these specialized schools have a focus on a graduation requirement of research in an area of math-science-technology where they are taught to ask the right questions, use 21st Century state of the art tools to find the right answers, and then effectively communicate these answers. For example, some schools have requirements where the students are assigned a research mentor with whom they will work over the course of the time they are at the school. Students also compete in science fairs, research symposia, etc. as the capstone for these research projects. These projects are often entered into national competitions such as the Siemens-Westinghouse Science Talent Search, the International Science and Engineering Fair, Chemagination, DuPont Challenge, Exploravision, Neuroscience Creativity Prize, Thinkquest, Young Epidemiology Scholars, and Young Naturalist Awards.

A third distinguishing feature of these schools is their level of partnership with other organizations. Collegiate, corporate, and alumni organizations have formed significant partnerships with these schools. While some partnerships have been in support of specific events, others have been long-term partnerships supporting research and innovation among students and faculty. Collegiate partners, for example, often provide classroom, dormitory, research, and financial support to these schools.[19] For example, at the Governor's School of South Carolina, every rising senior is placed for six weeks in the summer at an off-campus program. Many of the students work with a research professor at an in-state university.

Finally, while it's difficult to assess and compare educational environments, MSHSs are distinguished by the high level of student and faculty engagement. Many students get turned on to mathematics and science because their instructors are engaging and their own love of learning is contagious.[20] One finds a great deal more interaction between students and instructors at these schools. Students are eager to spend time with people who are interesting and interested in them. One school principal calls it "hanging on the faculty member's legs." It's not uncommon to find instructors surrounded by students during off periods or after classes. When a student conducts research under the tutelage of an interested teacher, the mutual excitement grows. This is one reason why most of these students do not want to take the summer off or spend it working at a fast-food restaurant. Instead, they are hooked on learning and want to take advantage of all that is offered.

This is also a reason why instruction is less traditional. As a general rule, instructors do not spoon-feed information; rather they focus on student responsibility for solving problems, digging for the information, researching for understanding. It's unusual to find traditional instruction at these schools – the "I'll tell you, then you'll repeat it back to me" style of instruction that is found in most educational settings. MSHS faculty focus on student learning rather than simply faculty teaching, and expect the development of critical thinking skills and learning beyond simple understanding.

Moreover, because students and faculty are passionate about STEM, the normal issues in conventional high schools where kids interested in science are labeled as nerds, or where girls are discouraged from being smart, largely disappear. As one high school principal said, "females stop worrying about their looks and whether they will be popular. Instead they compete with the males in their classes and find that the guys like them for their smarts and not just their looks."

Specialty Math and Science High Schools Are an Effective Tool for Boosting STEM Talent

While the educational environments and pedagogical processes at MSHS are exemplary, the key question is whether they produce results. While formal studies are few, there is some evidence that these schools are highly effective at producing graduates not only with high levels of aptitude in STEM, but who go on to further study and careers in STEM. For example, one study of 1,032 graduates finds that these schools perform very highly.[21] MSHSs' graduates leave high school and college as highly prepared, very satisfied and efficacious students of mathematics, science, and technology: 99 percent of graduates enroll in college within one year of high school (compared to 66 percent nationally) while 79 percent complete college in 4 years (compared to 65 percent in private universities and 38 percent in public universities).[22] Moreover, 80 percent of graduates intend to earn a master's or doctorate degree, while just 10 percent of 30 year olds have a graduate, professional or doctorate degree,[23] while 53 percent of students among those in the highest quarter of family SES expected to complete graduate or professional school.[24] Students also voice very positive views of their high school experience, with 85 percent of college seniors indicating that their high school enhanced their critical thinking and 76 percent indicating that their high school enhanced their research skills.

Most importantly, however, MSHS graduates earn undergraduate and graduate degrees in mathematics, science, and technology fields in significantly higher numbers than the general population. Approximately 56 percent of MSHS graduates earn undergraduate degrees in mathematics or science-related fields, compared to just over 20 percent of students who earn an undergraduate degree. It is especially important to note that over 40 percent of females earn such degrees – nearly double the national average. And a significant percentage of those female MSHS graduates who do earn a mathematics, science, or technology degree indicate plans to seek employment or advanced study in highly specialized fields. These findings are consistent with trend data gathered over time by MSHS schools that conducted independent graduate follow-up. Graduates of MSHSs distinguish themselves from their academic and professional peers. While it is likely that among any population of gifted and talented students a significant number would become high achievers in their chosen fields, the opportunities afforded to students through MSHSs clearly enhances such correlated critical skills.

Graduates of specialized schools have distinguished themselves in many ways in mathematics and science research in college and beyond, and there is abundant evidence that students' ability to ask questions and pose novel solutions was recognized and enhanced by their specialized school experiences. One female student, for example, matriculated at Harvard University and embarked on a four-year study of a particular species of mushroom. She had begun her groundbreaking research in a mentorship experience in high school, and her original high school research led to the revision of texts on the subject. Graduates of MSHSs frequently comment that the most influential experiences in high school were the opportunities to engage in their own research and inquiry – opportunities not available at their home schools. High school, suggested one graduate, "Taught me not to rush into difficult problems but to step back and evaluate the situation so that I can tackle it from the right angle." Another student, a Harvard undergraduate and Yale law school graduate, suggested that he would never have known that Harvard and Yale would be an option for him had he remained at his rural Midwestern school. Students from rural, poor, or inner-city schools have consistently commented that, upon matriculation at a MSHS school, they recognized for the first time that there were students who shared their interests, that it was acceptable to be smart, and that there were teachers who were interested in them and eager to challenge them.

Challenges

Significant challenges face current and emerging specialized mathematics, science and technology high schools. Specialized high schools are continuously confronted with issues of sustainability, committing a high level of energy to promote, improve and fund their schools. The governance structures of specialized schools differ widely. For example, some operate under the purview of a college or university, while others report to local boards and district-level stakeholders. Hence, with different funding sources, governance structures, and stakeholders, specialized schools regularly face issues related to public support and curriculum, facilities, and funding.

Public Support and the Issue of "Elitism"

Perhaps the largest challenge facing the MSHS movement is the ambiguity that exists in our nation regarding excellence. On the one hand there is growing recognition of the importance of meeting the new challenge of a "flat world" by ensuring that the best and the brightest enter in STEM fields and receive top level training and education. Yet, at the same time there is a suspicion that helping a relatively small group of students excel is some how elitist and unfair. At the local level, citizens sometimes balk at supporting specialized math and science schools as they are often regarded as elitist schools that drain financial and human resources from the general population of students. While boosting the quality of K-12 schools and especially underperforming ones, STEM education should not he held hostage to, in this case, misplaced concerns about fairness. It is clearly in the national interest to ensure that some students who are passionate about STEM receive the support and educational environment they need to excel.

This does not mean, as some might believe, that MSHSs cannot or should not focus on expanding their opportunities to the widest possible groups of students. In general, minorities and females are underrepresented in specialized mathematics, science and technology schools just as they are in these fields in higher education and in professional fields. Moreover, research literature in education is rife with evidence that minority and low-income/low socioeconomic status gifted and talented students are woefully under-identified, under-challenged, and under-represented in public schools.[25]

As a group, however, specialized mathematics and science schools have found not only effective strategies for identifying such students, but also actively implement plans for support and retention of such students. Many of these schools engage in energetic efforts to identify, engage and train the most capable and talented pool of students. Hence, to actively recruit and support talented students, regional or statewide mathematics and science programs offer opportunities to students who might otherwise not be recognized. For example, in Pinellas County, Florida, with approximately an 18 percent African-American population, less than 4 percent of those students are served in the public schools' International Baccalaureate (IB) program. The specialized mathematics and science school, however, typically serves over 10 percent of a group historically under-represented in higher education mathematics and science. More broadly, NCSSSMST, the association of MSHSs, through support from the Alfred P. Sloan Foundation, the Siemens Foundation, and Associated Colleges of Illinois, has initiated a multiyear study to identify and assess successful practices in reaching under-represented groups.

Facilities and Funding
School districts are often reluctant to commit the resources to create and provide ongoing support for schools for mathematics, science and technology. Such reluctance is manifested by concerns related to the high cost of science and technology laboratories and equipment. Specialized mathematics, science and technology schools require quality, up-to-date laboratories and research spaces. Viable laboratories should be designed to accommodate a variety of projects, innovative research studies, teamwork, and spaces for building technology projects, online connections, supportive technology and current equipment.[26] In the standard, comprehensive high school, the cost per student in a laboratory science class is one of the highest costs in the school. To provide the laboratories needed at specialized schools, the cost is even higher.

Effective MSHSs also need quality curricula; current textbooks and curriculum materials do not meet the demands of these schools. MSHSs devote significant energy and resources to and enhance currently available curricula. Other schools actively develop innovative curricula designed to challenge their own students and to inform educational practice at the local and state levels. Indeed, part of these schools' mission statements is a charge to transform mathematics and science education at the local, regional, or state levels. Such outreach efforts demand that faculty be allowed to stay current in their academic fields, engage in educational research, and be released for faculty development outside their own schools. All these additional resources – laboratories, curriculum and educational outreach – cost extra money. Given that much of the benefit of MSHS will accrue to the state as a whole, the nation, and indeed the world, in the form of more and better scientific research and engineering, it's not surprising that the locally-funded school system under-invests in this kind of knowledge infrastructure.

Policy Recommendations

Solving the STEM challenge will require an array of responses at a range of educational levels, (K-12, college, graduate school, work-related immigration). However, a key part of any solution needs to be the significant expansion of specialty math and science high schools. As we noted above, more so than other high schools, math and science high schools produce benefits that local communities, and even states will not capture. Rather than be seen as solely the responsibility of local school districts, or even states, they should be seen for what they are: a critical part of the scientific and technological infrastructure of the nation. Thus, we believe that the National Science Foundation should play a key role in supporting and expanding such schools. As a result, Congress and the Administration should set a goal of approximately quadrupling enrollment at such high schools to around 250,000 students. This will require both the creation of a significant number of new high schools, but also expansion of others with room to grow. To do this, **Congress should allocate $180 million a year for the next five years to the National Science Foundation to be matched with funding from states and local school districts and industry, and invested in both the creation of new MSHSs and the expansion of existing ones.**[27] Moreover, a share of these funds should go toward establishing MSHSs focused on under-represented populations. States and/or local school districts would be required to match every dollar of federal support with two dollars of state and local funding. Industry funding would count toward the state and/or local school district match.

Second, institutional partnerships are a key to success of MSHSs. Whether it's the donation of research equipment, the opening of their facilities to students and faculty, or mentoring of students, technology-based companies can play an important supportive role. As a result, **Congress should modify the research and experimentation credit to allow companies to take a flat (non-incremental) credit for donations of equipment to high schools.** Math and science specialty high schools are an institutional innovation that has a proven track record in helping educate more scientists and engineers. By building on this model Congress can help address the need for scientists and engineers.

Endnotes

1. Robert D. Atkinson, “Will We Build It and If We Do Will They Come: Is the U.S. Policy Response to the Competitiveness Challenge Adequate to the Task?” (Washington, D.C.: The Information Technology and Innovation Foundation, 2006): <www.itif.org/files/aaasfinal2006.pdf>.

2. National Science Foundation Statistics, “Global Higher Education in S&E” (National Science Foundation, 2006): <www.nsf.gov/statistics/seind06/c2/c2s4.htm>.

3. National Science Foundation Statistics, “Chapter 2: Higher Education in Science and Engineering,” (National Science Foundation, 2006): <www.nsf.gov/statistics/seind06/pdf_v2.htm>.

4. Anna-Lee Saxenian, *The New Argonauts: Regional Advantage in a Global Economy* (Cambridge, MA: Harvard University Press, 2006).

5. National Science Foundation Statistics, “Doctorates Awarded 1996-2005,” (National Science Foundation, 2006): <www.nsf.gov/statistics/nsf07305/content.cfm?pub_id=3757&id=2>.

6. Source: Richard Freeman, Harvard University.

7. David Hart, “Global Flows of Talent: Benchmarking the United States,” (Washington, D.C.: The Information Technology and Innovation Foundation, 2006): <www.itif.org/files/Global_Flows/pdf>.

8. A Senate bill would authorize up to $20million in seed money for colleges to set up “professional science master’s” degree programs to provide that kind of training.

9. Congress passed legislation in 2006 increasing the amount of Pell grant awards for students studying math, science or languages.

10. President Bush’s American Competitiveness Initiative proposes quadrupling spending for a program to train schoolteachers to lead Advanced Placement and International Baccalaureate classes in mathematics and science.

11. House legislation would boost funding for an NSF program that provides financial support to juniors and seniors majoring in math and science if they work as schoolteachers after graduation. The program gives scholarships of $10,000 a year in exchange for up to four years of teaching.

12. The National Academy of Sciences, “Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,” (The National Academies Press, 2006): <www.nap.edu/catalog/11463.html>.

13. The legislation states: “CHAPTER 1 – ASSISTANCE FOR SPECIALTY SCHOOLS FOR MATHEMATICS AND SCIENCE. SEC. 3171. ASSISTANCE FOR SPECIALTY SCHOOLS FOR MATHEMATICS AND SCIENCE: (a) In General – Consistent with sections 3165 and 3166, the Director shall make available necessary funds for a program using scientific and engineering staff of the National Laboratories, in which the staff – (1) assists teaching courses at statewide specialty secondary schools that provide comprehensive mathematics and science (including engineering) education; and (2) uses National Laboratory scientific equipment in the teaching of the courses. (b) Report to Congress – Not later than 2 years after the date of enactment of the Protecting America’s Competitive Edge Through Energy Act of 2006, the Director shall submit a report to the appropriate committees of Congress detailing the impact of the activities assisted with funds made available under this section.”

14. The demographics of the schools which are members of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology are: 75 percent are full-day schools, 25 percent are half-day programs, 18 percent are residential, 80 percent are non-residential, and 2 percent take both residential and non-residential students. 69 percent are grades 9-12, 4 percent are grades 10-12, 22 percent are grades 11-12, and 5 percent include elementary and/or middle school students. (NCSSSMST, 2004)

15. During this early 1900s a few specialized high schools emphasizing mathematics and the sciences were developed, such as the Bronx High School of Science and Stuyvesant High School in New York City. Congress played a role, allocating large sums of funding through the Smith-Hughes Vocational Act of 1917 to promote home economics, agriculture, and the manufacturing trades. One example of this was the establishment of Brooklyn Technical High School in the early 1920s.

16. By 1988 these schools had reached such a critical mass that a group of mathematics, science and technology schools began to network and recognized issues of common concern. The result of the dialogues that developed from shared concern was the establishment of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology (NCSSSMST). Beginning with fifteen charter members in 1988 the NCSSSMST has now grown to almost 100 institutional member schools and an even greater number of affiliated colleges and universities.

17. Many MSHS students are able to take these extra courses by taking regular education graduation requirements such as Economics, American Government, Physical Fitness and health online at the Florida Virtual High School.

18. Seth Hanford, "An Examination of Specialized Schools as Agents of Educational Change," (Education Resources Information Center (ERIC), 1997): <eric.ed.gov/ERICDocs/data/ericdocs2/content_stor-age_01/0000000b/80/22/36/e4.pdf>.

19. There are numerous examples of such partnerships. Collegiate Partners: Andrews University (Berrien County Mathematics and Science Center); Worchester Polytechnic Institute (Massachusetts Academy of Science and Mathematics); The City College of New York (High School for Mathematics, Science and Engineering); University of Arkansas (Arkansas School for Mathematics, Sciences, and the Arts). Corporate Competition Partners: Motorola Corporation (support for NCSSSMST Professional Conference); Baxter Healthcare of Tampa Bay FIRST Competition (support for Center for Advanced Technologies). Other Corporate sponsors for FIRST include Raytheon, GE, Motorola, NASA, the U.S. Department of Defense (support for Internet Science and Technology Fair). Academic Competition Partners: The Siemens Corporation; Intel; Young Epidemiology Scholars and the College Board.

20. Jonathan Plucker, "Aspirations of Students Attending a Science and Mathematics Residential Magnet School," (Education Resources Information Center (ERIC), 1996): <eric.ed.gov/ERICDocs/data/ericdocs2/content_storage_01/0000000b/80/23/df/32.pdf>.

21. Most recently, the NCSSSMST board of directors commissioned and supported a four-year longitudinal study of its graduates. This study gathered post-graduate data on students at one and four years after high school graduation and assessed students on several critical questions: their intended college major and plans for post-graduate study; the degree to which their high school enhanced their critical thinking, creative thinking, and research skills; and overall satisfaction with a specialized high school experience. J. Thomas and B.L. Love. "An Analysis of Post-Graduation Experiences Among Gifted Secondary

Students." *NCSSSMST Journal* 6.1 (2002): 3-8. See also Jay Thomas and Brenda Lee Love, "NCSSSMST Longitudinal Study of Graduates: A Three-Year Analysis of College Freshman and College Seniors," *NCSSSMST Journal* 7.2 (May 2002). (NCSSSMST = National Consortium of Specialized Secondary Schools of Mathematics, Science and Technology.)

22. Source for national figures are: U.S. Department of Education, National Center for Education Statistics, "Digest of Education Statistics," Table 181: <nces.ed.gov/programs/digest/d05/tables/dt05_181.asp>, and U.S. Department of Education, National Center for Education Statistics, 2000/01 Baccalaureate and Beyond Longitudinal Study: <nces.ed.gov/das/library/tables_listings/show_nedrc.asp?rt=p&tableID=1378>.

23. National data from United States Census Bureau, "2005 American Community Survey PUMS," accessed via DataFerrett, <www.census.gov/acs/www/Products/PUMS/acs_pums_download_via_ferrett.htm>.

24. National Center for Educational Statistics, "The Condition of Education 2006: Postsecondary Expectations of 12th-Graders," (National Center for Educational Statistics, 2006): <nces.ed.gov/programs/coe/2006/section3/indicator23.asp#info>.

25. For example, J.H. Borland, R. Schnurr, and L. Wright, "Economically Disadvantaged Students in a School for the Academically Gifted: A Postpositivist Inquiry into Individual and Family Adjustment," *Gifted Child Quarterly* 44.1 (2000): 13-32.

26. The general high school science laboratories usually do not meet all these demands. There are many NCSSSMST schools that have designed facilities that indeed meet these needs. For example, The Center for Advanced Technologies in Florida has included in its specialized high school a large research laboratory built to vocational education specifications. The laboratory includes industrial level power connections, bays to build robots and technical projects, laptop computers with science probes and related equipment, broadband Internet connections, science stations for long term experiments, work stations for students to collaborate and make presentations, and secure storage for chemicals and equipment. Unfortunately, most schools do not offer students technology or resources that are reflective of the resources they will encounter in college or, to be sure, in their professions.

27. Some of the expansion would come from construction and creation of new specialty MSHSs. Costs of building such a high school can range from around \$11 million (for rehabilitating an existing building) to over \$50 million for constructing a new MSHS in an area where land prices are more expensive. Some expansion of enrollment would come from expanding existing high schools, where the price would presumably be less. However, even at these schools the costs can be higher, particularly for more extensive laboratory equipment. Overall these funds will be used as a federal incentive to spur states and local school districts to create more specialty math and science high