ORANGE COUNTY
BOARD OF EDUCATION

AGENDA ITEM ABSTRACT

Meeting Date: December 5, 2011

AGENDA ITEM No. 11-12-07

ACTION: (Y/N) N

SUBJECT: Engineering is Elementary (EiE) Project Report

INFO. CONTACT: Dr. Denise Morton **PHONE:** 919 732-8126

ATTACHMENTS:
1. Overview of Engineering is Elementary Project
2. Why Teach Engineering to Children?
3. EIE PowerPoint
4. Staying Competitive (National Math and Science Initiative)
5. National Math and Science Initiative documents

PURPOSE: To provide the Board of Education for their review and discussion, background information related to the growing national concern surrounding the need for increased emphasis on high quality science and mathematics education. A report on the "Engineering is Elementary" Project, which is being presented as a possible thematic approach for implementation at the elementary level in the Orange County Schools, will also be provided.

BACKGROUND: In 2005, the National Academies report, Rising Above the Gathering Storm, raised major concerns over the U.S. decline in science, technology, engineering and math (STEM) career preparation in our country. This report and others highlight the major risk to the U.S. global competitiveness. Handouts #4 and #5 from the National Math and Science Initiative (NMSI) elaborate on this problem.

One approach to addressing this issue has been developed by the Boston Museum of Science and is called Engineering is Elementary (EiE), which is a new national initiative focused on improving science, technology, engineering and math (STEM) education for every child, with a particular focus on girls and students of color, who have long been underrepresented in STEM fields. This program is intended to encourage the inclusion of engineering and technology education in elementary classrooms by providing access to EiE materials and training and to help foster the next generation of engineers. EiE has created a research-based, standards-driven, and classroom-tested curriculum that integrates engineering and technology concepts and skills with elementary science topics. EiE lessons not only promote K-12 science, technology, engineering and mathematics (STEM) but also connect with literacy and social studies.

On November 15th, a district team of two Board members and five staff members visited Rachel Freeman Elementary School in Wilmington, North Carolina which is a model site for the EiE project. The team was able to visit classrooms, view EiE projects, and ask questions of the Rachel Freeman staff regarding the implementation and potential impact on student achievement.

FINANCIAL IMPACT: $92,000

STEM Coordinator Salary (includes benefits)	**$60,000**
Professional Development (@ $600 per day; estimated total if maximum days utilized)	**$7,800**

Initial Training (3-5 days depending on extent of content)

- Whole Staff
- Content suggestions:
  - Screaming the theme
  - Why Engineering?
  - Science, Engineering and Technology
  - STEM Notebooks
  - Creating and nurturing effective teams
  - Project Based and Inquiry Learning
  - Integration across curriculum
  - Engineering is Elementary curriculum training
  - Science Content

Ongoing Training (5-8 days per year)

- Whole Staff/Grade Levels/PLCs
- Provide ongoing support and deeper understanding through early release day workshops, meeting with grade levels during their planning time, afterschool training on mutually agreed upon schedule.

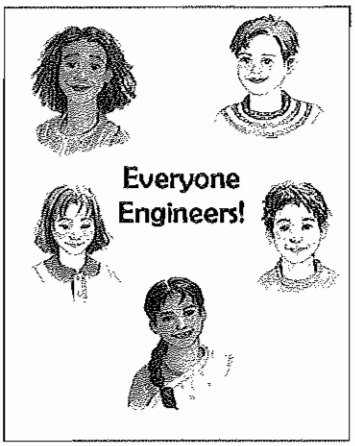
Materials

Engineering is Elementary materials kits with teacher guides—(estimate) →Recommend 2 full kits for each unit, 4 per grade level grades 2-5, (average cost $350 each) plus consumables refill (Average $150 each) and teacher guide (Average $50 each) for additional teachers in grade level	***$18,000***
General materials supply for K-1 small projects and grades 2-5 additional projects (estimate)	***$4,000***
STEM notebooks (1 per student@ $3 each)(estimate)	***$1,200***
Miscellaneous materials for Family STEM events, engineer's week, special projects (estimate)	***$1,000***
GRAND TOTAL	**$92,000**

RECOMMENDATION: The Superintendent recommends that the Board of Education receive and discuss the information and provide direction to staff.

Engineering is Elementary®
Engineering and Technology Lessons for Children
Problem Solving, Inquiry, and Innovation®
www.mos.org/EiE

Children are born engineers—they are fascinated with building, with taking things apart, and with how things work. However, K-12 educational settings have traditionally done little to develop children's engineering and technological literacy. The *Engineering is Elementary* (EiE) project fosters engineering and technological literacy among elementary school students and educators. EiE has created a research-based, standards-driven, and classroom-tested curriculum that integrates engineering and technology concepts and skills with elementary science topics. EiE lessons not only promote science, technology, engineering, and mathematics (STEM) learning in grades 1-5, but also connect with literacy and social studies. To date, EiE has reached over 1.7 million students and 22,000 teachers and is presently used in all fifty states.



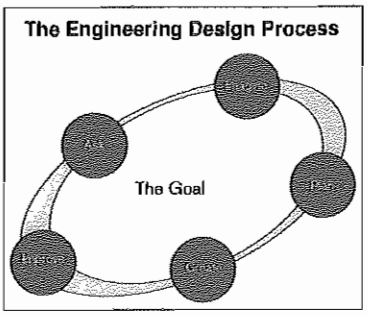
EiE Project Goals

- **Goal 1.** Increase children's technological literacy.
- **Goal 2.** Improve elementary educators' ability to teach engineering and technology.
- **Goal 3.** Increase the number of schools in the U.S. that include engineering at the elementary level.
- **Goal 4.** Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning at the elementary level.

The EiE Curriculum

Each EiE unit integrates an elementary school science topic with a specific field of engineering. EiE units are designed to engage students in the engineering design process and include:

- **Storybooks** featuring child characters from a variety of cultures and backgrounds, who introduce students to an engineering problem. Students are then challenged to solve a problem similar to that faced by the main character. In addition to providing context, the storybook also serves to introduce engineering and technology concepts and terms, and reinforce science vocabulary.
- **Lesson plans** for teachers. EiE teacher guides include vocabulary, learning objectives, tie-in science content, detailed materials and preparation sections, and step-by-step instructions on how to facilitate each EiE activity.
- **Duplication masters (DMs)** for student handouts. To accommodate differences in students' cognitive and linguistic abilities, EiE units contain two versions of many DMs: Basic (lower reading level, less writing, less cognitively complex, suggested for grades 1 and 2) and Advanced (higher reading level, more writing, more cognitively complex, suggested for grades 3-5). Teachers can choose the DMs that best meet the needs of their students.



- **Student assessments and rubrics**. Multiple choice and open-ended questions that teachers can use to gauge their students' understanding and learning of engineering, technology, and science concepts are provided in each EiE unit. Rubrics are provided at the end of each lesson to help teachers evaluate students' progress.
- **Background information** and additional reference resources for teachers.

Each EiE unit takes about 6-8 hours of instructional time to complete. EiE has developed materials for 20 elementary science school topics and engineering fields. For a complete list of EiE units and their related science topics, please visit **www.mos.org/eie/20_unit.php**.

All EiE units are designed to meet the ITEEA Standards for Technological Literacy. At its core, EiE is designed to have students engineer. The program develops interesting problems and contexts and invites children to have fun as they use their knowledge of science and engineering to design, create, and improve solutions.

Professional Development

Engineering is a new discipline for elementary school teachers. To learn more about engineering and technology content and pedagogy, the EiE project offers professional development workshops for elementary school teachers and teacher educators. These sessions provide teachers with an overview of engineering and technology concepts and skills, review the structure and philosophy that shape the EiE curriculum, engage participants in activities from the curriculum, and foster reflection about appropriate and effective instructional strategies. EiE professional development workshops are held at the Museum of Science and EiE staff are also available to facilitate off-site workshops as requested. For more information on EiE professional development and a list of upcoming workshops, please visit **www.mos.org/eie/workshops_programs.php**.

Research and Assessment

Research, evaluation, and assessment studies are integral to the development of the EiE curriculum, and an important facet of our curriculum development philosophy. The EiE team believes that a high-quality curriculum is one that is well-researched and thoroughly tested at all stages, from garnering a basic understanding of what students and teachers know about engineering and technology to the published product. From its inception in 2003, EiE has been committed to creating high-quality teacher guides and professional development for teachers and a world-class curriculum for students through multiple cycles of research, development, testing, and improvement.
We are collecting qualitative and quantitative data from students and teachers across the nation to better understand how children best learn about engineering and how our materials impact their understandings.

National, statistical, controlled studies indicate that children who engage with EiE materials have a much better understanding of engineering and technology than children who do not use EiE. Findings have also shown that children who engage with EiE perform better on assessment questions about the related science topic than children who do not use EiE.

For more information as well as links to EiE's formal research findings and publications, please visit **www.mos.org/eie/research_assessment.php**.

Multimedia Initiatives

EiE is also creating multimedia resources that include:

- **Informational Video**: A 16-minute video that provides an overview of the EiE project, footage of students engaged in EiE activities, and teacher interviews. Available at **www.mos.org/ezie/video**.
- **Content Connections**: An online, searchable, dynamic database of lessons, authored by EiE staff, teachers, and community members, that explicitly connect EiE lessons to mathematics, social studies, language arts, science, and fine arts.
- **How-To Videos**: A series of online videos created by EiE staff and designed to help educators organize and prepare materials for EiE lessons. A total of seven EiE units currently have How-To videos, and more are in progress.

- **Professional Development Videos**: The EiE team is capturing video footage of classroom teachers using EiE with their students. During interviews, the teachers reflect on their engineering practice and pedagogy. Once edited, these videos will be used as part of EiE's professional development efforts.

Content Connections and How-To Videos can be accessed by creating a free account through EiE Educator Resources (**www.mos.org/eie/Educator Resources.php**).

Out of School Time: Engineering Adventures

Engineering Adventures (EA) is a fun, engaging, hands-on, engineering curriculum being created by the EiE team for use in out-of-school-time (OST) settings such as after-school and camp programs. EA challenges children to solve design challenges using creativity, teamwork, science, and engineering. EA is arranged as a series of thematic units, each focusing on a field of engineering.

EA is not yet available to the public. The first EA unit will be tested nationwide in the spring of 2011 thanks to the generous support of the S. D. Bechtel, Jr. Foundation. For more information on EA, please visit **www.mos.org/eie/engineeringadventures**.

For much more information about the EiE project, please visit our website at **www.mos.org/eie**.

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Museum of Science
National Center For
Technological Literacy

Engineering for Children?!

Why teach engineering to children?

There are many reasons to introduce children to engineering in elementary school:

- Children **are fascinated with building and with taking things apart to see how they work,** they engineer informally all the time. By encouraging these explorations in elementary school, we can keep these interests alive. Describing their activities as "engineering" when they are engaged in the natural design process can help children develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering projects integrate other disciplines.** Engaging students in hands-on, real-world engineering experiences can enliven math and science and other content areas. Engineering projects can motivate students to learn math and science concepts by illustrating relevant applications.
- **Engineering fosters problem-solving skills,** including problem formulation, iteration, testing of alternative solutions, and evaluation of data to guide decisions.
- **Engineering embraces project-based learning, encompasses hands-on construction, and sharpens children's abilities to function in three dimensions** - all skills that are important for prospering in the modern world.
- **Learning about engineering will increase students' awareness of and access to scientific and technical careers**. The number of American citizens pursuing engineering is decreasing. Early introduction to engineering can encourage many capable students, especially girls and minorities, to consider it as a career and enroll in the necessary science and math courses in high school.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

Integrated STEM including Engineering In Elementary Schools

Liz Parry

Consultant, K-12 STEM / Engineering
Coordinator, K-20 Partnership Development,
NCSU College of Engineering
Chair, American Society of Engineering Education,
K-12 and Precollege Division

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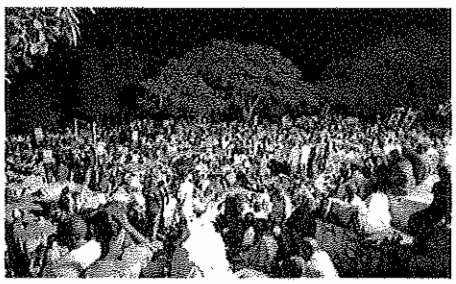
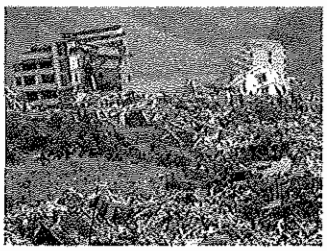
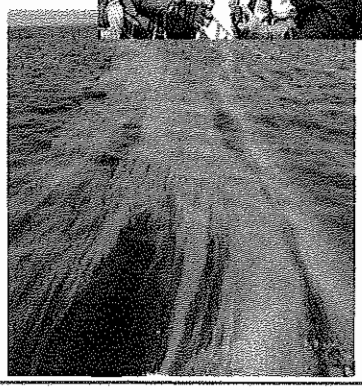
Why is engineering important?







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Findings from the National Academy of Engineering

- "As STEM education … does not reflect the natural interconnectedness of the four STEM components in the real world ...."
- "… potential value, related to student motivation and achievement, in increasing the presence of …, especially, engineering in STEM education … in ways that address the current lack of integration in STEM ..."
- "… the most intriguing possible benefit of K–12 engineering education relates to improved student learning and achievement in mathematics and science and *enhanced interest* in these subjects because of their relevance to real-world problem solving. .. limited amount of reliable data …"

Source: "Engineering in K-12 Education: Understanding the Status and Improving the Prospects"

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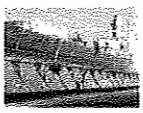
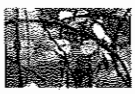
Engineering Grand Challenges

Make solar energy economical



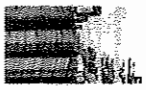
Restore and improve urban infrastructure

Secure cyberspace

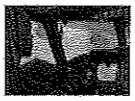


Provide energy from fusion

Advance health informatics

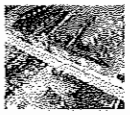


Enhance virtual reality



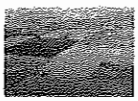
Develop carbon sequestration methods

Engineer better medicines

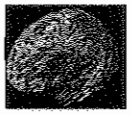


Advance personalized learning

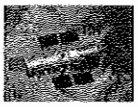
Manage the nitrogen cycle



Reverse-engineer the brain



Engineer the tools of scientific discovery



Provide access to clean water

Prevent nuclear terror

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Thinking Like an Engineer

Just the Facts....

✓Failure is an expected outcome (model, simulate, improve, repeat as necessary)

✓Engineering is a team sport

✓Decisions are made objectively based on data, constraints and criteria

✓It's a Process

✓There is always more than one

Habits of Mind

- ✓ ***Systems Thinking***
- ✓ ***Creativity***
- ✓ ***Communication***
- ✓ ***Collaboration***
- ✓ ***Optimism***
- ✓ ***Ethical Considerations***

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In the end, Engineering for All

✓Engineering and Technologically Literate citizens are the end goal.

✓Engineering in K-12 is an equalizer—it levels the playing field.

✓We not only need MORE engineers, but a MORE DIVERSE group of engineers.

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What is happening in elementary schools in NC?

- **Whole school implementations (4)**
  - Rachel Freeman, Wilmington
  - Brentwood, Raleigh
  - Clarke, Vance
  - Brunson, Winston-Salem
- **Individual classrooms**
  - Mecklenburg, Johnston, Cumberland, Onslow, Rowan, Cabarrus and growing
- **Ad hoc inclusion through outreach and informal education (formal and informal education)**

What does it look like?

- **Focus on foundational skills (all grades)**
  - Engineering Design Process
  - Teamwork: Intentional and Deliberate
  - STEM Notebooks: documentation of learning
- **Every student, every teacher**
  - Scream the theme
  - K-1 small engineering/integrated STEM tied to literacy/science
  - Grades 2-5 Engineering is Elementary unit implementation tied to Science SCOS
- **Community/Parent/Industry Involvement**

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Engineering is Elementary (EiE)

Lessons that integrate engineering and technology concepts into elementary science.

Goal 1. Increase children's technological literacy.

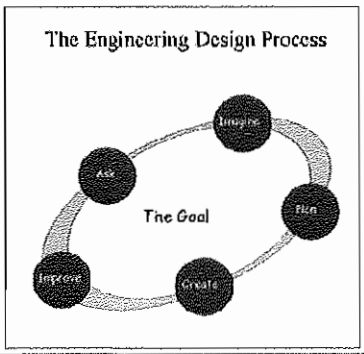
Goal 2. Increase elementary educators ability to teach engineering and technology.

Goal 3. Increase the number of schools in the U.S. that include engineering at the elementary level.

Goal 4. Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning at the elementary level.

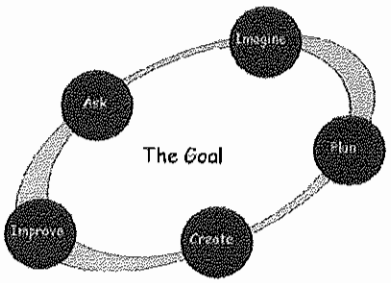
EiE Teacher Guide Structure

- Lesson 1: Engineering Story
- Lesson 2: A Broader View of an Engineering Field
- Lesson 3: Scientific Data Inform Engineering Design
- Lesson 4: Engineering Design Challenge



Skill Building

The Engineering Design Process



- Problem Solving
- Analysis and data-driven decisions
- Variables and optimization
- Teamwork
- Communication
- Creativity

Standards and Accountability

- Engineering projects and Engineering is Elementary (EiE) is tied to North Carolina Standard Course of Study (linked primarily through Science Essential Standards)
- Correlations to Common Core Math and ELA and Next Generation Science Framework
- Supports tenets of 2014 National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy assessment

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Snapshot: What can this do for kids?

Rachel Freeman School of Engineering, Wilmington, NC

Student Body: 90% Underrepresented minority, 90% Economically disadvantaged

End of Grade test scores for 2010 fifth graders:

- Reading 75% proficient (26% growth)
- Math 81% proficient (10% growth)
- Science 83% proficient (37% growth)

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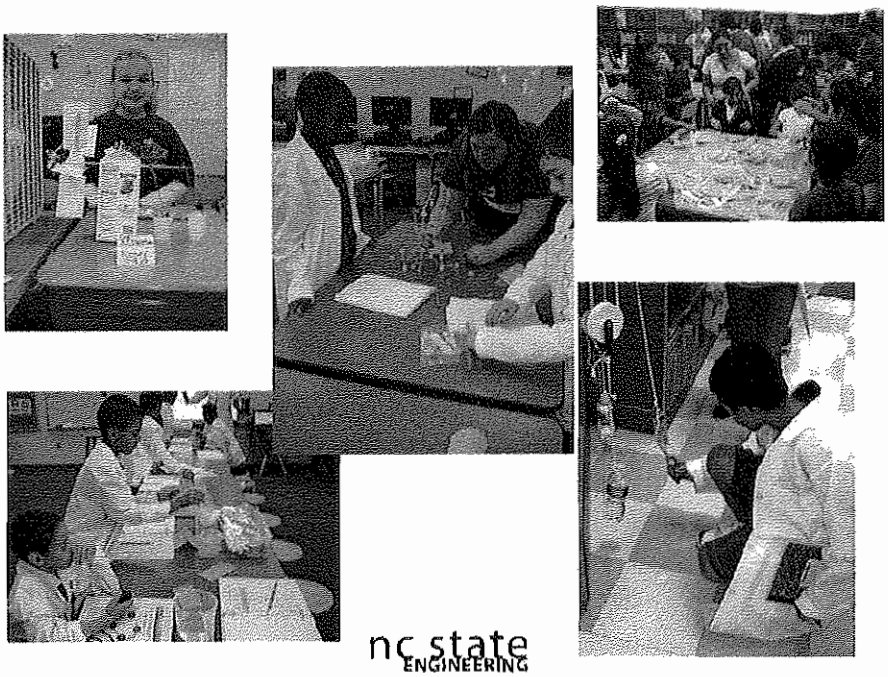

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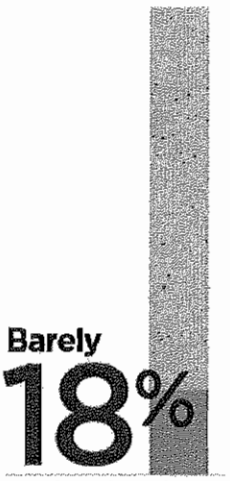
Staying Competitive

American students are falling behind in the essential subjects of math and science, putting our position in the global economy at serious risk. NMSI's Competitiveness Brochure discusses our nation's declining competitiveness in a global marketplace and details immediate action items to address this growing crisis.

Download the NMSI CompetitiveBrochure (PDF)

Here are just a few examples of this crisis:

- U.S. students recently finished 15th in reading, 25th in math, and 17th in science in the ranking of 31 countries by the Organization for Economic Cooperation and Development.
- Only 29 percent of American fourth grade students, a third of eighth grade students, and barely 18 percent of 12th grade students perform at or above the proficient level in science.
- About a third of high school math students and two-thirds of those enrolled in physical science have teachers who did not major in the subject in college or are not certified to teach it.
- In 2000, only 4.4 percent of the science and engineering jobs were held by African Americans and only 3.4 percent by Hispanics.
- In Business Week's ranking of the world's information-technology companies, only one of the top 10 is based in the U.S.
- Nearly 60 percent of the patents filed with the U.S. Patent and Trademark office in the field of information technology originate in Asia.
- The U.S. share of the world's leading-edge semi-conductor manufacturing capacity dropped from 36 percent to 11 percent in the past seven years.
- Of the new R&D sites planned for construction in the next three years by 177 companies queried in a survey, 77 percent are to be built in China or India.
- 75 percent of all high school graduates enter college; about half of all college freshman take at least one remedial course.
- U.S. advanced math and physics students were not leading, but lagging behind other students around the world in math and physics achievement.
- The U.S. ranks 17th among nations in high school graduation rate and 14th in college graduation rate.



FAQ

Q: What is the National Math and Science Initiative?

There are many local programs in education that work. But there is no method to bring those programs to scale to impact millions instead of hundreds of students. NMSI is an innovative new organization created to expand programs with proven success in math and science education across the nation.

By scaling up programs that have demonstrated a positive impact, NMSI aims to increase significantly the achievement of students in mathematics and science courses and to graduate more qualified math and science teachers. The initial focus is on multiplying two programs with 10 years of data proving they work: a training and incentive program for Advanced Placement courses and UTeach, an undergraduate teacher preparation program.

Q: Why was NMSI created?

Math and science, not government, will be needed to solve our biggest problems. Math and science are the foundational literacy of the Information Age – and concern is growing that low performance in math and science is hurting the United States' global competitiveness.

NMSI was launched in March 2007 by top leaders in American business, education, and science in response to the call for action by the National Academies' 2005 report, Rising Above the Gathering Storm.

NMSI's mission is to help the U.S. maintain its leadership position in technological innovation by providing a path to math and science careers for more students.

The need is pressing:

- Only 29 percent of American fourth grade students, 32 percent of eighth grade students, and 18 percent of 12th grade students performed at or above the proficient level in science.
- About a third of high school mathematics students and two-thirds of those enrolled in physical science have teachers who either did not major in the subject in college or are not certified to teach it.
- Among low-income students, 70 percent of their middle school mathematics teachers majored in some other subject in college.
- Those undergraduates who leave science and engineering majors for other majors are often among the most highly qualified college entrants, and they are disproportionately women and students of color.
- The U.S. ranks 16th of 17 nations in the proportion of 24-year-olds who earn degrees in natural science or engineering as opposed to other majors.

Q: How is NMSI funded?

NMSI is marshalling public-private cooperation to solve one of our country's most pressing problems, staying competitive in the crucial fields of math and science. ExxonMobil Corporation is the lead funder with a commitment of $125 million. As a company that employs 14,000 engineers and scientists, ExxonMobil knows how important it is to provide the best education and training possible for the national's young people. The Bill and Melinda Gates Foundation and the Michael and Susan Dell Foundation are also major donors and have collectively committed $15 million over the next three years. IBM and Perot Systems have provided millions of dollars with in-kind assistance.

Q: Who are the leaders of NMSI?

The board of directors includes key executives from The College Board, the National Academy of Sciences, Lawrence Berkeley National Laboratory, leading universities, major U.S. corporations, state education agencies and foundations focusing on education.

The Chief Executive Officer of NMSI is Mary Ann Rankin, former dean of the College of Natural Sciences; the Chief Operating Officer is Sue Payne, former Vice President for Mobil's Onshore U.S. Producing Business

Q: How is this different from other math and science initiatives?

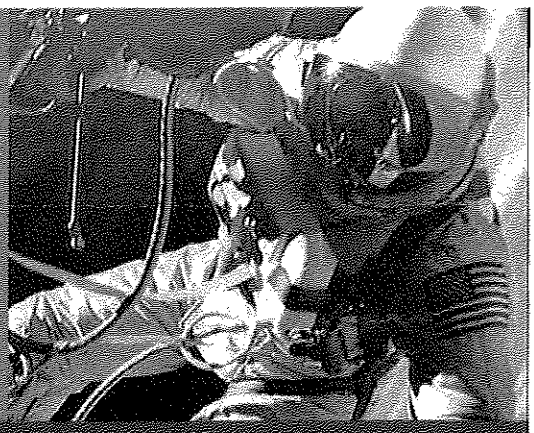
We're not trying to reinvent wheels, we are finding the best ones and rolling them out on a national scale. To ensure long-term impact, funding is targeted to programs with verifiable records of success that can be replicated nationally, in contrast to many pilot projects that begin with a flourish but are not applied on a national scale and fade over time.

NMSI serves as a strategic holding company, not only to channel public-private money toward proven programs, but to also monitor implementation and provide ongoing support.

As NMSI funding for grantees phases out, recipients are expected to seek other private-sector and state funds–which is more feasible as programs mature and demonstrate they are making a difference in their communities.

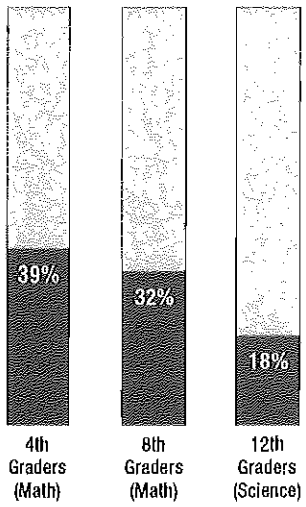
"The financial crisis just made the hole deeper, which is why our stimulus needs to be both big and smart, both financially and educationally stimulating. It needs to be able to produce not only more shovel-ready jobs and shovel-ready workers, but more Google-ready jobs and Windows-ready and knowledge-ready workers."

—Columnist Thomas L. Friedman, "The New York Times"

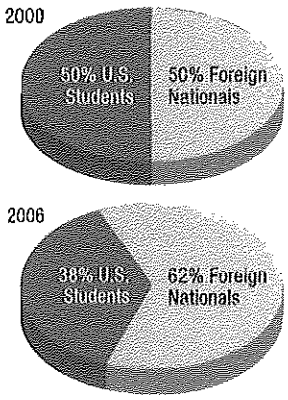


Consider These Recent Alarm Signals in Education:

Percentage of U.S. Students Performing at or Above Proficiency in Math and Science



Percentage of Engineering Doctoral Degrees Granted In the U.S.



+ The new Trends in International Mathematics and Science Study (TIMSS) showed some improvement in math performance by U.S. students, but foreign students improved even more. Average American science scores have stagnated since 1995.

+ The most recent National Assessment of Educational Progress figures showed that only 39 percent of fourth graders and 32 percent of eighth graders tested at or above proficiency in math, and only 18 percent of high school seniors perform at or above the proficient level in science. These results are a prescription for failure at a time when 8 out of 10 jobs in the next decade will require math and science skills.

+ A report issued by the National Center for Public Policy and Higher Education in December 2008 confirmed that other countries are outpacing the U.S. in providing access to college. Every state received a failing grade for college affordability except for California, which earned a "C" because of its community college system.

+ Just as science and technology are burgeoning around the world, the number of American engineers and physical scientists graduating has declined by 20 percent. The number of U.S. citizens receiving PhD's in engineering has declined by 34 percent and the number receiving bachelor's degrees in engineering has declined by 18 percent. Two-thirds of the students receiving PhD's in engineering in U.S. universities are non-U.S. citizens.

+ The Education Trust has reported that in high-poverty schools, two in five math classes have teachers without a college major or certification in math. This means many teachers are barely a chapter ahead of their students.

+ U.S. students recently finished well below average in international rankings by the Organization for Economic Cooperation and Development – 15th in reading, 19th in math and 14th in science. U.S. students ranked behind Canada, Japan, and Western Europe in math and science – even behind emerging European countries such as Slovenia, Estonia and even Liechtenstein. They scored ahead of just a handful of countries, including Greece, Turkey and Mexico.

Corporate America has a business interest in creating more homegrown engineers, amid growing evidence of an impending shortage. In the U.S., 62 percent of doctoral degrees in engineering went to foreign nationals in 2006, compared with 50 percent in 2000, according to a recent report from the American Society for Engineering Education. It took slightly less than a decade for the U.S. trade balance in high-technology manufactured goods to shift from a positive $40 billion in 1990 to a negative $50 billion in 2001.

In *Business Week*'s ranking of world information technology companies, only one of the top 10 is based in the U.S.

Only one of the 25 largest initial public offerings (IPOs) of stock in 2006 took place on American exchanges. IPOs in Europe surpassed those in America – in both number and dollar volume.

Nearly 60 percent of parents filed with the U.S. Patent Office in information technology now originate in Asia.

The U.S. share of the world's leading-edge semi-conductor manufacturing capacity dropped from 36 percent to 11 percent in the past seven years.

More than half of all science and engineering degreed workers are 40 years or older and 26 percent are over 50 (National Science Foundation), yet less than 15 percent of U.S. students have the math and science prerequisites to be successful (Southern Methodist University). Eighty percent of jobs in the next decade will require some form of math and science (National Science Foundation).

American students are increasingly at a global disadvantage. Thirty years ago, more than 30 percent of students attending college world-wide were Americans. Today, the United States can claim only 14 percent – and the number is declining. The rest of the world is becoming more educated (Tough Choices or Tough Times: The Report of the NEW Commission on the Skills of the American Workforce, National Center on Education and the Economy, 2007).

During much of the 20th century, Americans entering the workforce were considered the best educated in the world. But within the past 30 years, foreign countries can claim a higher percentage of their entering workforce with the equivalent of a high school diploma – and the United States continues to be surpassed (Tough Choices or Tough Times: The Report of the NEW Commission on the Skills of the American Workforce, National Center on Education and the Economy, 2007).