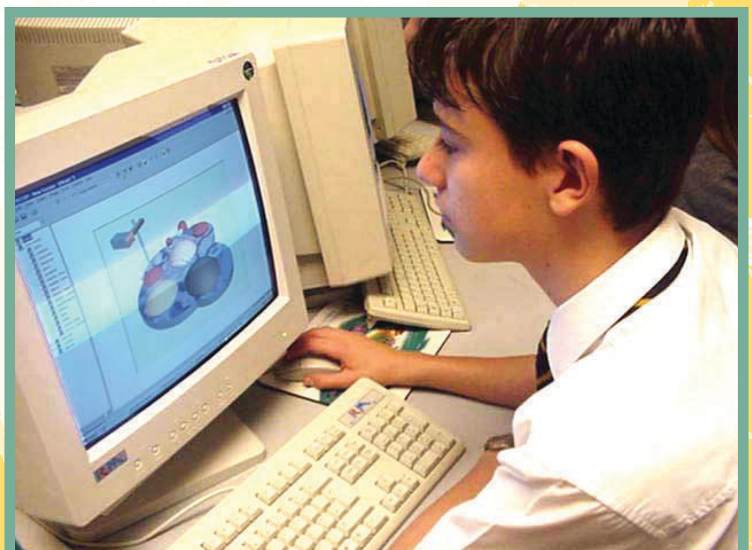
Preparing for the Perfect Storm

A Report on the Forum

Taking Action Together: Developing a National Action Plan to Address the "T&E" of STEM



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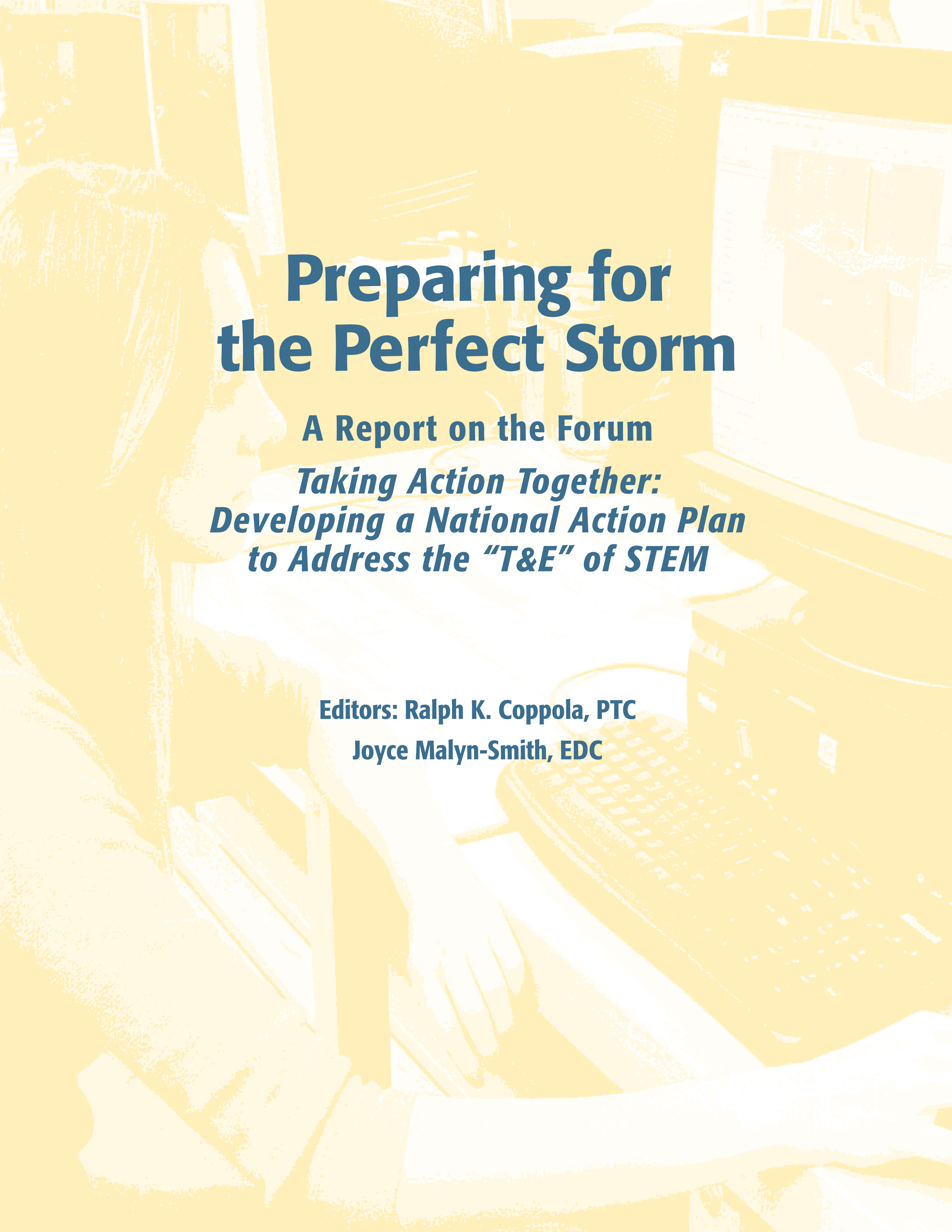

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A Report on the Forum

Taking Action Together: Developing a National Action Plan to Address the "T&E" of STEM

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Executive Summary

On September 7, 2006, 146 representatives of business, education, government, and civil society gathered at the National Academy of Engineering to develop a national action plan addressing the technology and engineering (T&E) components of STEM (science, technology, engineering, and mathematics) education and workforce needs. *Taking Action Together: Developing a National Action Plan to Address the "T&E" of STEM* was the fourth in a series of public events organized by the PTC-MIT Consortium to raise awareness of the T&E aspects of the impending STEM pipeline crisis and to gather input for the design of a national agenda for action. After reviewing three case studies of initiatives targeting technology and education in states and local communities, representatives of the PTC-MIT Consortium and invited Forum participants identified common areas of interest and developed an action plan to move forward a national T&E agenda. The plan proposes specific actions that will build and strengthen the T&E pipeline in the United States to address the looming shortage of talent prepared to enter T&E careers in the next decade.

Participants at the Taking Action Together: *Developing a National Action Plan to Address the "T&E" of STEM* Forum identified four major goals needed to move our nation from dialogue to action:

1. **Raise awareness among policy-makers, practitioners, and the general public.** Communicate the importance of design and innovation to our society, and share successful examples.
2. **Strengthen the pipeline of T&E talent.** Develop consensus around both a coherent set of standards and actions aligned to those standards, so that all students will have a basic understanding of T&E and be able to make educated decisions about careers in these areas.
3. **Enhance T&E workforce education through research.** Develop a national research agenda that provides data for decision-making.
4. **Develop partnerships to focus resources.** Aggressively partner with key stakeholders in business and government to collaboratively engage and mobilize the education community to create models that provide strategies for STEM teacher recruitment, retention, and continued professional development, and provide replication of best practice that can be transferred to education.

The action plan recommendations generated at this Forum have been added to recommendations for action from the three previous meetings organized by the

PTC-MIT Consortium and grouped into the following five categories: (A) Capacity Building, (B) Policy, (C) Focusing Existing Resources, (D) Awareness, and (E) Research, Assessment, and Certification. This report combines all recommendations to date into an overarching plan to set our nation on a course of action—a plan developed and recommended by more than 300 policy-makers and practitioners in the STEM stakeholder community who participated in the series of four meetings.

National Action Plan Recommendations to Address the "T&E" of STEM

A. Capacity Building:

A.1.1. Ensure that all students have an opportunity to learn design.*

A.2.1. Provide increased opportunities for students to learn Global Engineering.*

A.3.1. Strengthen the foundation of technology learning in schools and connect it across the curriculum.*

A.4.1. Provide a Dissemination and Implementation Network across the United States.*

A.5.1. Recruit new teachers, implement strategies and incentives to retain teachers, and increase opportunities for professional development.

B. Policy:

B.1.1. Enhance the re-authorization of No Child Left Behind (NCLB) by strengthening technology.*

B.2.1. Promote the adoption of T&E standards and assessments in all states.

C. Focusing Existing Resources:

C.1.1. Map and align standards, programs, and curricula at the K–post graduate and workforce training levels to meet critical skill needs.

C.2.1. Bring together key stakeholders to focus existing programs and resources on addressing the targeted STEM workforce needs in T&E.*

D. Awareness:

D.1.1. Promote T&E and early career exploration among students and teachers, beginning in middle school, if not before.

D.2.1. Promote the need for T&E education among policy-makers and the general public.

E. Research, Assessment, and Certification:

E.1.1. Encourage rigorous research-based approaches to teaching and learning.

E.2.1. Assess and certify the acquisition of critical skills from the K–12 level through professional practice.

E.3.1. Support the development of longitudinal evaluation efforts focusing on programs that address T&E career pathways, focusing on jobs that are at high risk of not being filled and have great consequences if they are not filled.*

Over the next 18 months, the PTC-MIT Consortium will lead a national effort to move this comprehensive national agenda forward and to create opportunities for participants in this Forum and previous PTC-MIT Consortium events to implement these goals. The Consortium will also report on our nation's progress in meeting these goals. The following next steps were recommended:

1. **Legislative briefings.** The PTC-MIT Consortium will conduct a series of legislative briefings to inform policy-makers of this national action agenda and its recommendations.
2. **Funders Forum.** The PTC-MIT Consortium will conduct a Funders Forum to deepen the dialogue on the importance of T&E and to connect recommended actions to funders' priorities for giving.
3. **Action committees.** The PTC-MIT Consortium will form action committees to develop activities addressing the specific recommendations for action in this national agenda.
4. **National network.** The PTC-MIT Consortium will invite a national network of stakeholders and constituent groups to participate in a communications strategy that will share information across organizations and agencies to benchmark progress toward these national goals.

*Recommendations that also resulted from the three meetings preceding the Taking Action Together Forum.

ACKNOWLEDGMENTS

The PTC-MIT Consortium would like to thank the following organizations and people who provided support for the *Taking Action Together* Forum.

Food was provided by Parametric Technology Corporation, Department of Defense Starbase Program, and the American Institute of Aeronautics and Astronautics.

Program planning and implementation support were provided by Education Development Center, Inc., and Parametric Technology Corporation.

The National Academy of Engineering donated the use of the facilities.

Facilitators and recorders were provided by ACT, Inc.; American Society of Mechanical Engineers; Appalachian Regional Commission; Arlington (Virginia) Public School System; Baltimore County Public Schools; Cable in the Classroom; California State University, Los Angeles; Center for Advanced Scholarship on Engineering, National Academy of Engineering; Education Development Center. Inc.; International Society for Technology in Education; International Technology Education Association; Massachusetts Institute of Technology; Museum of Science, Boston; Parametric Technology Corporation; Pennsylvania Department of Education; and Society of Women Engineers.

Keynote addresses were made by:

- Michael Golden, Deputy Secretary of the Office of Information and Educational Technology, Pennsylvania Department of Education
- Richard Rosen, Vice President, External Business Relations, Battelle
- Alice Seagren, Commissioner, Minnesota Department of Education

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Ralph Coppola, Director of Worldwide Education Anna Ring, Marketing Manager John Stuart, Senior Vice President	Parametric Technology Corporation
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Camilla Gaglio, Instructional Technology Coordinator	Arlington Public Schools
Thea Jones, Supervisor	Baltimore County Public Schools, Office of Instructional Technology
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Hilary Goldmann, Director, Government Affairs Mila Fuller, Director of Strategic Initiatives	International Society for Technology in Education
Barry Burke, Director, Center to Advance the Teaching of Technology and Science Kendall Starkweather, Executive Director/CEO	International Technology Education Association
Jeffrey Hoffman, Professor of the Practice of Aerospace Engineering, Department of	Massachusetts Institute of Technology

Aeronautics & Astronautics Kari McCarron, Senior Legislative Assistant	
Patti Curtis, Managing Director, Washington, D.C., Office	Museum of Science, Boston
Lenny Sweeney, Career and Technical Education Advisor	Pennsylvania Department of Education
Melissa Carl, SWE Washington, D.C., Representative	Society of Women Engineers and Society for Mechanical Engineers
Semahat Demir, Director of External Affairs	Society of Women Engineers

Part 1: Background

"I think more young women would consider careers in engineering if they had an opportunity to study design in school."

—Stacey Janssen, student
Washington Township H.S.
Washington, NJ

"Today's students are versed in technology and visually stimulated due to cultural norms. Students will be excited to be able to experiment with the software and develop these skills. I think that modeling in 3D will also capture and motivate students to consider careers in technology education and/or engineering."

—Carl Sandness, teacher
Hibbing High School
Hibbing, MN

Strategic Significance of the "T&E" of STEM

The strategic significance of STEM (science, technology, engineering, and mathematics) education in today's classroom has never been more evident. The national security and economic competitiveness of the United States rests on the skills developed through STEM education. But while such an emphasis has been encouraging to those who have advocated on its behalf, two letters seem to have gotten lost in the middle: the "T&E," technology and engineering.

Many policy-makers simply assume that if students learn science and math, they will have a path to T&E. While a foundation in math and science is important, preparing learners in these areas alone will not address critical STEM workforce requirements. Students that have no exposure to or experience with engineering have a very low probability of choosing engineering as a career or taking the courses needed to pursue a career in engineering. U.S. schools have supported science and math education for decades, and the enrollments and graduation rates in engineering have been dropping.[1] Design is a core element of engineering. The design process is a method of discovery, exploration, and problem-solving. Data show that learning design is motivating for students and excites them about choosing engineering as a career.[2] Applying mathematics and science principles to real-world challenges, through design, deepens the learning of those principles. We need to enhance design capabilities at schools by training teachers and providing materials and real-world design projects that use the latest approaches found in business and government. Students that learn design have *higher grades, higher motivation, better attendance, and lower anti-social behavior.* Learning design skills and how they are applied in business settings fosters *entrepreneurship, creativity, imagination, and innovation.*[3] These skills are also critical for global competitiveness.

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[1] Chubin, *National Action Council for Minorities in Engineering Testimony to the Government-University-Industry Research Roundtable,* 2002; National Science Foundation, Chapter 2, Highlights of *Science and Engineering Indicators 2006,* 2006.

[2] Passey, D., et al., *The Motivational Effect of ICT on Pupils,* Department for Education and Skills, London 2004, p. 28; Passey, *The Motivational Effect of ICT on Pupils (Executive Summary),* 2004, p6; Report from the Office of Her Majesty's Chief Inspector of Schools, *ICT in Schools: Effect of Government Initiatives: Secondary Design and Technology,* 2002, p. 4; Hodgson, T., & C. Allsop, Beyond Pro/DESKTOP Computer Aided Design (CAD): *The Transfer of CAD-based Design Modelling Skills from Schools to Higher Education,* Department of Design and Technology, Loughborough University, UK, 2002, p. 7.

[3] Ibid.

U.S. National Security and Defense Capability

T&E education represents an area of strategic learning and preparation needed to support U.S. workforce needs in areas impacting economic and national security.

The United States faces critical workforce needs in the areas of engineering and technology. A large percentage of the engineering workforce is eligible to retire. The average age of the aerospace worker in industry is 44. The average age is 51 at NASA and 53 in the DoD. Over 26 percent of the aerospace workforce will be eligible for retirement in 2008.[4] Currently, there are not sufficient numbers of students in the pipeline to replace them. Less than 10 percent of high school graduates pursue undergraduate degrees in engineering, and only about half of them ultimately earn a degree in engineering.[5] In recent years, the enrollment numbers in engineering have dropped even further.[6] The Department of Defense (DoD) employs approximately 67 percent of all federal scientists and engineers and approximately 90 percent of all federal mechanical engineers.[7] This is also true for companies with national security contracts. Aerospace Industries Association President and CEO John Douglass has stated that "with $161 billion in sales . . . U.S. aerospace is a strategic industry in the nation's economy, homeland security, and national defense."[8]

In all classified and many non-classified strategic jobs, we need to employ qualified U.S. citizens. If the United States does not have the human resources to satisfy these needs, U.S. national security will be at risk.

U.S. Standard of Living, Economic Security, and Innovation Capability

Throughout our nation's history, the skills and education of our workforce have been a major determinant of the standard of living. The 21st century has brought opportunities for most countries in the world to participate in the global knowledge economy. According to the Council on Competitiveness, "Innovation will be the single most important factor in determining America's success through the 21st Century,"[9] adding, "Innovation fosters the new ideas, technologies, and processes that lead to better jobs, higher wages and a higher standard of living.

[4] CFUSAI, 2002, http://fermat.nap.edu/books/0309091756/html/88.html

[5] Chubin, *National Action Council for Minorities in Engineering Testimony to the Government-University-Industry Research Roundtable,* 2002.

[6] National Science Foundation, Chapter 2, Highlights of *Science and Engineering Indicators 2006,* 2006.

[7] *Department of Defense Briefing,* Virginia, December 2005.

[8] U.S. Department of Labor, *High Growth Industry Profile: Aerospace,* http://www.doleta.gov/BRG/Indprof/Aerospace_profile.cfm

[9] Council on Competitiveness, *InnovateAmerica,* 2004, Washington, DC, p. 5

For advanced industrial nations no longer able to compete on cost, the capacity to innovate is the most critical element in sustaining competitiveness. But the United States now finds itself at a potential inflection point—facing new realities that pose significant challenges to our global innovation leadership."[10]

A knowledge economy depends on the development and use of technological tools and systems. The ability to create, innovate, and continually improve these tools and systems will differentiate between the leaders and the followers in a global knowledge economy. If the United States intends to lead, we need to ensure that we have a strong and secure workforce that includes sufficiently large numbers of engineers who innovate and create, technologists who develop practical applications, and technicians who maintain technological systems.

The pressures of continual innovation in a global knowledge economy require a workforce that is more than technology literate and fluent. A continually innovative workforce requires a pipeline of *innovative thinkers* grounded in principles of design and the design process. All students, therefore, need to become innovators grounded in principles of design and the design process, to ensure that a sufficiently large percentage will enter the 21st century workforce.

THE PTC-MIT CONSORTIUM

The mission of the PTC-MIT Consortium is to address the STEM workforce, with a focus on the T&E of STEM, through a partnership with the federal government.

The Consortium represents more than 80 organizations with constituents across the United States, including federal and state agencies; corporations; professional societies; higher education; K–12 education; groups serving minorities, women, and persons with disabilities; informal science centers; and community education programs.

Consortium Working Group members set strategic direction for the Consortium. Working Group members include:

- ACT, Inc.
- Museum of Science, Boston
- Cambridge University
- Carnegie Mellon University
- Center for the Advancement of Scholarship on Engineering Education
- Design & Technology Education Association
- Education Development Center, Inc.
- Federal Aviation Administration
- Harvard University
- International Technology Education Association
- International Society for Technology in Education

[10] Council on Competitiveness, *National Innovation Initiative,* http://www.compete.org/nii/

- Massachusetts Institute of Technology
- Minnesota Department of Education
- National Council for Community & Education Partnerships
- Parametric Technology Corporation
- Pennsylvania Department of Education
- State Educational Technology Directors Association
- Society of Women Engineers
- Texas Southern University

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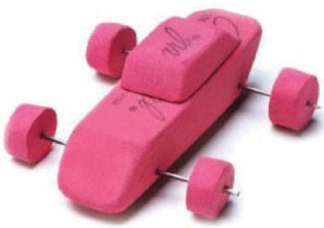
Previous Consortium Actions to Address T&E Workforce Needs

The *Taking Action Together* Forum is the fourth in a series of meetings focused on addressing the needs of the T&E workforce. The following events organized by the PTC-MIT Consortium laid the groundwork for the Forum: Taking Action Together:

- *Moving Beyond the Problem—Strategic Next Steps for Enhancing the STEM Workforce,* Meeting hosted by Senator Mike Enzi and Senator Edward M. Kennedy, March 31, 2006, U.S. Capitol
- Congressional Reception and Poster Session: *STEM: Education for the Future: How American Educators Integrate the T&E into K–16 Classrooms,* hosted by the Senate STEM Education Caucus and the House STEM Education Caucus, July 12, 2006, Rayburn House Office Building
- Business/Industry/Education Focus Group: *Identifying Workforce Needs for the Aerospace/Defense/Industry,* Needham, Mass., July 13, 2006

You can tell when a student is ready to learn design.



The following findings and recommendations emerged as a result of these meetings:

- An overarching **STEM framework** is needed to map standards, programs, and curricula at the K–12 and undergraduate levels to critical skill needs.
- A strong **focus on design,** a core part of engineering, must become integrated into academic instruction at the K–12 and undergraduate levels. Learning design is a means by which students can learn innovation. It is also a motivator that uses discovery, exploration, and problem-solving.
- **Global Engineering approaches,** being used by business and government professionals, must be integrated into academic preparation at the K–12 and undergraduate levels. Students need to learn how to work collaboratively in geographically distributed teams to prepare for their roles in a global economy.
- Employers want technicians and engineers with **excellent academic preparation** and 7–10 years of **real-world experience.** Providing real-world opportunities for K–12 and undergraduate students could cut workforce preparation time by a decade.
- While it is important for all students to be technologically "literate," for the United States to succeed in a highly competitive global economy, we should **aim to have all students become technologically "fluent."**
- **Rigorous research-based approaches** to teaching and learning should be the foundation of K–12 and undergraduate T&E programs.
- **Traditionally underrepresented groups, including women and minorities** must be engaged and recruited into T&E jobs to have enough people to meet the workforce needs, to spark creativity and innovation through diverse perspectives and approaches to problem-solving, and to communicate and connect with various partners, clients, and members of the supply chain in a global economy. Programs should be designed to involve these populations.
- **Assessments and certifications** are needed to create a baseline and to benchmark achievements toward our national STEM workforce goals.

Roles Identified for Stakeholders: Building a Robust "T&E" Pipeline

Congress

- Support inclusion of key elements of technology in legislation, such as the re-authorization of NCLB.
- Build awareness for T&E within the STEM legislative community. Recognize that it is *not* enough to teach science and math to build the engineering pipeline; students also need to learn T&E to build the STEM workforce. Participate in events to heighten public visibility on this issue
- Deepen support and incentives for STEM beyond the "bookend letters" of science and math to include more robust support for T&E.

- Provide support for programs and assessments that work and that address the STEM workforce needs.

Federal Agencies

- Support comprehensive efforts to strengthen T&E education in support of an invigorated STEM workforce.
- Contribute information to an overarching STEM framework.
- Ensure funding for technology as a curriculum content area at the K–12 level.
- Focus existing resources on addressing the STEM workforce needs.
- Support assessment and evaluation of programs.
- Build and support partnerships to leverage investments, successful programs, and resources.
- Provide authentic, real-world, compelling content and expertise in high-interest areas, such as space exploration.
- Use the latest collaboration tools to share information and expertise.

Business

- Work with the PTC-MIT Consortium to provide in-kind resources and money.
- Develop partnerships that support the T&E of STEM.
- Define and disseminate job skill needs.
- Provide real-world design challenges based on industry needs.
- Provide internships for students and externships for teachers to help infuse real-world problem-solving into the educational experience.
- Share best practices.
- Encourage the involvement of other businesses.
- Host national activities.
- Help to make STEM more visible.

Education

- Collaborate across disciplines and programs.
- Ensure that innovation is taught at early grade levels.
- Ensure that technology and design are included as content areas in the curricula.
- Build proficiency and competency, leading to technological literacy and fluency.
- Use authentic tools for instruction.
- Embrace assessment and evaluation.
- Support the technology career development of students.

James McLurkin, Roboticist, Inventor, Researcher, Teacher, MIT Computer Science and Artificial Intelligence Lab, hanging out with four of his robot pals on the set of the Discovery Channel mini-series "The Science of Star Wars". James investigates the science and engineering of robots. James stated "My goal is to understand where intelligence comes from, how it works, and how to construct artificial intelligence on real robots."

Part 2: Taking Action Together

Developing a National Action Plan to Address the "T&E" of STEM Forum

Purpose

Forum Goals, Outcomes, and Deliverables

Goals

1. Raise awareness among stakeholders of the T&E of the STEM workforce challenge and the current activities and programs in place by stakeholder groups to address this issue.
2. Produce a national action plan, addressing the T&E workforce, by identifying specific T&E activities and projects that will be implemented collaboratively.

Intended Outcomes

As a result of the *Taking Action Together* Forum, attendees will do the following:

- Understand the broad implications of this country's insufficient production of T&E workers for the business, education, and government sectors, and articulate how surmounting this challenge aligns with the missions and best interests of their own organizations
- Identify two to five projects that address these challenges by leveraging the interdisciplinary, combined strengths of the group
- Agree to participate in one or two of the communal projects, as defined by the group during the day's workshop, which will then be monitored and coordinated by the PTC-MIT Consortium

Deliverables

- Action plan for the two to five follow-up projects
- Consolidated Action Plan that includes the actions recommended in prior PTC-MIT Consortium events

Agenda

The *Taking Action Together* Forum brought 146 representatives of business, education, government, and civil society to the National Academy of Engineering on September 7, 2006, to take action together in addressing the T&E components of STEM. The following activities guided their work.

8:30–9:15	Registration, Continental Breakfast & Networking
9:15–10:45	Welcome and Plenary Session: T&E Around the Country (Auditorium) • Michael Golden, Deputy Secretary of the Office of Information and Educational Technology, Pennsylvania Department of Education • Alice Seagren, Commissioner, Minnesota Department of Education • Richard Rosen, Vice President, External Business Relations, Battelle
10:45–11:00	Break (Great Hall)
11:00–12:30	Morning Breakout Sessions: Identifying Common Interests
12:30–1:30	Lunch (available in the Great Hall) and Networking
1:30–1:35	Welcome from the National Academy of Engineering (NAE) Norman Fortenberry, NAE (Auditorium)
1:35–1:50	Report on Morning Breakout Sessions (Auditorium)
1:50–3:15	Afternoon Breakout Sessions: Taking Action Together
3:15–3:30	Break (Great Hall)
3:30–4:15	Report on Afternoon Breakout Sessions (Auditorium)
4:15–4:30	Next Steps
4:30	Adjourn

Case Studies

The Forum opened with an examination of three PTC-MIT Consortium partners' activities, presented by the plenary speakers:

- **Metro High School:** Richard Rosen, Vice President, External Business Relations, Battelle
- **State of Pennsylvania Design Program Partnership with the PTC:** Michael Golden, Deputy Secretary of the Office of Information & Educational Technology, Pennsylvania Department of Education
- **State of Minnesota Academic Competitiveness Highlighting Individual Excellence and Valuing Education (ACHIEVE) program:** Alice Seagren, Commissioner, Minnesota Department of Education

These case studies, each addressing the needs of the T&E workforce, provided participants with rich examples of T&E in action at the state and local levels.

Case Study #1: Metro High School

Students at the Metro High School in Columbus, Ohio, focus on an intensive STEM-oriented curriculum to prepare them to succeed in college and in a global information economy. Metro High School is designed to serve students who want a personalized and extraordinary learning experience that prepares them for a connected world in which math, science, and technology are vitally important. The Metro School, developed by Battelle, is putting into action its long-term commitment to address the needs of the STEM workforce and the insufficient number of people going into STEM fields. In collaboration with the PTC-MIT Consortium, Battelle is introducing design as a core part of the STEM component of the Metro School, and will be doing outreach and collaboration to schools across the state of Ohio, using Global Engineering and virtual collaboration/project management tools and techniques.

Case Study #2: State of Pennsylvania Design Program Partnership with PTC

The State of Pennsylvania Design Program Partnership with the PTC provides more than 49 teachers with access to design software and training to integrate and use the software in their middle and high school classes. Computers are provided by Governor Rendell to students across the state. The partnership focuses on the requirements of both comprehensive and technical high schools, and is aligned with the state standards in Career & Work, Science & Technology, and Mathematics. More than 300 students study design to reinforce the content contained in science and tech-ed curriculums, using professional design software to create projects and solve real-world problems in academic classes and career technical programs across the state. Future plans include area businesses providing industry-specific real-world design challenges. Global Engineering will also be introduced, to enable teachers and students to collaborate with universities and local industry on design projects, building on the successful design program already established. This partnership provides important connections with regional workforce investment boards, economic development councils, industrial resource centers, and companies—such as, FAY-PENN in southwest Pennsylvania and the Delaware Valley IRC in southeast Pennsylvania.

Case Study #3: State of Minnesota Academic Competitiveness Highlighting Individual Excellence and Valuing Education (ACHIEVE) Program

The PTC-MIT Consortium is working with the State of Minnesota to design and establish the world's first state-wide Global Engineering Education Program. This initiative brings together the University of Minnesota and State of Minnesota area schools and businesses to engage in collaborative geographically distributed design. The Consortium is assisting Minnesota in preparing teachers across the state to use computer-aided design tools, and in connecting schools with local design and manufacturing companies to develop partnerships, using Minnesota's High Tech Association. The design program employs a train-the-trainer model. After the partnership announcement with Governor Pawlenty in July 2006, more than fifty teachers were trained in design before the school year began in September. Governor Pawlenty also provided support for teacher professional development to sustain the initiative.

Morning Breakout Sessions

Individuals had a choice of six breakout groups, which they joined based on their organization type:

- Federal and state agencies and congressional staff, facilitated by Lenny Sweeney, Pennsylvania Department of Education
- Corporations, facilitated by Ralph Coppola, Parametric Technology Corporation
- Professional societies and higher education, facilitated by Jeff Hoffman, Massachusetts Institute of Technology, and Norman Fortenberry, Center for the Advancement of Scholarship on Engineering Education, National Academy of Engineering
- K–12 education, facilitated by Kendall Starkweather, International Technology Education Association, and Mila Fuller, International Society for Technology in Education
- Groups serving underrepresented populations, facilitated by Semahat Demir, Society of Women Engineers (SWE), and Melissa Carl, SWE and American Society of Mechanical Engineers
- Informal science centers and community education programs, facilitated by Patti Curtis, Museum of Science, Boston

Session Goal

Each group developed a list of the top three priorities on which to take action to address the T&E pipeline issue. These lists were reviewed by the Synthesis Team (EDC and facilitators) during lunch, then combined and shared with the larger group to structure the afternoon's work and future actions of the PTC-MIT Consortium.

Session Guiding Questions

Participants were asked to introduce themselves and then answer the following questions:

1. Why is your organization interested in this problem, and how does it align with your organization's mission?
2. What specific programs are the best models you have seen to address this issue? Do you have data? (No need to specify, just answer yes or no)
3. What's important that is not being addressed?
4. From the list created in Question 3, what are your group's top three priorities to work on?

(See Appendix B: *Facilitators Guide* and Data Collection Forms for more information about the structure and action planning activities of this Forum.)

AFTERNOON BREAKOUT SESSIONS

The Synthesis Team (a subset of members of the PTC-MIT Consortium Steering Committee and morning session facilitators) reviewed the action priority lists developed by each breakout group and identified the following five priority action areas:

1. Capacity-Building
2. Policy
3. Assessment, Research Evaluation, and Certification
4. Recruitment, Retention, and Professional Development of T&E Teachers and University Faculty
5. Awareness

Forum participants selected the topic of most interest to them, and then participated in an action planning session led by a facilitator.

Results of Action Planning Breakout Sessions

Not surprisingly, some of the recommended actions intersected across groups. The information below summarizes the results and lists the key action steps identified by participants.

Priority Action Area: Capacity-Building

Goal: Build core knowledge and skills for all students in T&E (design/systems/spatial learning/technology applications), and help students develop an interest in T&E, ultimately pursuing and persisting in courses that lead to T&E careers.

Project plan (action ideas, or a combination of ideas, suggested by the group):

- Document and share best practices and lessons learned in the T&E of STEM.
- Build international connections and explore successful models in the United States and other countries, and adapt and implement appropriate lessons learned with the aim of strengthening the T&E workforce pipeline.
- Enhance design and technology curriculum by infusing promising practices, as well as the use of professional-level tools, technologies, and approaches used in business and government, such as Global Engineering and real-world design challenges.
- Inform policy-makers, parents, educators, industry, community leaders, etc. that design and innovation need to be critical parts of T&E educational experiences for both students and teachers, with opportunities to engage in real-world problem-solving.
- Ensure that policy-makers, parents, educators, industry leaders, community leaders, etc. understand that design and innovation are critical to both students' and teachers' real-world learning, and support the implementation of initiatives and programs that use such approaches as Global Engineering and real-world design challenges to strengthen T&E in schools.
- Develop a template, portal, clearinghouse, or framework to pull all the STEM programs together, determine what resources exist and what is being done, examine metrics, and determine which are successful.
- Use a gap analysis to determine where additional resources and programs are needed.

Recommended actions:

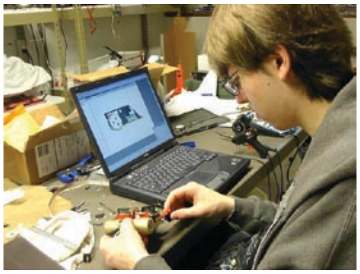
- Ensure that all students have an opportunity to learn design. A.1.1.
- Provide increased opportunities for students to learn Global Engineering. A.2.1.
- Map and align standards, programs, and curricula at the K–12 post-graduate and workforce training levels to meet critical skill needs. C.1.1.

Priority Action Area: Policy

Goal: Develop national and regional policies and a commitment to strengthen T&E education and workforce development by focusing efforts and investments.

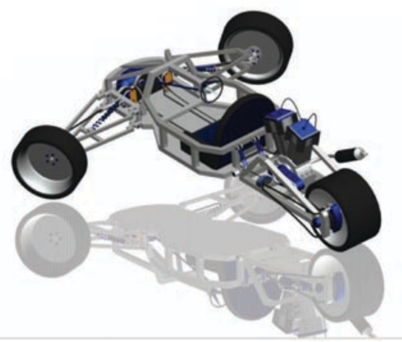
Project plan (action ideas, or a combination of ideas, suggested by the group):

- Inform legislators and the general public about the need for T&E education and how this need can be addressed.



"…in Standards for Technological Literacy…the International Technology Education Association has successfully distilled an essential core of technological knowledge and skills we might wish all K-12 students to acquire."

–William A. Wulf, President National Academy of Engineering, *Standards for Technological Literacy*



- Develop a compelling and easily understood case statement focusing on the need for a highly educated and skilled T&E workforce.
- Integrate professional development of technology education teachers with professional development for math and science teachers when addressing areas of curricular synergy.
- Include T&E, at the K–12 and undergraduate levels, in both authorizing and appropriating legislation focused on STEM at the national and state levels.
- Ensure that there are national assessments and certification for T&E, from the K–12 levels through professional practice.
- Support the deployment of technology standards in all states, based on the Educational Technology and Technology Education National Standards.
- Require a technology course for all students.
- Include Technology Education and Educational Technology in No Child Left Behind (NCLB) and ensure that there is a national assessment that covers both Technology Education and Educational Technology.
- Explore how year-long learning models can be used to enhance T&E education with the infusion of internships for students, externships for teachers, and real-world design challenges based on industry applications and issues.
- Ensure that all students have an opportunity to gain fundamental knowledge of T&E and are able to use that knowledge to make educated decisions about careers.
- Ensure that all students have a basic understanding of T&E, within the STEM context, and are able to make educated decisions about career options in these areas.

Recommended actions:

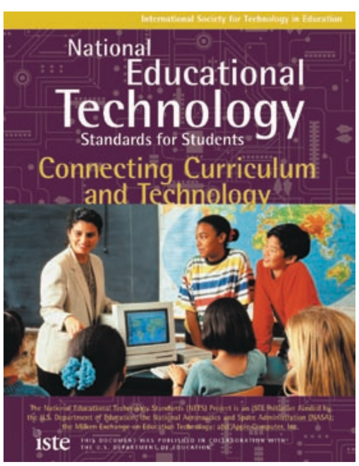
- Promote the adoption of T&E standards and assessment in all states. B.2.1.
- Enhance the re-authorization of No Child Left Behind (NCLB) by strengthening technology. B.1.1.
- Promote the need for T&E education among policy-makers and the general public. D.2.1.

Priority Action Area: Assessment, Research Evaluation, and Certification

Goal: Gather the data needed to facilitate informed decisions by policy-makers and practitioners, educators, and employers. (As a resource for this discussion, participants at the Forum were given the new book *Tech Tally,* published by the National Academies Press, which is a framework for assessment and evaluation of T&E.)

"ISTE NETS are a stepping stone to more advanced learning."

–Chris Stephenson, Executive Director of the Computer Science Teachers Association



"ISTE NETS are the 'gold standard' for the field."

–Tim Magner, Director, US Department of Education, Office of Educational Technology

Project plan (action ideas, or a combination of ideas, suggested by the group):

- Provide data and real-time information to decision-makers to enable them to make better decisions about policy, best practices, admissions, and employment. Data can also facilitate the development of a case statement about the importance of T&E in addressing the STEM workforce. Comparative data, such as TIMSS (Third International Mathematics and Science Study), are important and yield good information, but these data are not sufficient; TIMSS data, for example, do not address T&E. There is a significant need for STEM data, especially in the area of T&E, as there are few data sets and studies that focus on T&E. When studies are done, especially when they are comparative and involve multiple variables, it is critical that the data are disaggregated so that multiple research strategies can be employed.
- Support studies and mechanisms that focus on longitudinal data collection, as these data are valuable. Unfortunately, there is very little support for education research in STEM at this critical time, when we need to synthesize findings and develop concentrated evaluation efforts that include common data standards for this field and solid, baseline data.
- Create a registry of available evaluation data. Access to this information can help set us on a solid path toward improvement. Timely feedback, evaluation, and technical assistance will make program evaluations more helpful to participants. The focus of STEM evaluations should be on education with a link to the impact of education on the workforce. We are guided by these general principles: (1) For project evaluation to have a positive impact in building a robust STEM workforce, evaluations must be long-term and extend past the life of the grant projects, and (2) Ongoing research is needed to judge the effects of the many STEM projects that are nascent.
- Develop a national research agenda and plan that develops common data definitions and standards, defines what needs to be taught, identifies most effective teaching and learning models, produces more evaluation and assessment experts, supports synthesis of findings across agencies, and develops support to pursue the work.
- Have good T&E data to support informed formative and summative decision-making.
- Promote the adoption of T&E standards and assessment in all states.

Recommended actions:

- Encourage rigorous research-based approaches to teaching and learning. E.1.1.
- Assess and certify the acquisition of critical skills from the K–12 levels through professional practice. E.2.1.
- Support the development of longitudinal evaluation efforts focusing on

"ACT's research suggests several critical steps to advancing the STEM education pipeline and maintaining, even enhancing, our nation's competitive position in the global market. We need to identify the foundational skills that are prerequisite to successful performance in the STEM professions, and ensure that all students are provided with a rigorous core curriculum that ensures they possess these skills when they leave school. Second, we need a systematic approach for measuring students' progress in attaining these skills as they move through middle and high school so that targeted instructional interventions can be provided as necessary. Finally, we need to establish processes and tools (e.g., skill-based certificates) that enable educators, trainers, and the students themselves, to verify to employers and interested others that the students have acquired the critical skills needed to succeed and advance in STEM careers."

–Richard L. Ferguson, CEO
Chairman of the Board
ACT, Inc.

programs that address T&E career pathways, focusing on jobs that are at high risk of not being filled and have great consequences if they are not filled. E.3.1.

Priority Action Area: Recruitment, Retention, and Professional Development of T&E Teachers and University Faculty

Goal: Promote the need for activities targeted at recruitment, retention, and continual professional development of technology (technology education and educational technology) and engineering K–12 teachers and university faculty.

Project plan (action ideas, or a combination of ideas, suggested by the group):

- Build partnerships with companies that are engaged in authentic STEM work.
- Give teachers time to strategize and opportunities to collaborative across disciplines.
- Make professional development mandatory.
- Have such organizations as ITEA and ISTE collaborate on mutually supportive initiatives targeted at addressing all aspects of the technology issue.
- Have companies share activities and best practices, used in industry, with teachers, including tools used in real-world applications, which teachers can then adapt for their classrooms.
- Support and promote project-based learning.
- Ensure that teacher education institutions prepare teachers in the latest approaches used in business and government. All teachers should be prepared to use technology in the classroom.
- Use NCLB to support T&E. Colleges of education need to “shake things up”; students coming out need to be trained to facilitate innovation, discovery, exploration, and creative, real-world problem-solving.
- Take a positive approach to education reform, building on strengths and addressing future needs. Student input in learning should be sought and collected with online polls. Leverage the use of volunteers, such as retired engineers and others with expertise in T&E, and focus resources on improving STEM education nationally.
- Support partnerships and consortia to focus existing resources on addressing the STEM workforce pipeline.
- Develop partnerships at the national and state levels among key stakeholders, such as K–12 and undergraduate education and STEM companies, to collaboratively develop and implement models that provide STEM strategies for teacher recruitment, teacher retention, and continual professional development.

- Develop an operational definition of STEM, identifying data collection processes and gathering data, developing a marketing/public awareness plan, and developing strategic models for STEM teacher recruitment and STEM teacher professional development.
- Develop a consensus on the key definitions of T&E terminology.
- Recruit new teachers, implement strategies and incentives to retain teachers, and increase opportunities for professional development.
- Map and align standards, programs, and curricula at the K–12 levels through professional practice to meet critical skill needs.

Recommended actions:

- Recruit new teachers, implement strategies and incentives to retain teachers, and increase opportunities for professional development. A.5.1.
- Provide a dissemination and implementation network across the United States. A.4.1.

Priority Action Area: Awareness

Goal: Build public awareness, among all stakeholder groups, of the relevance, importance, and pervasiveness of T&E in society and the consequences and societal impact of strong and weak T&E education and workforce systems, identifying the roles and responsibilities of business, education, government, and the public.

Project plan (action ideas, or a combination of ideas, suggested by the group):

- Build awareness among policy-makers, practitioners, and the general public, which is essential to building a workforce strong in the T&E of STEM. This awareness should define what the country needs to stay competitive and what skills students need in the workforce.
- Define key workforce skills, align educational practice with these skills needs and ensure that this is a priority in schools.
- Speak more frequently and in a consistent voice to the media, who relay important information to and communicate with our intended audience.
- Provide the public with good role models. Demystify the role of an engineer/inventor. There are few engineers on television, and they are not represented in the public entertainment arena. Include writing and communication skills in the engineering curriculum so that engineers are more comfortable communicating with the media and the general public, and are more willing to share what they do with the community more often.
- Communicate what is working, in terms of student achievement, and results. State and local summits can be venues where communities can discuss specific issues, develop goals, and elicit support for programs. National summits will draw greater attention to this issue, increasing awareness and encouraging collaborations, which can then increase interest in jobs in these fields.

"Engineering is all about the invention of devices and processes. Any young engineer with imagination can make a huge contribution. Women are really needed because they think differently than men and they're bringing a whole new vision of creativity that will have far-reaching impact on our world."

–Corrine Lengsfeld, Engineer *Changing Our World: True Stories of Women Engineers*, p. 24

"As an engineer, this time of development is so exciting. I have the ability to improve people's quality of life in very visible ways. The possibilities are enormous! It's engineers that will turn those possibilities into reality."

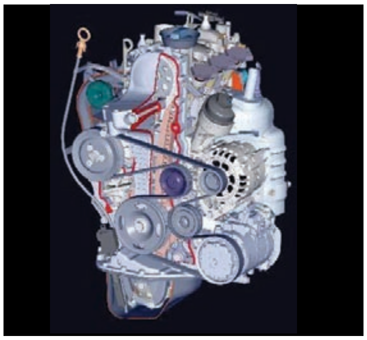
–Ruthie Lyle, Engineer
***Changing Our World: True Stories of Women Engineers*, p. 124**

"This is engineering at its best. I bring people and ideas together and turn them into reality."

–Dava Newman, Engineer
***Changing Our World: True Stories of Women Engineers*, p. 171**

"3D design is a very tangible application of math and science. It gives students an experience that may lead to their choosing engineering as a career."

–Scott Mattingly, teacher
Beckendorff Junior High
Katy, TX



- Make sure that policy-makers and the public know that for national security reasons, many more well-educated and prepared engineers who are U.S. citizens are needed to fill our national security jobs.
- Make sure that businesses and government agencies know that they can help by providing internships for students, externships for teachers, and design challenges. These approaches can be used to infuse real-world experiences into education.
- Encourage technologists and engineers to work with scientists and mathematicians on this national effort. Together we need to create a clear message that is sent throughout the nation, and provide examples of the contribution that engineers make to society, in order to inspire interest in both students and public relations groups.
- Seek funding to catalyze "making the case" for the T&E of STEM. An awareness campaign needs to be combined with serious follow-through in schools. There needs to be an assessment of technology literacy and fluency.
- Make sure that T&E is included in today's biggest driver of educational change, i.e., NCLB, and is part of the NCLB assessment plan.
- Create summits at different levels that will involve different key stakeholders, focusing on making the case and increasing awareness beyond the STEM community.
- Bring together key stakeholders to focus existing programs and resources on addressing the targeted STEM workforce needs in T&E.
- Promote T&E and early career exploration among students and teachers, beginning in middle school, if not before.
- Promote the need for T&E education among policy-makers and the general public.

Recommended actions:

- Bring together key stakeholders to focus existing programs and resources on addressing the targeted STEM workforce needs in T&E. C.2.1.
- Promote T&E and early career exploration among students and teachers, beginning in middle school, if not before. D.1.1.
- Enhance the re-authorization of No Child Left Behind (NCLB) by strengthening technology. B.1.1.
- Strengthen the foundation of technology learning in schools and connect it across the curriculum. A.3.1.

Part 3: Recommendations

Recommendations for Action

The following Recommendations for Action represent suggestions from all four events that were held by the PTC-MIT Consortium. (Those also suggested at the meetings held prior to the Taking Action Together Forum are noted with an asterisk [*].) The recommendations are categorized into five topical areas:

A. Capacity-Building

B. Policy

C. Focusing Existing Resources[11]

D. Awareness

E. Research, Assessment, and Certification

These topical categories are used to best represent the types of recommendations provided. Some of the topical categories were combined. For example, "Capacity-Building" comprises all of the recommendations focusing on implementation, as well as recommendations in the category "Recruitment, retention, and professional development of T&E teachers and university faculty."

[11] The afternoon sessions did not have a category on focusing existing resources, yet several recommendations fell under that topic. Therefore, the category "Focusing Existing Resources" was created for these recommendations.

RECOMMENDATION	ACTION STRATEGY	WHO SHOULD BE INVOLVED
A. Capacity-Building		
A.1.1. Ensure that all students have an opportunity to learn design.* **Rationale:** Through learning design, students (1) learn to be innovators and problem-solvers, (2) learn about T&E jobs, and (3) become motivated to consider T&E careers.	**A.1.2.** Provide students from kindergarten through university levels, with experiences in real-world design. Have them work on real-world problems or design challenges, and engage in internships and - identified by practitioners in business or government, to gain an understanding of real-world problem-solving.	**A.1.3.** (1) Practitioners from business and government; (2) standards-developing organizations, such as International Technology Education Association (ITEA), International Society for Technology in Education (ISTE), American Association for the Advancement of Science (AAAS), National Research Council (NRC), and National Council of Teachers of Mathematics (NCTM); (3) higher education; (4) K–12 groups; (5) federal and state agencies and organizations, such as National Conference of State Legislatures (NCSL) and National School Boards Association (NSBA); (6) informal science and technology centers and community education groups; and (7) policy-makers at the federal and state levels.
A.2.1. Provide increased opportunities for students to learn Global Engineering. * **Rationale:** Global Engineering is the design of systems in a geographically distributed environment. It is a strategic economic niche for the United States. Much of the engineering design and manufacturing done by businesses and government is done in a geographically distributed environment. However, higher education and K–12 education are not providing opportunities for students to learn Global Engineering. Building this capability provides an opportunity for the United States to identify the high-end, creative, innovative manufacturing jobs that can reside in this country, while the lower-end routine jobs can be done in locations abroad with lower-cost labor.	**A.2.2.** Have students create, collaborate on, and manage the design of systems in a geographically distributed team environment, employing the latest collaboration tools used by practitioners in government and business.	**A.2.3.** (1) Business and government, (2) higher education, and (3) K–12 school groups and other interested parties, such as informal science and technology centers and community education programs.

A.3.1 Strengthen the foundation of technology learning in schools and connect it across the curriculum.* **Rationale:** In order to increase the talent pipeline, all learners must develop a strong foundation in technology skills and knowledge, and learn how technology is used and applied in all aspects of living, learning, and working in the 21st century.	**A.3.2.** Link technology education (learning how to solve problems and extend human potential through design) with other subjects, such as science, math, and educational technology (learning how to use technologies). Focus activities on topics where there are shortages and a strategic need, such as engineering, physical sciences, and material sciences.	**A.3.3.** Key K–12 stakeholders, such as ITEA, ISTE, and the State Educational Technology Directors Association (SETDA); government agencies at the federal and state levels; professional societies; and support from higher education and business.
A.4.1. Provide a dissemination and implementation network across the United States.* **Rationale:** The U.S. educational system is decentralized. Disseminating and implementing scalable initiatives is difficult since each district makes its own decisions about these issues.	**A.4.2.** Use existing networks of organizations to access the local decision-makers and provide a vehicle for communication and access to existing resources outside the local sphere.	**A.4.3.** The PTC-MIT Consortium, which can leverage the power and reach of more than 80 partner organizations across the country to disseminate and implement education initiatives in every state and territory; each organization in the Consortium has a connection to or "ownership" of key areas of STEM education and employment at all levels, from K–post-secondary education through professional practice.
A.5.1. Recruit new teachers, implement strategies and incentives to retain teachers, and increase opportunities for professional development. **Rationale:** Many of the 38,000 technology teachers across the country are nearing retirement, and there are not enough people in the pipeline to replace them. Teachers with good credentials in T&E-related fields can find higher-paying jobs in industry.	**A.5.2.** Develop partnerships, nationally and at the state level, to collaboratively engage and mobilize key K–16 stakeholders to create models that provide strategies for teacher recruitment, teacher retention, and continued professional development. Provide ongoing professional development opportunities to enhance teachers' skills with new tools and approaches to T&E used by practitioners in business and government. Identify and use incentives to attract and retain quality technology teachers. Provide externships in business and government settings, for both professional development opportunities and additional compensation.	**A.5.3.** Federal and state government agencies, organizations such as ITEA, ISTE, and SETDA, business, foundations, and higher education.

RECOMMENDATION	ACTION STRATEGY	WHO SHOULD BE INVOLVED
	Encourage partnerships among schools, businesses, and higher education, focused on enhancing educational opportunities and building the T&E pipeline, which will benefit all of the stakeholders and help to build a professional cadre of teachers prepared to address the latest challenges in T&E.	
	B. Policy	
B.1.1. Enhance the re-authorization of No Child Left Behind (NCLB) by strengthening technology.* **Rationale:** Tomorrow's economic competitiveness depends on the quality of today's education system. Many of our nation's critical national security STEM jobs cannot be outsourced or filled with foreign talent.	**B.1.2.** Enhance technology in NCLB in the following ways to ensure that all Americans have the opportunity to become "technological thinkers" and to develop and demonstrate core STEM skills and abilities: (1) Add new titles for "Technology Education" focusing on "Design" and "Use of Data and Accountability"; and (2) strengthen the current sections on Technology with such modifications as adding "Technology for School Administration" and updating the "Definition of a Highly Qualified Teacher."	**B.1.3.** (1) Congress, (2) the U.S. Department of Education, (3) standards-developing organizations, such as ITEA, ISTE, AAAS, NRC, and NCTM, and (4) key education stakeholder groups at the K–12 level, such as state departments of education, professional societies, and SETDA.
B.2.1. Promote the adoption of T&E standards and assessment in all states. **Rationale:** Clear goals and plans are needed to guide and benchmark national, regional, and state progress on the development of skills and knowledge related to the T&E of the STEM pipeline.	**B.2.2.** Have the PTC-MIT Consortium convene standards-making organizations to issue the statement that all states should adopt a set of standards for T&E and develop or adopt assessments targeted at both formative and summative student achievement in these areas. Make available existing national and state standards on a Web-based portal to enable states to use and benefit from the work that has been done in this area. Involve state legislative organizations and departments of education in creating plans to develop or adopt T&E standards and assessments.	**B.2.3.** The PTC-MIT Consortium; standards-developing organizations, such as ITEA, ISTE, AAAS, NRC, NCTM, and the Museum of Science; National Conference of State Legislatures (NCSL) and National School Boards Association (NSBA); state boards of education; state departments of education; SETDA; NSBA; NCSL; business roundtables; and industry groups.

RECOMMENDATION	ACTION STRATEGY	WHO SHOULD BE INVOLVED
C. Focus Existing Resources		
C.1.1. Map and align standards, programs, and curricula at the K–post graduate and workforce training levels to meet critical skill needs.* **Rationale:** The current STEM pipeline is unreliable and fragmented. Resources are wasted on duplication of programs and services as well as programmatic gaps in the skill development pipeline at the national, regional, and local levels.	**C.1.2.** Use the PTC-MIT Consortium's STEM framework to identify and align existing investments and programs to reduce duplication and identify gaps. Facilitate partnerships and connections and invite all stakeholder programs to become part of this national effort. Develop criteria for the success of programs that focus on the T&E of STEM. Create a Web-based clearinghouse to be the "go to" place for information on all the STEM programs. Determine metrics, and assess which are successful.	**C.1.3.** The PTC-MIT Consortium; Education Development Center, Inc. (EDC); U.S. Department of Labor; business; higher education; K–12 groups; and professional societies.
C.2.1. Bring together key stakeholders to focus existing programs and resources on addressing the targeted STEM workforce needs in T&E.* **Rationale:** Although many organizations focus attention on various aspects of STEM workforce needs, there is little information shared across organizational boundaries about existing programs or resources for the T&E of STEM, and few opportunities for collaboration in safe, non-threatening environments.	**C.2.2.** Identify the need and the existing capabilities that can be focused on addressing that need. Focus existing resources on addressing the identified need(s). Perform a gap analysis to determine what needs cannot be met with existing resources. Develop a plan to address the needs not being met. Obtain the resources to address the needs that are not being met. Implement plans to address the unmet needs.	**C.2.3.** The PTC-MIT Consortium and other groups that have an interest in addressing this area, such as federal and state agencies, business, professional societies, higher education, K–12 education, groups serving underrepresented populations, and informal science and technology centers and community education programs.

RECOMMENDATION	ACTION STRATEGY	WHO SHOULD BE INVOLVED
D. Awareness		
D.1.1. Promote T&E and early career exploration among students and teachers, beginning in middle school, if not before. **Rationale:** Career development begins early in life and is shaped by experiences in school, resulting in academic and career decisions that lead to post-secondary education and employment. In middle school, students begin to explore the world around them and make preliminary academic and career decisions that can set them on or divert them from a STEM pathway.	**D.1.2.** Develop a marketing/public awareness plan to promote T&E careers and translate workforce expectations into a rigorous K-post-secondary curriculum. Develop videos and other media to promote T&E careers. Develop case statements with facts about T&E jobs, working conditions, and salaries. Promote the use of comprehensive, research-based career guidance services beginning in middle school.	**D.1.3.** The PTC-MIT Consortium; higher education; K–12 groups, such as career guidance services; business, particularly the human resource and technical divisions, with support from upper management; national and state-level groups, such as the National Governors Association, NCSL, NSBA, workforce investment boards, and chambers of commerce; and service organizations, such as Rotary International.
D.2.1. Promote the need for T&E education among policy-makers and the general public. **Rationale:** The general public is less aware of the critical need for T&E workers and the worker shortages that will translate into job opportunities for their children and their families.	**D.2.2.** Develop a case statement, using a risk-management assessment, identifying the consequences of not having sufficient people in the T&E pipeline. Develop messages and talking points targeting policy-makers and the general public	**D.2.3.** Public relations firms, engineers, economists, policy-makers, relevant industries, the national security community, educators, the media, state and federal agencies, community groups and students.

RECOMMENDATION	ACTION STRATEGY	WHO SHOULD BE INVOLVED
E. Research, Assessment, and Certification		
E.1.1. Encourage rigorous research-based approaches to teaching and learning.* **Rationale:** A key part of attaining the STEM workforce goal is encouraging continual improvement of our educational systems through a commitment to research-based approaches to teaching and learning.	**E.1.2.** Promote a more globally competitive workforce that engages in lifelong learning. Encourage discovery of a fundamental understanding of teaching, learning, and assessment as well as the translation of research findings into improved practice in formal and informal education settings. Speed the research-practice cycle by informing policy-makers and practitioners of relevant research, both in progress and as studies are completed. Issue documents that identify strategies to translate research findings into educational practice.	**E.1.3.** Higher education, government agencies at the federal and state levels, NGOs, K–12 groups, and business.
E.2.1. Assess and certify the acquisition of critical skills from the K–12 level through professional practice. **Rationale:** Benchmarks are necessary to measure progress toward the goal of developing the talent pool.	**E.2.2.** Establish a K–12/industry/higher education-endorsed assessment and certification program for students and practitioners that will validate and document their critical skills and represent a pathway to career advancement. Develop common data definitions and standards to facilitate comparisons of data and support the synthesizing of findings across organizations. Develop a Web-based portfolio of certification information that also includes traditional assessment and degree information that can be used to gain entry to post-secondary programs and jobs.	**E.2.3.** Assessment and certification organizations, such as ACT, Inc., the College Board, and Accreditation Board for Engineering and Technology; federal agencies; professional societies; higher education; and business.
E.3.1. Support the development of longitudinal evaluation efforts focusing on programs that address T&E career pathways, focusing on jobs that are at high risk of not being filled and have great consequences if they are not filled.* **Rationale:** Connecting program evaluation to workforce goals will help focus resources on attainment of workforce goals for the T&E of STEM.	**E.3.2.** Make the case and obtain commitment for longitudinal evaluation. Explore self-funding mechanisms, develop a business plan, and prepare a case statement to obtain funding for the development work.	**E.3.3.** Federal policy-makers; foundations; practitioners in the targeted jobs; evaluation groups, such as ACT, Inc.; and NGOs.

Appendices

Appendix A: Participants in the Forum *Taking Action Together*

Appendix B: *Facilitators Guide* and Data Collection Forms

Appendix C: Definitions of Key Terms

Appendix D: STEM Career Development Model

Appendix A: Participants in the Forum
Taking Action Together

ACT, Inc.	Katharine Carter, Research Assistant Nancy Segal, Assistant Vice President & Director of the Washington, D.C., office
Air Force Association	Douglas Birkey, Legislative Assistant Lois O'Connor, Director of Development
The American Association for the Advancement of Science (AAAS)	Joan Abdallah, Director, K-16 Programs
American Institute of Aeronautics and Astronautics (AIAA)	Pramud Rawat, Chairman Baltimore Section
American Institute of Chemical Engineers (AIChE)	Darlene Schuster, Director, Institute for Sustainability
American Institutes for Research	Aimee Evan, Research Associate
American Society of Civil Engineers	Lisa Jennings, Program Manager, Diversity and Pre-College Outreach
American Society of Civil Engineers Foundation	DariaMaresh, Manager, Extraordinary Women Engineers Project
American Society of Mechanical Engineers International	Kathryn Holmes, Government Relations Representative
Appalachian Regional Commission	Concepción Reyna, Policy Advisor Jeffrey Schwartz., Education Program
Arlington Public Schools	Camilla Gagliolo, Instructional Technology Coordinator
Association for Computing Machinery	David Bruggeman, Public Policy Analyst
Baltimore County Public Schools, Office of Instructional Technology	Thea Jones, Supervisor
Battelle	Rich Rosen, Vice-President External Business
Battelle Aberdeen Operations	Katy Delaney, Senior Manager Media Relations
Biotechnology Institute	Claire Cornell, Director of Development Scott May, Vice President
British School of Washington	Jennifer Arwas OBE, Head Gareth Hall, Head of Design & Technology
Business-Higher Education Forum	Justin Wellner, Assistant Director

Cable in the Classroom	Douglas Levin, Senior Director, Education Policy Helen Soulé, Executive Director Rhonda Yates, Senior Director, Strategic Initiatives
California State University, Los Angeles	Ethan B. Lipton, Associate Vice President for Academic Affairs & Dean of Education Support Services
Center for Woman & Information Technology (CWIT)	Bria McElroy, Director of University Initiatives
Chartwell Education Group, LLC	Susan Sclafani, Managing Director
Civil Engineering Forum for Innovation (CEFI)	Susan Skemp, Executive Vice President
Clemson University	Bill Havice, Associate Dean
College of Education, University of Maryland	Davina Pruitt-Mentle, Director, Educational Technology Policy, Research and Outreach
The College of New Jersey	Ronald Todd, Research Professor
Consortium for School Networking (CoSN)	Keith Krueger, CEO
Council of Chief State School Officers	Scott Frein, Director of Advocacy
Delaware Valley Industrial Resource Center (DVIRC)	Anthony Girifalco, Executive Vice President Michael Pahides, Senior Vice President – Development & Education Mel Payne, Project Director
Department of Defense (DoD) Ordnance Technology Consortium	Todd Borghesani, Serious Games Consultant
Department of Defense, Office of the Assistant Secretary for Reserve Affairs	Ernie Gonzales, Director Youth Outreach Programs
Department of Energy (DOE) National Nuclear Security Administration (NNSA)/SMS Office of University Partnerships	Chris Brengel, Program Analyst
Department of Energy National Nuclear Security Administration	Mary Martin, Physicist Beverly Berger, Director, University Partnerships
Draper Laboratory	Linda Fuhrman, Program Manager

Education Development Center, Inc.	Siobhan Bredin, Project Director Bethany Carlson, Research Associate Vivian Guilfoy, Senior Vice President Joseph Ippolito, Senior Project Director Joyce Malyn-Smith, Director Strategic Initiatives, Workforce & Human Development
Federal Aviation Administration	Shelia Bauer, National Aviation and Space Education Program Manager Amy Corbett, Regional Administrator, New England Region
Federation of American Scientists	Kay Howell, Vice-President for Information Technologies Michelle Roper, Information Technologies Manager for the Digital Promise Project and the Discover Babylon Project
FIRST (For Inspiration & Recognition of Science & Technology)	Mildred Porter, Regional Director
General Mills, Inc	Anita Hall, Program Manager
George Washington University	Shelly Heller, Assoc Dean Natalie B. Milman, Assistant Professor
Global Wireless Education Consortium	Susan Sloan, CEO
Government-University-Industry Research Roundtable (GUIRR)	Spence M. (Sam) Armstrong, USAF & NASA retired
HCI - SchoolBizMatch	Robyn Hickey, President
Hewlett-Packard	Dan Marcek, University Relations
Howard Hughes Medical Institute	Debra Felix, Program Officer
Instructional Technology at Duquesne University	Debbie Piecka, Manager, Instructional Tech Seminars and Doctoral Student
International Society for Technology in Education	Mila Fuller, Director of Strategic Initiatives Hilary Goldmann, Director, Government Affairs Heather Istwany, Office Assistant
International Technology Education Association	Barry Burke, Director, Center to Advance the Teaching of Technology and Science Kendall Starkweather, Executive Director/CEO
Invention Innovation Centers Project Ohio Space Grant Consortium (NASA)	Wes Perusek, Director
Johns Hopkins University	Iman ElShehaby, Graduate student, BIGSTEP fellow
Junior Engineering Technical Society (JETS)	Megan Balkovic, Director of Development
Kennedy Krieger School - Greenspring	Jennifer Kraft, Education Technology Facilitator

Maine Mathematics and Science Alliance	Francis Eberle, Executive Director
Maryland MESA, Johns Hopkins Applied Physics Lab	Rotunda Floyd, Executive Director
Maryland Public Television	Robert J. Shuman, President & CEO
Maryland State Department of Education	Mary M. Thurlow, Coordinator for Science
Massachusetts Institute of Technology (MIT)	Jeffrey Hoffman, Professor of the Practice of Aerospace Engineering, Department of Aeronautics & Astronautics Kari McCarron, Senior Legislative Assistant
Mayo Clinic	Bruce Kelly, Director of Government Relations
Mechanical Engineering, Rensselaer Polytechnic Institute	Deborah Kaminski, Director of Outreach
Minnesota Department of Education	Alice Seagren, Commissioner
Montgomery County Public Schools	W. Ed Ball, Curriculum Coordinator – Pre-engineering and Technology Ed Michelle Lipson, Instructional Specialist Steve Mikulski, Instructional Specialist – Tech Ed & Engineering Sandra Navidi, Curriculum Coordinator
Museum of Science, Boston National Center for Technological Literacy	Patti Curtis, Managing Director, Washington Office
Material World Modules (MWM) Maryland	Stephen M. Priselac, Director
The National Academies	Jay Labov, Senior Advisor for Education and Communications Merrilea Mayo, Director, Government-University-Industry Research Roundtable (GUIRR)
National Academy of Engineering	Norman Fortenberry, Director, Center for the Advancement of Scholarship on Engineering Ed Greg Pearson, Program Officer
National Action Council for Minorities in Engineering (NACME)	Tom Price, Senior Vice President Operations
National Aeronautics and Space Administration (NASA)	Tony Springer, Lead Communication and Education Sharon S. Welch, Innovative Work Team Lead Tammy Rowan, Technology Program Manager, Office of Education (NASA)
National Alliance of State Science and Mathematics Coalitions	Jessica Venable, Program Officer

National Association of Secondary School Principals	Amanda Karhuse, Government Relations Manager
National Association of State Universities and Land-Grant Colleges (NASULGC)	David Shulenburger, Academic Vice President Howard Gobstein, Vice President, Science Policy
National Center for Education Evaluation and Regional Assistance	Gil Narro Garcia, Senior Research Analyst
National Council for Community and Education Partnerships (NCCEP)	Alex Chough, Director, External Relations Ranjit Sidhu, Executive Vice President
National Council of Teachers of Mathematics	Jim Rubillo, Executive Director
National Education Association	Andrea Prejean, Senior Policy Analyst
National Governors Association	Charles Toulmin, Senior Policy Analyst
National Inventors Hall of Fame	Brenda Wojnowsk, President, Inventive Education
National Science Board - Commission on 21st Century Education in Science, Technology, Engineering, and Mathematics	Elizabeth Strickland, Sigma-Xi National Science Board Fellow
National Science Center	Micki Bowman, Executive Actions Officer
National Science Foundation	Julia Clark, Program Director Gerhard Salinger, Program Officer Karen Zuga, Program Officer
The New England Council	Julie Dawson, Mananger of Federal Affairs
North Carolina A&T State University	Miriam L. Wagner, Director of GEARUP
Office of Chief Scientist of the Army	Patricia Frazier, Army Educational Outreach Coordinator
Office of Minnesota Governor Tim Pawlenty	Chris Graham, Federal Affairs Specialists Billi Jo Zielinski, Deputy Director of Federal Affairs
OSS Associates	Howard M. Brown, Chief Executive Officer
Outreach George Lucas Education Fund (GLEF), Thornburg Center (TCPD.org), and National Institute for Community Innovations (NICI).reform.net	Bonnie Bracey Sutton, Independent Consultant, STEM specialist, Digital Divide expert

Parametric Technology Corporation	Ralph Coppola, Director of Worldwide Education Ronald Ray, Executive Advisor Anna Ring, Marketing Manager John Stuart, Senior Vice President
Pennsylvania Department of Education	Michael Golden, Deputy Secretary, Office of Information & Educational Tech Lenny Sweeney, Career and Technical Education Advisor
Project Lead The Way	Richard Blais, Vice President Niel Tebbano, Vice President
Puget Sound Center for Teaching, Learning, and Technology	Karen Peterson, CEO
Rhode Island Department of Education	Peter McLaren, Science and Technology Specialist
Science Communication Studies	Joan Aron, President
Science, Technology, Engineering, Mathematics Education Society (STEMES)	Jun Ni, Ph.D. M.E., President and Founder
SK Management, Inc.	Steven Kussmann, President
Society of Women Engineers	Semahat Demir, Director of External Affairs
Society of Women Engineers and American Society of Mechanical Engineers	Melissa Carl, Washington Representative
Software & Information Industry Association (SIIA)	Mark Schneiderman, Director of Education Policy
State Educational Technology Directors Association (SETDA)	Mary Ann Wolf, Executive Director
Stevens Institute of Technology	Beth McGrath, Director, Center for Innovation in Engineering & Science Education Liesl Hotaling, Assistant Director, Center for Innovation in Engineering and Science Education
Thornburg Center	Vic Sutton, Associate
TIES (Teaching Institute for Essential Science)	Jan Morrison, Executive Director
Triangle Coalition for Science and Technology Education	Vance Ablott, Executive Director
U. S. Department of Labor	Paul Lyons, Senior Executive Fellow for Engineering Entrepreneurship
U.S. Department of Education	Anthony Fowler, Director, Interagency Affairs
Universities Space Research Association	Constance Blackwood, Director of Education and Public Outreach

US Army Garrison, Fort Detrick	Edward Nolan, Director, Community Support Programs
Virginia Department of Education	Lynn Basham, Technology Education Specialist
Walter Reed Army Institute of Research	Martin Jett, Chief, Department of Molecular Pathology Debra Yourick, Associate Director, Research, Marketing and Policy Development

Appendix B: Facilitators Guide and Data Collection Forms

Forum on Taking Action Together: Developing a National Action Plan to Address the "T&E" of STEM

FACILITATORS GUIDE

Background: Forum Goals, Outcomes, and Deliverables

Goals

1. Raise awareness among stakeholders of the "T&E" of the STEM workforce challenge and the current activities and programs in place by stakeholder groups to address this issue.
2. Produce an action plan that includes two to five discrete and powerful activities or projects that participants identify as wanting to work on together to address the T&E of STEM workforce concerns, and identifies ways in which stakeholder groups will work together to leverage their own resources and/or seek additional funding to accomplish stated plans.

Outcomes

As a result of the September 7 workshop, attendees will:

- understand the broad implications of this country's insufficient production of T&E workers for the business, education, and government sectors, and articulate how surmounting this challenge aligns with the missions and best interests of their own organizations
- identify two to five projects that address these challenges in some way by leveraging the interdisciplinary, combined strengths of the group
- agree to participate in one or two of the communal projects, as defined by the group during the day's workshop, which will then be monitored and coordinated by the PTC-MIT Consortium

Deliverables

- Workshop materials, charts, and notes
- Action plans for two to five follow-up projects

Table of Contents

Morning Breakout Sessions Guide

Overview (Total Session Time: 90 minutes)

Breakout Groups

Individuals will select which breakout group to join, based on their organization type:

- Federal and state agencies and congressional staff—Facilitator: Lenny Sweeney
- Corporations—Facilitator: Ralph Coppola
- Professional societies and higher education—Facilitators: Jeff Hoffman, Norman Fortenberry
- K–12 education—Facilitators: Kendall Starkweather, Mila Fuller
- Groups serving underrepresented populations—Facilitator: Semahat Demir, Melissa Carl
- Informal science centers and community education programs—Facilitator: Patti Curtis

Session Goal

Develop a list of the top three priorities on which to take action to address this issue. These lists will be reviewed by the Synthesis Team (EDC and facilitators) during lunch, then combined and shared with the larger group to inform the afternoon's work and future actions of the Consortium.

Session Guiding Questions and Recommended Timing

Refer participants to the *Thinking/Planning Sheet* (on page 4), which they will have received in advance. You may wish to give the group some time at the beginning of the session to complete the sheet and then ask them to introduce themselves and answer Questions 1–3 all at once, or you may wish to have them go around the circle and answer the questions one at a time. *NOTE: The first question will serve as an introduction.*

The recommended amount of time for Questions 1–3 combined is 70 minutes, which breaks down like this:

1. Introduce yourself. Why is your organization interested in this problem, and how does it align with your organization's mission? (*~1 minute per person = 20 minutes)*
2. What specific programs are the best models you have seen to address this issue? Do you have data? (no need to specify, just answer yes or no) *(20 minutes total—10 minutes to complete the individual **Thinking/Planning Sheet** on page 4, and 10 minutes—~30 seconds per person—to share the information with the group)*
3. What's important that is not being addressed? *(~3 minutes per person = 30 minutes)*
4. From the list created in Question 3, what are your group's top three priorities to work on? *(~2 minutes per person = 20 minutes)*
   NOTE: If your group has difficulty narrowing the list to three, you can include up to five priority areas.

Information Gathering

- Each group will have a note-taker who will use the attached template to take notes on a laptop during the discussion and then give the completed notes to the Synthesis Team at the end of the session.
- In order to ensure the accuracy of the recommended programs or models, the note-taker will also collect the individual worksheets and supply them to the Synthesis Team.

How Information from This Session Will Be Used

The "action priority" and "successful models" lists from each breakout group will be reviewed by the Synthesis Team during lunch and used to inform the afternoon's work.

NOTE-TAKING TEMPLATE: Morning Breakout Sessions				
Breakout Group Name:				
Facilitator(s):				
Question 1		**Question 2**		**Question 3**
Organization	**Why Interested**	**Successful Programs/Models**	**Have Data? (Y/N)**	**What's Important That Is Not Being Addressed**

Question 4: From the list created in Question 3, what are your group's top three priorities to work on?

Morning Breakout Sessions: Thinking / Planning Sheet

Breakout Groups (by organization type): (1) Federal and state agencies and congressional staff, (2) corporations, (3) professional societies and higher education, (4) K–12 education, (5) groups serving underrepresented populations, and (6) informal science centers and community education programs

Session Goal
Develop a list of the top three priorities on which to take action to address this issue. These lists will be reviewed by the Synthesis Team (EDC and facilitators) during lunch, then combined and shared with the larger group to inform the afternoon's work and future actions of the Consortium.

Session Guiding Questions

1. Why is your organization interested in this problem, and how does it align with your organization's mission?
2. What specific programs are the best models you have seen to address this issue? Do you have data? (no need to specify, just answer yes or no)
3. What's important that is not being addressed?
4. From the list created in Question 3, what are your group's top three priorities to work on?

How Information from This Session Will Be Used
The action priority lists and thinking/planning sheets from each breakout group will be reviewed by the Synthesis Team during lunch and used to inform the afternoon's work.

Participant / Organization Name:

Breakout Group Name:

1. Why Interested	2A. Successful Programs / Models	2B. Have Data? (Y / N)	3. What's Important That Is Not Being Addressed

Afternoon Breakout Sessions Guide

Overview (Total Session Time: 90 minutes)

Breakout Groups (by Priority Action Area)
Three to five specific Priority Action Areas will have been determined by the Synthesis Team, using the results of the morning sessions. Participants will select which group they wish to join.

Afternoon Session Goal
To work in cross-sector groups to translate the priorities that emerged from the morning session into concrete plans of action. Each Breakout Group will develop one action plan that group members wish to pursue.

Afternoon Session Guiding Questions and Recommended Timing

1. Introductions *(15 minutes)*: Name; stakeholder segment you represent.

2. Cross-Sector Discussion *(15 minutes)*: What are some current programs, policies, or opportunities that impact this priority area, either directly or indirectly? (As a reference, each group will be provided with a master list of programs generated in the morning sessions. This is a chance for group members to share information across stakeholder boundaries, since they were separated during the morning sessions.)

3. *STRETCH BREAK (5 minutes)*: Tell participants to take a break and to start thinking about actions we could take that would have an impact.

4. Brainstorm *(15 minutes)*: What are some actions we could take that would impact this priority area? (Remind group members not to censor their own or others' ideas at this point; they will get the chance to evaluate during the next step.)

5. Narrowing *(15 minutes)*: Evaluate the brainstormed ideas and choose one on which to base the group's plan of action.

   NOTE: As facilitator, your goal is to guide your group members so that they produce a broad project plan with action steps, stakeholders, and a general timeframe (see Project Plan Template). The path you and your group take to get there is up to you. Two options are described below, but please feel free to use, alter, or ignore these options based on your own judgment, experience, and assessment of your group.

   - Option 1: Ask group members to look at the list of ideas and identify categories or themes that seem to be particularly important to this group. Use these emerging classifications to then pick the most promising actions and/or combine actions into a new one that the group can rally behind.
   - Option 2: Ask group members to consider the ideas with respect to such issues as feasibility, potential impact, and opportunities for funding. Then, depending on the number of brainstormed ideas, give each group member three to five "votes" that they can distribute across their favorite ideas or give to a single idea. Eliminate the ideas from consideration that receive the fewest votes and allow for discussion/advocating in between rounds of voting until one idea or a combination of ideas remains.

   NOTE: Strongly encourage group members to choose a single idea or to combine elements of different ideas into one, rather than splintering in support of multiple ideas.

6. Planning *(25 minutes)*: As a group, identify the ultimate goal(s) of the chosen action, the broad action steps needed to reach the goal, the stakeholders—both at this meeting and others—who need to be involved, and a general timeline (see Project Plan Template).

Information Gathering and Reporting Out

- Each group will have a note-taker who will use the attached template to take notes on a laptop during the discussion and then give the completed notes to the event coordinators at the end of the session.
- Each group should nominate a designated reporter who will outline the group's plan at the end of the session to all attendees. The reporter should mention (1) the ultimate goal of the group's project plan, (2) the action steps the group envisions, and (3) who else needs to be involved in order for the plan to succeed.

How Information from This Session Will Be Used

Following the forum, the PTC-MIT Consortium Steering Committeewill review the priorities and action plans to determine how the group can best proceed.

Afternoon Breakout Sessions Note-Taking Template

Priority action area:

Facilitator name:

What are some current programs, policies, or opportunities that impact this priority area, either directly or indirectly?

Programs/Policies/Opportunities	Impact on Priority Action Area

Brainstorm: What are some actions we could take that would impact this priority area?

Project Plan: What action idea (or combination of ideas) is the group's final choice?

Project Plan: What is the ultimate goal of the group's chosen action?

Project Plan: Action Steps	Stakeholders *(Who needs to be involved to ensure success?)*	Timeframe

Project Plan: Who are some potential funders?

Instructions: *Use this template as a guide to the planning portion of the afternoon sessions. Your group's note-taker will fill in the official version, which will be submitted to the PTC-MIT Consortium event coordinators for follow-up and coordination of activities. This copy is for your own reference during the discussion.*

Project Plan Template (Afternoon Breakout Sessions)		
Priority action area:		
What action idea (or combination of ideas) is the group's final choice?		
What is the ultimate goal of the group's chosen action?		
Action Steps	**Stakeholders *(Who needs to be involved to ensure success?)***	**Timeframe**
Who are some potential funders?		

Appendix C: Definitions of Key Terms

Computer Aided Design (CAD): (1) The use of a computer to assist in the process of designing a part, circuit, building or system. (2) The use of a computer to assist in the process of creating, storing, retrieving, modifying, plotting, and communicating a technical drawing in 2D or 3D.[1]

Design: An iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems.[2]

Design principle: Design rules regarding rhythm, balance, proportion, variety, emphasis, and harmony, used to evaluate existing designs and guide the design process.[3]

Design process: A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow down the possible solutions to one final choice.[4]

Education technology: "Educational Technology is concerned with technology *in* education. It is involved in the *use* of technology as a 'tool' to enhance the teaching and learning process across all subjects. Educational Technology is concerned about teaching and learning *with* technology."[5]

Engineer: "With a strong background in mathematics, the basic physical sciences, and the engineering sciences, the engineer must be able to interrelate engineering principles with economic, social, legal, aesthetic, environmental and ethical issues, extrapolating beyond the technical domain. The engineer must be a conceptualizer, a designer, a developer, a formulator of new techniques, a producer of standards—all to help meet societal needs. The engineer must plan and predict, systematize and evaluate—must be able to judge systems and components with respect to their relation to the health, safety and welfare of people and to the loss of property. Innovation must be central to the engineer."[6]

Engineering: The profession of or work performed by an engineer. Engineering involves knowledge of the mathematical and natural sciences (biological and physical) gained by study, experience, and practice that are applied with judgment and creativity to develop ways to use the materials and forces of nature for the benefit on mankind.[7]

Engineering design: The systematic and creative application of scientific and mathematic principles to practical ends, such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.[8]

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[1] ITEA (International Technology Education Association), *Standards for Technological Literacy*, 2002, p. 236.
[2] Ibid., p. 237.
[3] Ibid.
[4] Ibid.
[5] ISTE (International Society for Technology in Education), *National Educational Technology Standards*, 2000.
[6] *Engineering Education and Practice in the United States: Engineering Infrastructure Diagramming and Modeling*, National Academy Press, Washington, DC, 1986. p. 238
[7] Ibid.
[8] Ibid.

Engineering technician: "[Engineering technicians usually have a] minimum of two years of post secondary education. Ideally in engineering technology, with emphasis in technical skills, the engineering technician must be a doer, a builder of components, a sampler and collector of data. The technician must be able to utilize proven techniques and methods with a minimum of direction from an engineer or engineering technologist. He/she shall not be expected to make judgments, which deviate significantly from proven procedures. The technician should be able to conduct routine tests, present data in a reasonable format, and be able to carry out operational tasks following well-defined procedures, methods and standards."[9]

Engineering technologist: "The Engineering technologist must be applications-oriented, building upon a background of applied mathematics through the concepts and applications of calculus. Based upon applied science and technology, the technologist must be able to produce practical, workable results quickly; install and operate technical systems; devise hardware from proven concepts; develop and produce products; service machines and systems; manage construction and production processes; ands provide sales support for technical products and systems."[10]

Engineering technology: "[Engineering Technology] is that part of the technological field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupation spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer."[11]

Global Engineering: Global Engineering is an approach to manufacturing that facilitates rapid iteration and innovation necessary for successful product development. It employs geographically distributed product or system design; configuration or combination of separately designed components into systems; collaboration cross diverse functional divisions or organizations; communication and effective decision-making; control and management of product information and product development processes that reduce product costs and deliver products to market faster.[12]

Innovation: "An improvement of an existing technological product, system or method of doing something!"[13]

Instructional technology: The use of computers, multimedia, and other technological tools to enhance the teaching and learning process, sometimes referred to as "educational technology."[14]

Problem-solving: The process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem or meet a need or want.[15]

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[9] Ibid., pp. 76–77.
[10] *Engineering Education and Practice in the United States*, p. 75.
[11] Ibid.
[12] Gerdes, Victor B. P.E., CRITICAL CAPABILITIES FOR SUCCESSFUL DISTRIBUTED COLLABORATIVE PRODUCT
DEVELOPMENT, Proceedings of DETC 2004:ASME 2004 International Design Engineering Technical Conferences and The Computers And Information In Engineering Conference, Salt Lake City, Utah USA, September 28–October 2, 2004
DETC2004-57731.
[13] ITEA, *Standards for Technological Literacy*, 2001. p. 239
[14] Ibid.
[15] Ibid., p. 240.

Process: (1) Human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems. (2) A systematic sequence of actions that combine resources to produce an output.[16]

Technological fluency: The capacity to use technology at a high level of proficiency to address or solve problems.

Technological literacy: The ability to use, manage, understand, and assess technology.[17]

Technology: (1) Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. (2) The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.[18]

Technology Education: A study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities.[19]

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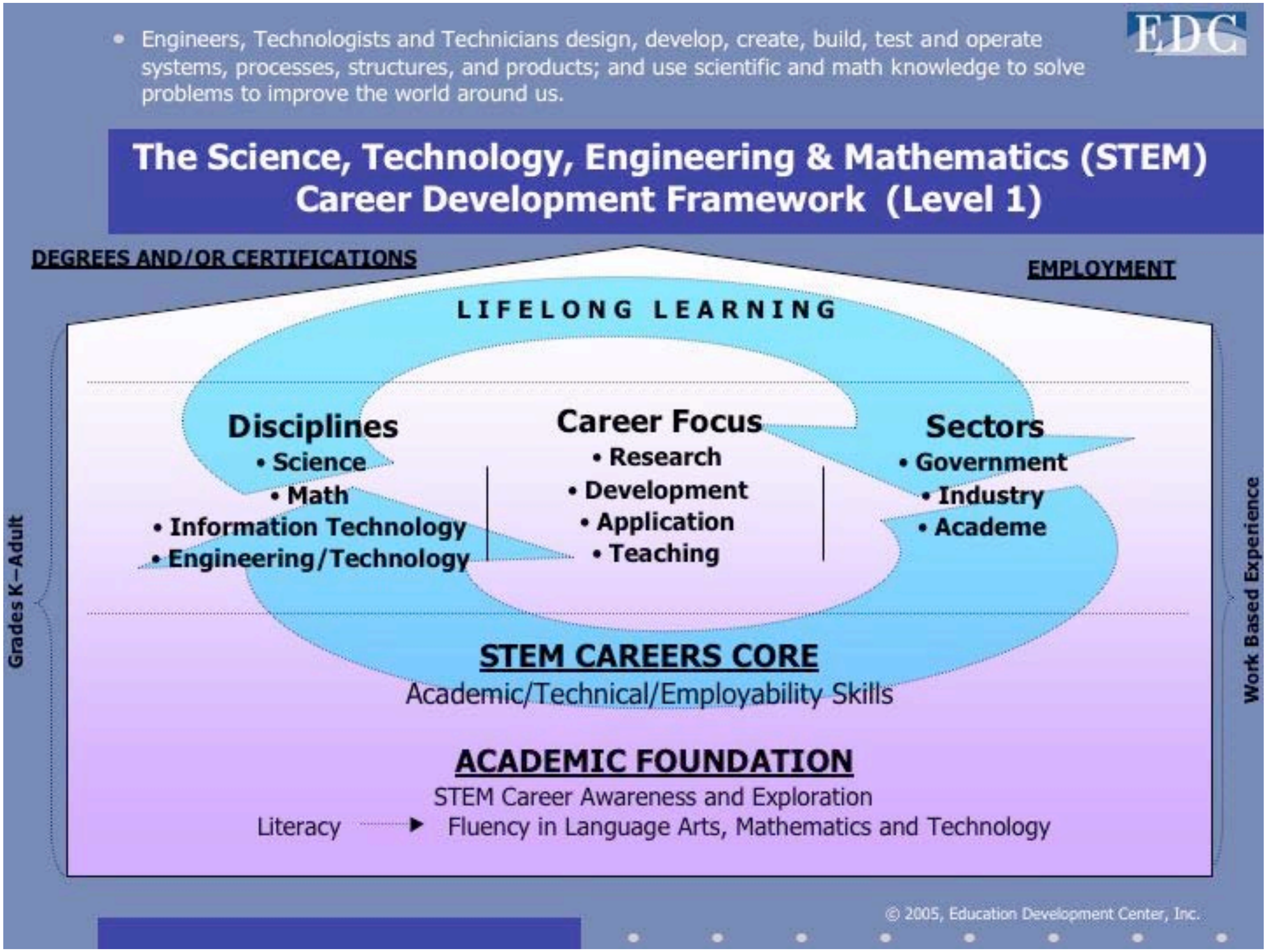
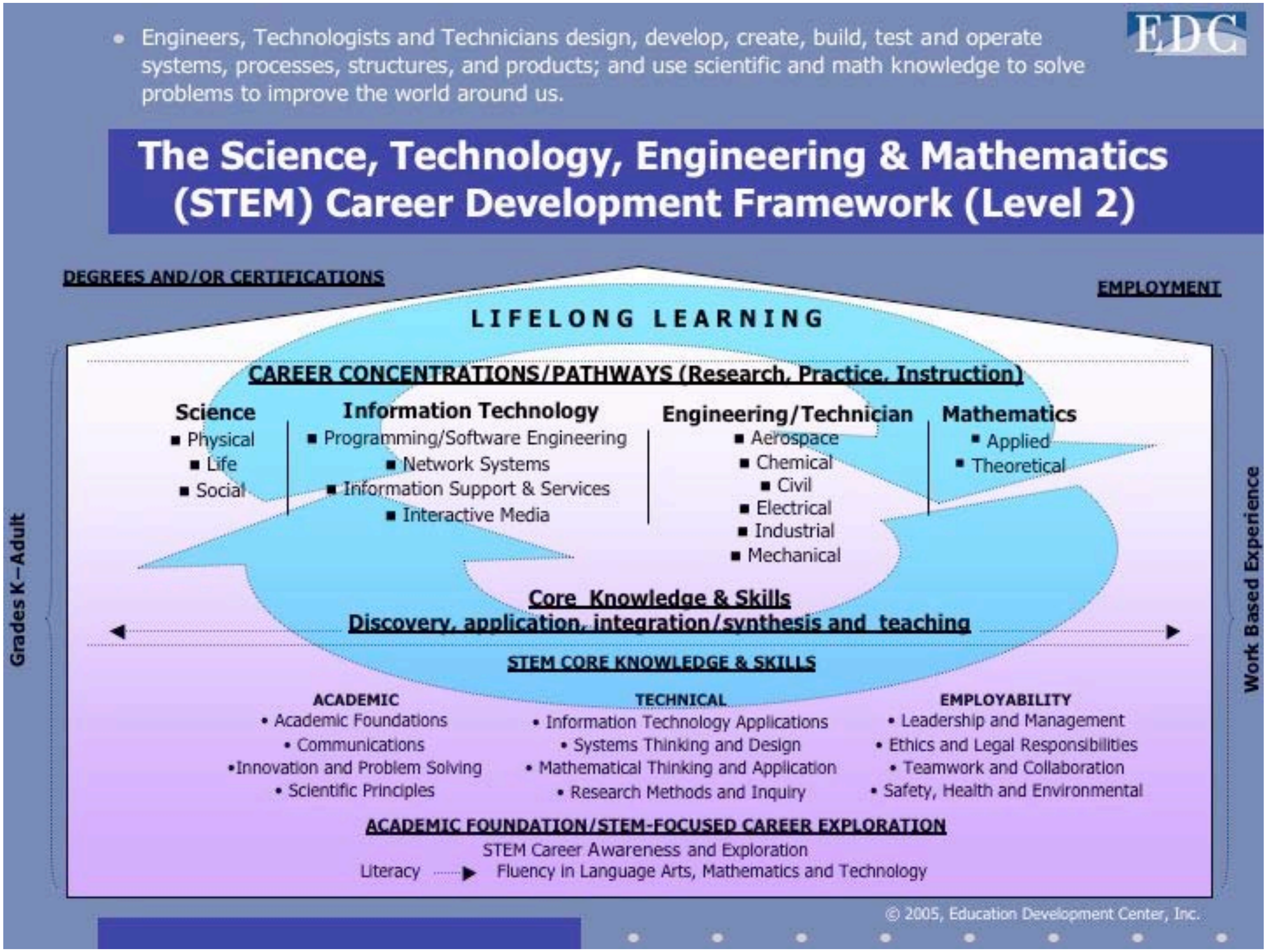
[16] Ibid.
[17] Ibid., p. 242.
[18] Ibid. P. 242

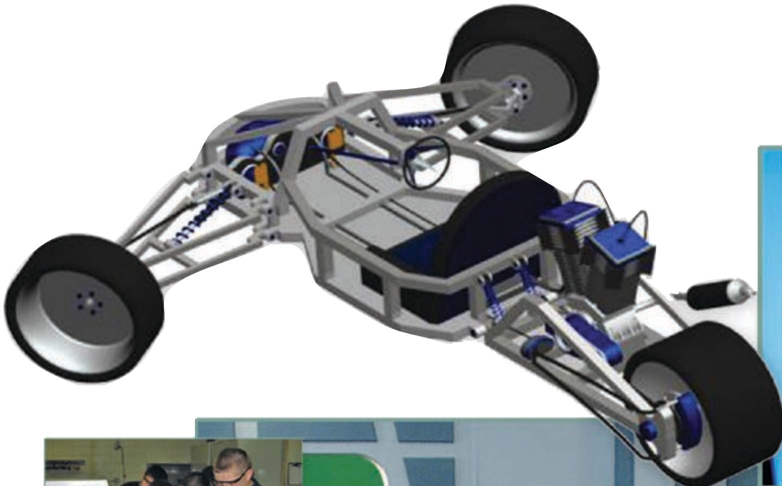
[19] "Dugger, W. & Naik,, N., "Clarifying Misconceptions between Technology Education and Educational Technology" in *The Technology Teacher*, Sept. 2001, P. 31

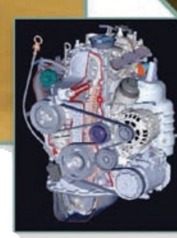
Appendix D: STEM Career Development Model




• Engineers, Technologists and Technicians design, develop, create, build, test and operate systems, processes, structures, and products; and use scientific and math knowledge to solve problems to improve the world around us.
EDC
The Science, Technology, Engineering & Mathematics (STEM) Career Development Framework (Level 2)
DEGREES AND/OR CERTIFICATIONS
EMPLOYMENT
LIFELONG LEARNING
CAREER CONCENTRATIONS/PATHWAYS (Research, Practice, Instruction)
Science
■ Physical
■ Life
■ Social
Information Technology
■ Programming/Software Engineering
■ Network Systems
■ Information Support & Services
■ Interactive Media
Engineering/Technician
■ Aerospace
■ Chemical
■ Civil
■ Electrical
■ Industrial
■ Mechanical
Mathematics
■ Applied
■ Theoretical
Core Knowledge & Skills
Discovery, application, integration/synthesis and teaching
STEM CORE KNOWLEDGE & SKILLS
ACADEMIC
• Academic Foundations
• Communications
•Innovation and Problem Solving
• Scientific Principles
TECHNICAL
• Information Technology Applications
• Systems Thinking and Design
• Mathematical Thinking and Application
• Research Methods and Inquiry
EMPLOYABILITY
• Leadership and Management
• Ethics and Legal Responsibilities
• Teamwork and Collaboration
• Safety, Health and Environmental
ACADEMIC FOUNDATION/STEM-FOCUSED CAREER EXPLORATION
STEM Career Awareness and Exploration
Literacy → Fluency in Language Arts, Mathematics and Technology
Grades K–Adult
Work Based Experience
© 2005, Education Development Center, Inc.

Preparing for the Perfect Storm by supporting the "T&E" of STEM





PTC-MIT Consortium