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NGA Center for
BEST PRACTICES

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THE NATIONAL GOVERNORS ASSOCIATION (NGA), founded in 1908, is the instrument through which the nation's governors collectively influence the development and implementation of national policy and apply creative leadership to state issues. Its members are the governors of the 50 states, three territories and two commonwealths.

The NGA Center for Best Practices is the nation's only dedicated consulting firm for governors and their key policy staff. The Center's mission is to develop and implement innovative solutions to public policy challenges. Through the staff of the Center, governors and their policy advisors can:

- quickly learn about what works, what doesn't, and what lessons can be learned from other governors grappling with the same problems;
- obtain specialized assistance in designing and implementing new programs or in making current programs more effective;
- receive up-to-date, comprehensive information about what is happening in other state capitals and in Washington, D.C., so governors are aware of cutting-edge policies; and
- learn about emerging national trends and their implications for states, so governors can prepare to meet future demands.

For more information about NGA and the Center for Best Practices, please visit www.nga.org.

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INTRODUCTION: The Importance of STEM Education

Across the country, governors and other state policymakers are coming to recognize the urgent need to dramatically increase student achievement and attainment in K–12 science, technology, engineering, and mathematics (STEM). These STEM fields play an increasingly critical role in ensuring states' economic vitality and the economic growth of the nation as a whole. Every high school graduate needs essential competencies in STEM as preparation for postsecondary education, work, and citizenship. Regardless of the path they choose after high school graduation, all K–12 students can benefit from a rigorous and relevant STEM education.

As part of the *Innovation America* initiative, the National Governors Association (NGA) issued a policy guide for governors on K–12 STEM education, *Building a Science, Technology, Engineering, and Math Agenda*, in February 2007. The guide recommended that governors lead efforts in their states to:

1. Align state K–12 standards, assessments, and requirements with postsecondary and workforce expectations for what high school graduates know and can do;
2. Examine and increase the state's internal capacity to improve teaching and learning, including the continued development of data systems and new models to increase the quality of the K–12 STEM teaching force; and
3. Identify best practices in STEM education and bring them to scale, including specialized schools, effective curricula, and standards for Career and Technical Education (CTE) that prepares students for STEM-related occupations.

These policy recommendations are to support states in reaching the goal of graduating every student from high school with the essential STEM knowledge and competencies to succeed in postsecondary education and work. This requires schools with challenging math and science courses for every student that emphasize how math, science, and technology shape our world and where faculty and students work “outside the school walls” to investigate solutions to real world problems. These schools will prepare all students for success after high school, regardless of whether they specialize in STEM fields or not.

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A state with an effective STEM policy agenda uses its funding and statutory authority to set academic content standards, required assessments, and high school graduation requirements that are aligned across the K–12 level and with postsecondary and workforce expectations; establish content-rich teacher preparation and certification requirements that are aligned with K–12 needs; develop new models of curricula that support effective K–12 STEM classrooms and schools; and focus investments on what works.

For governors, legislators, and other state policymakers seeking to develop and implement effective STEM policy agendas, there is no higher priority than getting their constituents to wake up to the realities of the globalized, technology-driven age. The public and stakeholder groups must be made to understand that the mission of improving K–12 STEM education for all students is not merely important, it is *extraordinarily* pressing, and the success or failure of that mission will have lasting consequences for America's economic and social well-being. Not only is this the sort of issue that the bully pulpit exists to promote, but at the present time, the bully pulpit could be put to no greater use.

NGA recognizes that communications is a critical element to building an effective STEM agenda. NGA recommends that governors lead the development of a communications strategy to engage the public in the urgency of improving STEM. The six states that received NGA STEM Center grants in July 2007 are each required to “create and execute a communications plan to build and sustain public support for K–12 STEM education redesign and improvement that will help secure the state's economic future.” NGA has prepared this Communications Toolkit to help governors and their staffs successfully promote policy efforts to improve K–12 STEM education across the country.

As governors move this important STEM policy agenda forward, they may find that some of their constituents have yet to be persuaded of the need for improvement. Some citizens and stakeholders may fail to grasp the strong link between high-quality STEM education and economic development in the state. Others may question the value of rigorous and relevant STEM courses for high school students who do not intend to pursue science- or math-intensive careers. And still others may believe that STEM education should be reserved for only the most advanced students. All of these message barriers can and must be addressed.

This toolkit provides core messages, materials, and communications strategies to help governors overcome such challenges and build strong support for STEM education initiatives. These strategies draw from Dr. Frank Luntz's research findings — which he presented to the nation's governors as part of the NGA *Innovation America* initiative — on the messages and ideas about innovation that most strongly resonate with the public.

INTRODUCTION: The Importance of STEM Education

Given that every state has its own unique set of policy challenges and considerations, we encourage each governor to adapt these materials to his or her STEM policy agenda and include state-specific data and information. The toolkit is not meant to provide an inflexible script; rather, it offers a number of resources and approaches designed to help governors and their policy partners craft a communications strategy that will serve their particular needs, enabling governors to engage and educate individuals across the state about STEM education, how the state's STEM policy agenda complements existing education programs, and how high-quality STEM education for all students fosters both the educational and economic health of the state and its regions.

Further, the NGA Center for Best Practices and the NGA Office of Communications are committed to providing governors with ongoing technical assistance in policy development and communications as state policymakers adapt this toolkit to support their K–12 STEM policy agendas.

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STEM Education Strategic Planning

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Expected Outcomes of a STEM Communications Effort

This toolkit is designed to support governors in communicating the need to provide a high-quality STEM education for all K–12 students, based on NGA's policy recommendations regarding STEM, and the long-term benefits of such an effort for each state's education and economic future.

Successful implementation of a STEM education communications effort can achieve far-reaching results, helping to:

1. Position the state as a leader in the nation and the world in innovation, economic and workforce development, and educational improvement by effectively instituting a K–12 STEM education initiative;
2. Establish a network of supporters and advocates who can help the governor integrate his or her K–12 STEM education policy agenda into current education policy and ongoing education reform activities;
3. Demonstrate the benefits of rigorous and relevant STEM education for all students for stakeholder groups as well as the state;
4. Ensure that the media cover STEM education reform efforts to encourage the adoption of innovative approaches to improving K–12 education and preparing the state for the evolving global economy;
5. Position the governor as the leading voice in the state on K–12 STEM education and economic improvement activities and the primary resource for the media and key stakeholders; and
6. Create a supportive state policy framework as a key foundation to successful K–12 STEM education redesign, based on the policy recommendations for governors in the NGA guide *Building a Science, Technology, Engineering, and Math Agenda*.

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Core STEM Education Communications Strategy

Governors need a strategic communications plan detailing specific messages, materials, and tactics that can be employed to help build support for a statewide STEM education initiative. The following strategies are designed for easy adaptation in a state in an efficient and straightforward fashion. Following this core communications strategy are specific recommendations on communications tactics as well as examples of specific documents and materials.

1. IDENTIFY TARGET AUDIENCES

The target audiences for this communications strategy can include:

- Local policymakers (at the city, county, and state levels);
- School district superintendents, school principals, and other administrators;
- Business community (regional and statewide);
- STEM-specific education organizations (e.g., state affiliates of the National Science Teachers Association);
- K–12 educators (including classroom teachers and others in supportive roles);
- Higher education community (including community colleges as well as four-year colleges and universities);
- State boards of education and education agencies;
- Students and families (including parent-teacher organizations); and
- News media (e.g. local and state newspaper reporters; political and metro columnists; editorial boards; broadcast public affairs producers and reporters; trade journals and magazines; community publications).

It is difficult for communications efforts to reach all audiences with equal strength. Therefore, it is important for governors to first prioritize the top three to five target audiences for their STEM initiative, which will then help guide the development of messages, selected strategies, and tactics. Primary audiences should be identified based on their ability to help implement STEM education efforts across the state (e.g., the business and higher education communities). Messages and activities will first focus on those primary audiences, with secondary audiences added into the initiative as work moves forward.

2. TARGETED RESEARCH

Effective communications begins with a thorough understanding of the audiences and environments in which they operate. To obtain this information before launching a STEM education communications effort, governors can conduct qualitative and quantitative research to determine primary stakeholders and their preferences, effective messages and materials, and general public opinion benchmarks. Such research tactics could include:

- **Quantitative survey** — A poll of the general public and/or specific stakeholder audiences. This series of questions can be conducted by telephone or online, and can be used to determine the baseline of STEM education understanding in the state.
- **Focus groups** — Focusing on specific stakeholder audiences, these discussion groups can provide deep insight behind the data provided during a survey. They can also be used to test specific communications tactics and the effectiveness of messages and communication products.
- **One-on-one discussions** — To supplement the focus groups, one can also conduct a series of one-on-one discussions with key audience leaders, such as corporate executives, college and university presidents, state government officials, and school district superintendents. These conversations allow for deeper insight into how specific thought leaders in the state view STEM education and its effect on the economy and the community.

One or all of these research approaches can be used to inform both the communications and policy development components of the governor's STEM education agenda, providing a ground-level perspective on current STEM programs and opportunities for building support for STEM efforts across the state.

3. DEVELOP MESSAGES

In the “Stem Messaging” section of this toolkit, we recommend general and audience-specific messages on the importance of rigorous and relevant STEM education for all students. Governors and their staff must develop messages that are appropriate to the priority target audiences.

4. DEVELOP MATERIALS

Before embarking on a communications effort to effectively promote a STEM education initiative, the governor's office should consider developing a number of collateral materials.

Since a rigorous and relevant STEM education system is a shared responsibility of the governor, state agencies, the business community, K–12 educators, the higher education community, parents, students, and the public, these additional stakeholders may be persuaded to help develop and disseminate those materials or to develop additional ones that will resonate with their specific audiences.

Communications materials may include:

- Media releases (see pages 25–33 for specific examples);
- Media kits (including all available informational materials);
- New media materials (see pages 9–10 for specific examples); and
- News clippings on governor-led STEM education efforts to date.

5. OUTREACH THROUGH TRADITIONAL MEDIA

Most communications professionals view traditional media as those newspapers (daily and weekly), magazines and similar print periodicals, radio stations, and television (and cable) stations that have delivered information to our communities for decades. The traditional communications tactics and activities available to governors include:

- A public announcement of STEM education initiatives, with related media outreach. These kick-off events and related news conferences provide a critical opportunity to bring on board key stakeholders (including legislators; the state schools chief; prominent business, higher education, and community leaders; and teachers and students) and to use their participation to show the public that the new initiatives have strong and widespread support from the outset.
- Frequent media events highlighting ongoing STEM education successes and specific activities happening in schools, communities, and businesses throughout the state. *For additional information on promoting STEM education through public events, see pages 11–13.*
- Ongoing media updates and publication of op-ed pieces and letters to the editor, allowing the governor’s message to reach key audiences virtually unfiltered by the media. *For sample media releases, see pages 25–33; for sample op-ed pieces highlighting the full impact of STEM education, see pages 35–40. A specific example of a STEM media update in Massachusetts can be found at <http://www.doe.mass.edu/research/reports/1007stem.pdf>.*

- One-on-one outreach to and speaking engagements at key organizations such as the Chamber of Commerce, state teachers union, STEM teachers associations, and the PTA to build continued support from priority audiences. *For examples of such speaking opportunities, please see recent STEM summits held in Minnesota (<http://education.state.mn.us/mdeprod/groups/Communications/documents/Announcement/011043.pdf>) and Massachusetts (<http://www.massachusetts.edu/stem/index.html>).*
- Recruitment of third-party advocates for STEM education efforts, such as regional business leaders, university presidents, and celebrities to provide greater acceptance throughout the community. *An example of such efforts can be found in Arizona, where Apple supports the state's STEM programs as a co-sponsor of the "How can you improve your world through innovation" video contest, found at <http://edcommunity.apple.com/innovation/contest.php>.*

6. OUTREACH THROUGH NEW MEDIA

In recent years, new media has played a prominent role in disseminating information to key audiences. Commonly defined as Internet-based media, new media has evolved from traditional Web sites a decade ago into a full portfolio of information sources, including blogs, YouTube, podcasts, MySpace, and other electronic tools, including official state Web sites.

Since 2002, the number of adults who say that the Internet has played a major role in their career pursuits has risen 50 percent. In the past two years alone, 60 million Americans have turned to online resources to help them make at least one major life decision. Given such extraordinary growth, governors' communications strategies should include the creative use of new media tactics. Examples include:

- **Enhanced state Web sites.** Information about STEM education and its benefits should be consistent across various state government Web sites, including the governor's home page and the sites of agencies such as the Departments of Education and Workforce Development. To sustain audience interest, it is important to include features that can be updated on regular basis (such as a STEM news ticker or a blog on STEM-related developments in the state). Sites also should include buttons that direct specific audiences to targeted messages and content. For example, parents and students might be directed to information on STEM-related careers, college and technical training programs, community partnerships, and scholarship opportunities. *Some states have chosen to dedicate new Web sites to their STEM initiatives, such as Minnesota (<http://www.mn-stem.com/>), Indiana (<http://www.istemnet-work.org/>), and Ohio (<http://www.ohiostem.org/>)*

Governors can also bring together several key stakeholders to develop specific Web sites focused on STEM as a key part of college and work-force readiness and opportunity. Scholastic developed an innovation site (<http://www.youinnovate21.net>) in partnership with NGA and Arizona Governor Janet Napolitano as part of NGA's **Innovation America** initiative.

- **Online messages on STEM.** Public service announcements (PSAs) can be placed on Web sites that serve very specific audiences (e.g., sites focusing on teen culture or sites catering to parents of young children). Online PSAs are an affordable and effective way to reach select audiences. *An example of a parent-targeted PSA is available from the American Association for the Advancement of Science (www.try-science.org/parents/video/science.mov).* To generate interest in STEM education among students, governors can consider sponsoring a student video PSA contest to show the place of STEM-related innovations in school, work, and everyday life. Such a competition might be co-sponsored (and prizes underwritten) by an organization such as a local technology firm, museum, or zoo. Judges might include the governor, the state schools chief, a veteran teacher in a STEM field, the state's "teacher of the year," and a professional or celebrity working in a STEM discipline. Winning PSAs could be posted on state and business STEM Web sites and shown in public schools. Such efforts energize audiences and trigger active — rather than passive — involvement from those the governor is trying to reach. *Arizona and Apple, Inc. are currently co-sponsoring a similar competition for students, asking them to share their answer to the question: "How can you improve your world through innovation" in a 45-second video. More information can be found at <http://edcommunity.apple.com/innovation/contest.php>.*
- **Student and/or professional blogs and podcasts.** These can be used to engage audiences in an ongoing, two-way discussion of STEM-related topics. For example, bloggers may ask readers to send descriptions of innovative class projects that teachers have used in physics, algebra, or other STEM-related courses. Or they might interview working professionals — such as software engineers, doctors, and video-game designers — about the nature of their careers and the educational pathways that led them there. Blogging software (such as WordPress and Typepad) is relatively inexpensive and easy to use, as is the software used for producing podcasts (some, such as Audacity, can even be downloaded for free). *Florida Governor Charlie Crist does a weekly Audio and Podcast, which can be found at <http://www.click-caster.com/charliecrist>.*

7. PROMOTING STEM EDUCATION THROUGH PUBLIC EVENTS

There are three legs to the 21st century communications stool. The first two — reaching the traditional media and new media — are detailed on pages 8–10 of this toolkit. The third leg is communicating messages directly to audiences at public events. What events and activities can governors participate in that will effectively reach audiences on the importance of STEM to them?

Specific public events the governors can consider include:

Community Forums and Town Hall Meetings

Such sessions allow the governor to deliver his or her message on STEM education directly to citizens, with no filter or editorial commentary. Hosting town hall meetings on STEM education allows the governor to engage educators, community and business leaders, parents, and local policymakers on this important issue, while demonstrating that all stakeholders play a role in the development and implementation of a high-quality STEM education initiative. *Many states already hold town hall meetings on other subjects. For example, as part of its NGA Honor States grant Arkansas held multiple meetings to discuss how to work together to help the schools address areas that need improvement (<http://arkedu.state.ar.us/commemos/custview.cgi?filename=3577>).*

Partner Meetings

As has been discussed throughout this document, a rigorous and relevant STEM education for all students is a shared responsibility of a wide range of stakeholders across the state. To ensure the buy-in and ongoing support of these stakeholders, the governor can participate in regular meetings with partners across the state, updating them on STEM education efforts and highlighting how they can continue to be involved. For instance, the governor can call on the semiconductor industry to work more closely with K–12 educators on STEM education efforts, can encourage K–12 and postsecondary institutions to strengthen their relationships on STEM education and college readiness, or can work with the real estate industry to highlight strong local STEM education as a selling point in home sales. These discussions can occur at regularly scheduled conferences and meetings of such partners or can be arranged separately to discuss STEM efforts.

Speeches

STEM education casts a wide shadow, with real impacts on and benefits for K–12 education, higher education, workforce development, economic development, and other areas critical to a state. Following the launch of a STEM initiative, the governor and other state officials should, where

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appropriate, refer to STEM in public speeches, thus strengthening the linkages between STEM education and a given issue with the media, the general public, and specific audiences. *Examples of such speeches can be found on page 41 of this toolkit and at <http://www.mauinews.com/story.aspx?id=27204>.*

Conference Presentations

As the governor begins identifying tangible results from the state's STEM education efforts — increased high school graduation rates, lower unemployment rate, or similar measurements — he or she has the opportunity to tell that story at conferences and public events. Focused on state or regional conferences, the governor — along with educators and business leaders — can detail the action steps taken and the results achieved as a result of the STEM education initiative. Such events could include educator conferences, corporate gatherings, community based organization meetings, and philanthropic discussions, particularly of those groups in partnership with the governor in the STEM initiative. *An example of this tactic can be found at <http://www.edfunders.org/programs/conference/Wednesdaybreakouts.asp#dide>, which highlights a presentation from the New Mexico lieutenant governor at the Grantmakers for Education Eleventh Annual Conference.*

Press Conferences

The governor can look to include STEM education in regular press conferences and briefings. Citing the importance of STEM education in answers to school improvement or economic development questions keeps the issue top of mind. On occasion, the governor may hold a press conference on the specific topic of STEM education. *An example of this is the Minnesota Department of Education's 2006 announcement of the Regional Forums to Improve Science, Technology, Engineering and Math (STEM) Education (<http://education.state.mn.us/mdeprod/groups/Communications/documents/Announcement/011146.pdf>).*

Corporate Site Visits

As the state's economic developer in chief, the governor is often asked to attend plant opening and expansion ceremonies. During these public events, the governor has an ideal platform to discuss STEM education and its impact on continued economic growth and job creation. It is clear that STEM education and economic development are closely joined, with success in one area generating success in the other. Because of this, it is important for the governor to regularly discuss STEM education as a pathway to economic development. These visits provide such an opportunity. Similarly, the governor can partner with leading companies to promote upcoming STEM education activities. *An example of working with businesses can be found at*

http://www.biospace.com/news_story.aspx?NewsEntityId=66369, which announces corporate partnerships to promote Pennsylvania's STEM Education Summit.

K–12 School Visits

The governor makes regular visits to K–12 schools across the state, charting school progress, discussing innovative programs, and highlighting the importance of a strong education. As part of these visits, the governor can discuss STEM education and the opportunities it provides to the state's students. Focusing on career aspirations and economic growth opportunities in the state, the governor can link classes of today with careers of tomorrow. *An example of such visits can be found at <http://www.highbeam.com/doc/1G1-144727802.html>, which highlights Missouri Governor Matt Blunt's visit to Lee's Summit West High School.*

Community College Visits

Many of today's employers and their employees turn to community colleges for job retraining and support for career changes. Many community colleges are partnering with high schools to offer high quality career and technical education (CTE) pathways to STEM-related occupations. When visiting these colleges, the governor can focus on the changing economy and the new skills today's workers need. *An example of recognizing the role of community colleges can be found at <https://www.governor.virginia.gov/MediaRelations/NewsReleases/viewRelease-print.cfm?id=243>, where Virginia Governor Tim Kaine recognizes top community college students in the state.*

Business Summits

Once a year, the governor can bring together business leaders and organizations to discuss the future of the state's economy. Focusing on a highly skilled workforce, the governor can discuss STEM education efforts and how they are effectively training today's students for the growth industries across the state. Business leaders can highlight successful partnerships with the schools.

Webcasts

Building off of the success of other online efforts pursued by the governor's office, the state can host a series of webcasts on STEM education, making meetings and events available to stakeholders via the Internet. Publicized prominently and in advance, these webcasts can exponentially expand the reach of all communications activities.

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STEM Education Message Development

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STEM Education Core Message Map

As governors around the nation ramp up their STEM education policy efforts, the NGA Center for Best Practices has prepared a set of core talking points that can be adapted for your communications activities. Wherever possible, we recommend that you identify and use specific data points related to your state to help support these core messages. Those statistics can help support and champion the need for rigorous and relevant STEM education for all students in the state and the specific STEM policy agenda you may pursue.

Following these core talking points, you will find recommendations on how best to tailor these messages to specific audiences.

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STEM provides education and economic opportunity, both now and into the future**KEY MESSAGE 1**

STEM education prepares *all students* for the challenges and opportunities in the 21st century economy.

KEY MESSAGE 2

STEM education improves the impact and overall effectiveness of the state's K-16 education system.

KEY MESSAGE 3

A STEM-literate workforce adds value, productivity, and innovations to the state's economy.

SUPPORT POINT 1-1

As technology becomes more sophisticated, and as more nations compete with the United States in the global economy, the next generation of students must be well-grounded in STEM to succeed economically.

SUPPORT POINT 2-1

Rigorous and relevant STEM education improves student achievement in all subjects and helps teach problem-solving, critical thinking and collaborative skills to all students.

SUPPORT POINT 3-1

STEM-literate workers help create a culture of innovation in business, reinvent business models and strategies, and create new products and processes — all critical components in economic development.

SUPPORT POINT 1-2

The need for more rigorous and relevant STEM education is clear: American high school students trail behind many of their international peers in achievement. The 2006 PISA ranks U.S. 15-year-olds 24th in math and 19th in science among the 29 OECD nations.

SUPPORT POINT 2-2

More and more leaders in sciences, business, and education tie the United States' abilities to innovate and compete in the global economy to the public schools' ability to educate all students in STEM.

SUPPORT POINT 3-2

The future of our economy depends on cutting edge, innovative workers with high-end STEM knowledge and skills.

SUPPORT POINT 1-3

Studying STEM will better prepare high school students for work. Industry surveys demonstrate that many 21st century careers will require an understanding of math, science, technology, and engineering and the problem-solving, critical thinking and adaptive skills gained through STEM.

SUPPORT POINT 2-3

STEM education ensures all students are equipped with the knowledge and skills to succeed in college and career. Rigorous and relevant STEM courses encourage greater student involvement in the learning process, equipping students for future education and work.

SUPPORT POINT 3-3

If we as a nation and as states are to continue to compete in the global economy, we need to "out innovate" the competition. STEM education is a key building block to that innovation process.

Tailoring STEM Education Messages for Specific Audiences

The need for rigorous and relevant STEM education for all students should be seen as critical for a wide range of stakeholders, from parents and students to educators, policymakers, employers, and employees. However, surveys by Public Agenda show, for example, that parents and students understand the general importance of STEM but do not believe it relates to them (see http://www.kauffman.org/pdf/important_but_not_for_me.pdf). Each of these audiences has its own set of interests and expectations and must be communicated with differently. For some, such as parents and general citizens, STEM must be presented in terms of its role in the development of well-rounded young people. For others, such as employers and legislators, the need for more rigorous and relevant STEM education for all students is most compelling when portrayed as a way to fill critical shortages in the labor pool or to lay the groundwork for economic development across the state. The challenge is to develop messages that appeal not just to the public in general but to each of these stakeholder groups as well.

KEY AUDIENCES

In particular, governors should consider tailoring messages for these audiences:

- **Teachers and School Administrators** — With educators, the core message is that every K–12 student benefits from a rigorous and relevant education in science, technology, engineering, and math. Governors, other policymakers, and business leaders need to make clear in the message and in policy that educators will receive support in improving STEM for all students and show how doing so will make schooling more interesting and relevant for their students.
- **Business Community** — With the business community, the core message is that effective STEM education for all students ensures a well-trained and economically competitive workforce. Businesses across the state need to understand the positive impact that high-quality STEM education will have on the quality of *their* employees and also need to be advocates for the governor's STEM policy agenda.
- **Higher Education Administrators and Faculty** — With colleges and universities, the core message is that high-quality STEM education improves the college readiness of all high school graduates. Across the nation, postsecondary institutions are playing a leading role in helping grow a workforce to fill high-wage, high-skill STEM-related jobs. Governors should work with their higher education institutions to

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ensure that STEM education policy efforts at the elementary and secondary levels are aligned with postsecondary entrance requirements and expectations. Higher education leaders and faculty need to see state support for their role in preparing effective STEM teachers for the public schools.

- **State Legislators and Local Elected Officials** — With state and local officials, the core message is that high-quality K–12 STEM education for all students is a key to economic growth in all regions of the state. These officials can help local businesses link with local education institutions to ensure students are gaining the training and knowledge needed to fill current and future worker needs.
- **Parents and Students** — The core message for students and their parents is that STEM education prepares all students for success in school and career. Governors should lead in encouraging students to take rigorous and relevant STEM coursework as a gateway to interesting and financially rewarding occupations and encouraging parents to advocate for high-quality STEM education as a key to their child’s future.

It is important to recognize that some audiences may push back against the term “STEM.” While it is the vernacular currently used by those involved in such efforts, it is an acronym that may be unknown or unclear to some audiences governors are trying to reach. Phrases like “science and math education” can and should be used to ensure messaging is effective and well-received by key audiences.

KEY CONNECTIONS

When reaching out to the above audiences, the governor may wish to link the improvement of STEM education to a range of other public policy priorities. These important connections include:

STEM and Higher Education

STEM education efforts prepare K–12 students for the rigors of postsecondary education. Through STEM coursework, students learn of new academic and career opportunities they can pursue, many of which were previously unknown to them. STEM education is another tool to successfully link secondary and postsecondary education in the state, strengthening the governor’s P-16 or P-20 education council. Higher education also prepares most of the STEM teachers for the state’s public schools.

STEM and Economic Development

STEM education helps produce a workforce prepared for the challenges of the 21st century global economy. As the governor announces challenges or opportunities regarding business investment in the state, STEM education efforts can be positioned as one of the elements responsible for this increased investment. Innovation is at the core of state economic growth, and STEM education is a key driver in that innovation.

STEM and Workforce Development

The importance of developing STEM knowledge and skills is not limited to current students. Current workers need STEM knowledge and skills to adapt and be successful as their jobs change. As governors look to improve their state's worker training and retraining efforts, STEM education can be a strong complementary program.

STEM and the Environment

As the demand for “green” policies and environmental issues continues to grow, STEM education plays an important role in helping governors educate their public on the issues behind such environmental policies. Greater education and knowledge of science issues — learned through STEM efforts — can help advance such policies.

STEM and Homeland Security

With an increased emphasis on homeland security at both the national and state levels, STEM education — particularly in the area of technology — is a key tool in developing a workforce capable of protecting our borders. STEM education programs provide workers the skills and understanding they need to hold homeland security jobs in the 21st century.

The most successful STEM education initiatives are integrated with other related policy and communication programs and initiatives occurring in the state. Before launching a STEM education effort, the governor's staff should do a comprehensive inventory of current state efforts that touch STEM issues (e.g., science education, economic development, technology education, worker retraining) as well as third-party efforts (led by, for example, the business, philanthropic, or higher education communities). After the inventory is completed, the governor should bring these key leaders together to identify and commit to common messages and goals. This way, stakeholders will understand that all of these related efforts are united in a mission of improving education and economic opportunity throughout the state.

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THE POWER OF DATA

Governors should use state-specific statistics and data that demonstrate the importance of rigorous and relevant STEM education for all K–12 students to the state’s economic future. Such information might include:

- High school student enrollment patterns in specific courses such as physics, computer science, and calculus;
- Trends in achievement test scores (including AP and ACT scores) in those fields;
- Comparative data from other nations on student achievement in STEM courses, if the state participates in international assessments;
- Data on the numbers of college and graduate students majoring in STEM-related fields and receiving a degree in that field;
- Data on the state’s fastest-growing industries and the demand for STEM-literate employees in those industries;
- Data on employee shortages in key fields that require STEM knowledge and skills;
- Data on earnings projections for specific STEM-related careers; and
- Survey data on the value placed by stakeholder groups (e.g., parents, students, public, business) on rigorous and relevant STEM education for all students.

Such data points are useful in helping governors communicate to different audiences that the need for rigorous and relevant STEM education for all students is fact, not simply opinion. Statistics on job growth, employment trends, student achievement, and such can be used to illustrate why K–12 STEM education efforts should be supported and why STEM is of particular importance to a specific audience, industry, or geographic region in the state.

THE POWER OF STORYTELLING

Because STEM education is an unfamiliar issue to many audiences, and because it may be hard for some to grasp its importance or to connect it to their own lives, governors should consider translating the data and messages into stories whenever possible. By using storytelling to communicate the importance of STEM education, governors and other advocates can personalize the topic, allowing all stakeholders to better recognize the goals, understand the challenges, and embrace the benefits of STEM education. Used as part of an integrated communications effort, stories help demonstrate how everyone benefits from a strong STEM education system, even those who previously would not have thought so.

Consider some sample storylines that might appeal to specific audiences:

Students

A ninth grader dreams of becoming a video game designer, but does not see the relevance of graduating from his inner-city high school. After learning about the math and technology skills that the designers of “Halo” and “Doom” needed to build their games, he decides to enroll in a technology class in 10th grade, starting a STEM pathway and eventually graduating from high school.

A seventh grader hopes to be the first in her family to graduate from high school and enroll in college. She yearns for a career in medicine, but knows no one who has become a doctor or nurse. After being encouraged by her guidance counselor and her minister, she begins to take science and math classes in junior high school. Her biology teacher helps her see the multiple pathways available in the medical field and the courses she must take to get into a postsecondary program.

Teachers

A high school social studies teacher seeks to find a “different” way to teach a unit on environmental policy. The teacher integrates STEM content — like biology, algebra, and technology — to help her students better understand the environmental challenges that spurred changes in policy. The class may choose to look at the science behind laws that prohibited leaded gas and use math to quantify the impact such policy changes have had on the local and national community.

Businesses

After years of layoffs and reduced revenue, a national company is considering whether to modernize and expand a local factory or relocate to another state. The CEO is concerned the community lacks the skilled workforce needed to operate a new modernized facility. In speaking with the local school superintendent, the CEO learns of a new STEM education initiative in the high schools and the community college that is equipping students with cutting-edge technology and the critical thinking skills to use that technology to solve problems, attributes the CEO is seeking in employees. As a result, the company decides to go ahead with a modernization and expansion plan that will provide 150 new jobs.

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State Policymakers

The governor, the secretary of economic development, and several state legislators are negotiating with a national company to convince the firm to locate a new biosciences division in the eastern part of the state. As part of the negotiations, the corporate board discusses its concerns about finding enough qualified employees in the region. The governor describes the state's STEM education initiatives that are improving STEM in the region, and the state legislators highlight the work internship program that every high school senior in the area participates in before graduation. A month later, the company and policymakers jointly announce the construction of a new division and 350 additional jobs.

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STEM Education Frequently Asked Questions

STEM FAQs

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SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS



STEM Education Frequently Asked Questions

The following “frequently asked questions” are intended to be helpful when speaking with the media and stakeholder audiences about a state’s STEM education initiative. These questions and answers can become part of your media kit and included on state Web sites. The answers should be tailored to include state-specific data as supporting evidence.

What does it mean to be STEM-literate as a high school graduate?

Ultimately, STEM literacy means that a student possesses the ability to apply understanding of how the world works within and across the areas of science, technology, engineering, and math. STEM literacy is an interdisciplinary area of study that *bridges* the four areas; it does not simply mean achieving literacy in each of these strands or silos. A STEM-literate student also is experienced in problem-solving, analytical, communication, and technology skills.

The Organisation for Economic Cooperation and Development’s (OECD’s) 2003 Programme for International Student Assessment (PISA) Assessment Framework defines expected literacy for 15-year-old students in the content areas of science, technology, engineering, and mathematics.

What is a STEM classroom?

A STEM classroom promotes integrated learning, investigation, and questioning. A hallmark of such a classroom is an emphasis on design and problem-solving in “intellectually messy” learning situations that weave together the disciplines through topics (e.g., nanotechnology, biomedical engineering, and astrobiology). A STEM classroom might pose a problem and then require students to do original research inspired by a class-wide inquiry project, where they must use technology to gather and analyze data, design, test, and improve upon a proposed solution, and then communicate their findings to their peers in another country.

What is a rigorous high school level STEM curriculum for all students?

States should require a college preparatory curriculum, with a strong STEM component, as the default for all their high school students, with students taking three years each of math (algebra and higher) and science. NGA recommends that a state’s required curriculum for high school graduation, along with K–12 standards and assessments, should be aligned with the expectations of postsecondary education and employers in the state.

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How does STEM education impact the economy?

In the 21st century global economy, a highly skilled, technologically savvy workforce is increasingly in demand. Survey after survey has made clear that today's employers, regardless of industry, need STEM-literate workers. The economic success of states and nations is grounded in people who aren't just smart, but who also are creative, analytical, and willing to take risks. Innovation is the key to our nation's long-term economic success, as the way that new ideas enter the economy and change what is produced, how it is produced, and the very process of production itself. Rigorous and relevant STEM education supports innovative thinking in all students.

What are the key elements of an effective K–12 STEM policy agenda?

An effective K–12 STEM policy agenda is focused on all students, not just a certain group. A state with an effective STEM policy agenda uses its funding and statutory authority to set academic content standards, required assessments, and high school graduation requirements that are aligned across the K–12 level and with postsecondary and workforce expectations of what students and employees know and can do; establish content-rich teacher preparation and certification requirements that are aligned with K–12 needs; develop new models of curricula that support effective K–12 STEM classrooms and schools; and focus investments on what works.

What is the governor's role in building a STEM education initiative?

The governor links education goals of the state to the economic future of the state. Policy and communications leadership for a STEM agenda begins with the governor, who has the bully pulpit to reach the public and other audiences, the authority to convene key stakeholders to develop a K–12 STEM policy agenda, and the budget and executive order levers to affect policy change. Governors see most clearly that STEM education is not just an education issue, but also an economic development issue, a workforce development issue, an environmental issue, and a community investment issue, requiring a broad and deep coalition of supporters.

How is this STEM education initiative different from past state efforts?

Only in recent years have we seen how a strong education in STEM for all students benefits our state. In the past, we have focused STEM education initiatives just on those students seeking specialized careers in science or engineering. The goal of today's STEM education efforts is that all students graduate from high school with the essential STEM competencies necessary to succeed in postsecondary education and work, whether they specialize in STEM fields or not.

STEM Education Sample Media Releases

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NGA Center for
BEST PRACTICES

Sample One: STEM Launch Template

(You should tailor this press release to fit your state and distribute it to your local and regional media contact lists to capitalize on the media's interest in the announcement of your state's STEM education initiative.)

FOR IMMEDIATE RELEASE
XXX day, MONTH X, 2008

Contact: XXXXXX
XXX-XXX-XXXX

GOVERNOR <NAME> LAUNCHES NEW EDUCATION INITIATIVE

<NAME>'s STEM Education Initiative Designed to Strengthen Schools, Improve Economy, and Propel <STATE> Students

CITY — Pledging that <STATE> intends to remain a national leader in jobs creation and economic growth, Governor <NAME> announced a major expansion of the state's efforts to improve and redesign science, technology, engineering, and mathematics (STEM) education today. Through this significant investment in innovation, <NAME> signals a commitment to providing a skilled labor pool prepared for 21st century jobs.

"The economic future of this state, and this nation, depends on a well-trained, well-educated workforce," Governor <NAME> said. "By providing STEM education as a cornerstone of our education system, we ensure our high school and college graduates have the skills, knowledge, and drive to succeed in our ever-changing economy."

At a State Capitol announcement, <NAME> said he was committing \$XXX, XXX to improving STEM-based classes in the state's public schools. Additional private funding, provided through a grant from the <NAME> Foundation, will be used to recruit and retain STEM teachers in high-need schools.

"If our economy is to continue to grow, if we are to continue to innovate and improve, we need an educated workforce," <NAME> said. "When corporations look to relocate or build a new facility, we want them to think of <STATE> first. We want them to know we have the workforce needed to exceed their expectations. STEM education helps us get there."

The STEM education initiative is designed to provide high quality postsecondary pathways in STEM-related fields to all high school graduates. As part of the effort, local companies such as <NAME> and <NAME> will make internships available to current high school students and will provide company employees to help develop and teach STEM courses.

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“Improving STEM education for all students will increase our competitiveness and boost our economic strength,” said <BUSINESS COMMUNITY REP>. “In <STATE>, economic success depends on three things: innovation, hard work, and know-how. STEM ensures our future workers have all three and are primed for success in career and in life.”

The governor’s STEM education effort is part of the state’s overall education and economic development goals, including increasing the state high school graduation rate, boosting college- and work-readiness rates, improving the college-attainment rate, and providing pathways to successful work for all high school graduates. State education and workforce development officials will work with local business and educators to develop plans for specific STEM efforts for the coming school year.

To learn more about Governor <NAME>’s STEM Initiative, please visit <INSERT NEW STEM WEB SITE>.

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Sample Two: California

03/13/2007 GAAS:193:07 FOR IMMEDIATE RELEASE

Gov. Schwarzenegger Hosts California's First Career Technical Education Summit

Governor's Summit Helps Schools Prepare Students for 21st Century Careers

Ensuring California's schools are prepared to give students the training needed for the jobs of the future, Governor Arnold Schwarzenegger today convened the first career technical education summit.

The summit brings together education, business, labor, foundation and political leaders to strategize how career tech education can maintain California's competitive edge in the global marketplace. In addition, the summit will include a workshop to give school districts hands-on help in applying for career technical education bond funds. This event is hosted by ACE Clearwater Enterprises, a family-owned manufacturer of sheet metal products for the aerospace, automotive and power generation industries.

As a result of the governor's progressive career technical education vision, this important program area now has increased funding, bond financing and a heightened public profile — reversing decades of underinvestment by the state and local school districts and bucking current federal efforts to reduce funding.

"California is a global center of innovation and a nation-state in terms of economic power. But we must make investments in career tech education if we are going to keep our competitive edge," said Governor Schwarzenegger. "The world's economies are strategically investing in career and technical education. They are preparing a workforce to succeed in the global market. At the same time in California, we have thousands of students dropping out of high school. Career tech education fulfills the needs of the workforce and the needs of our students by giving them multiple pathways for success."

Since taking office, Governor Schwarzenegger has increased funding for career technical education by 18 percent. The governor's proposed 2007–08 budget includes \$52 million to build and improve career technical education programs by enhancing curriculum, streamlining teacher recruitment and training and maximizing bond funds for new facilities. Formerly known as vocational education, career technical education gives students a pathway to postsecondary education and careers, in growing fields such as medical and construction technology.

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This past November, California voters passed an education bond that includes \$500 million in grants for career technical education facilities. The quick, efficient distribution and use of these funds is a top priority for the governor. He has directed the Office of Public School Construction to expeditiously implement the career technical education portion of the bonds.

Data shows that while California companies need and want qualified workers, the United States isn't preparing workers for the new economy. According to the most recent available data, 30 percent of applicants have the wrong skills for available jobs (U.S. Chamber of Commerce, 2002) and more than 80 percent of manufacturers reported a shortage of qualified candidates (National Association of Manufacturers, 2001). Many in-state companies can't fill positions in fields like biotech, impacting their ability to compete successfully (Bay Area Economic Forum, 2005).

The California Labor and Workforce Development Agency estimates that by 2014, California will need 73,100 carpenters; 25,100 electricians; 132,000 nurses; and 11,700 welders. The state's nanotechnology sector needs 250,000 production workers in the next 10 years.

<http://gov.ca.gov/index.php?/print-version/press-release/5618/>

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Sample Three: Alabama

July 09, 2007

Governor Riley Promotes Focus on Math, Science Education

MORRIS — Governor Bob Riley emphasized the importance of math and science education during a visit to Bryan Elementary School in Morris on Monday, where he met with 250 teachers who are training to make their schools ready for the Alabama Math, Science and Technology Initiative (AMSTI). The governor also participated in two hands-on science experiments during his visit.

“Strong skills in math and science are critical both to our children’s future and to Alabama’s ability to compete. Many of the fastest growing industries, such as aerospace and biotech, require highly skilled workers with solid abilities in math and science,” said Governor Riley, who has made funding for AMSTI a priority.

Throughout the summer, teachers across the state are going back to class to attend two-week AMSTI training sessions at 16 locations. In order for a school to become an AMSTI school, math and science teachers at the school must attend two weeks of training for two consecutive summers. In return, they are provided all of the math and science equipment and materials needed for hands-on activities in their classrooms. In addition, they receive follow-up training and classroom support as they implement the new teaching methods learned at the training sessions.

AMSTI’s success is seen in both the hard numbers that show students in AMSTI schools making gains in math and science and from the support and praise the program receives from teachers, students and administrators. AMSTI is now the focus of a study being conducted with funding from the United States Department of Education and is being used as a model in other states.

During the summer training sessions, teachers are grouped according to subject and grade levels as they learn specific activities and strategies they will use to teach the content mandated by Alabama state standards. The training also helps deepen the content knowledge of teachers. The program has been so successful that many universities now offer math and science credit to participants.

Funding for AMSTI is being increased from \$22 million to \$35.8 million in the coming fiscal year.

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FACT SHEET: ALABAMA MATH, SCIENCE & TECHNOLOGY INITIATIVE (AMSTI)

- AMSTI is an innovative program to improve math and science teaching statewide. It engages students with hands-on learning so they don't simply read about the topics; they experience them in the classroom.
- Test scores show AMSTI is working to improve student achievement. On the Stanford 10 test, students in AMSTI schools score almost 14 points higher in math and almost 12 points higher in science than students in non-AMSTI schools. On the Alabama Reading and Mathematics Test, almost 11 percent more students scored at or above proficiency levels in math as compared to non-AMSTI schools.
- Governor Riley has made funding and expansion of AMSTI a priority throughout his term. Four years ago, the program received no state dollars. The budget for the coming fiscal year includes \$35.8 million for AMSTI. With the increase, 589 schools will become AMSTI schools.
- In order for a school to become an AMSTI school, math and science teachers at the school must attend two weeks of training for two consecutive summers at AMSTI Summer Institutes. In return, they are provided all of the math and science equipment and materials needed for hands-on activities in their classrooms. In addition, they receive follow-up training and classroom support as they implement the new teaching methods learned at the training sessions.
- This summer, more than 5,000 teachers from 259 schools are attending AMSTI Summer Institutes at 16 locations across the state.
- During this training, teachers are grouped according to subject and grade levels as they learn specific activities and strategies they will use to teach. AMSTI Summer Institutes also help deepen the content knowledge of teachers. The program has been so successful that many universities now offer math and science credit to participants.

<http://www.governorpress.alabama.gov/pr/pr-2007-07-09-01-amsti-photo.asp>

Sample Four: Washington

Office of Governor Chris Gregoire

FOR IMMEDIATE RELEASE — September 7, 2007

Contact: Governor's Office, 360-902-4111

Alt Contact: Office of the Superintendent of Public Instruction:
360-725-6015

Washington Awarded One of First-Ever National Math and Science Initiative Grants for AP and Pre-AP Courses

Governor and State Superintendent announce award that will foster next generation of scientists and engineers

OLYMPIA — Following a highly competitive application process, Washington has succeeded in securing one of the first-ever awarded grants from the National Math and Science Initiative's (NMSI) Advanced Placement training and incentive program. NMSI is a major new non-profit designed to help America maintain its global leadership position in technological innovation.

"This is a terrific opportunity and resource for Washington students," said Governor Chris Gregoire. "This award will help us provide significant additional support to teachers and students and, ultimately, will move us closer to a world-class, learner focused education system."

Terry Bergeson, state superintendent of public instruction, said the grant represented a perfect addition to work already begun in schools. "The grant will allow us to coalesce our resources, making kids more successful," she said. "For years, we've increased the number of students taking Advanced Placement courses. Last year the governor provided state money to bolster enrollment in these courses. We've seen how valuable the courses are, especially to students in highly mobile, rural districts. The grant will expand those opportunities to more students."

Washington's proposal, submitted by Mentoring Advanced Placement (MAP), a non-profit organization headquartered in Vancouver that links business mentors with Advanced Placement (AP) teachers and students, was selected among only seven states to receive the first grants given by NMSI. The grants will each provide up to \$13.2 million during the next six years to state non-profit entities to help fund training and incentive programs for AP and Pre-AP courses.

Research demonstrates that students who have access to strong AP programs are more prepared to do college level work in math, science, and engineering.

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“The response NMSI has received from across the country has been remarkable,” said Tom Luce, President and CEO of NMSI. “Their interest in our approach tells me they believe in the potential of NMSI and are eager to improve math and science performance.”

Launched in March 2007, NMSI was developed in response to the call for action by the National Academies’ 2005 blue ribbon panel report, *Rising Above the Gathering Storm*. According to the panel of 20 experts, improving American students’ performance in math and science coursework is the most effective way to increase the United States’ global competitiveness. Exxon Mobil Corporation announced its support for the initiative with a commitment of \$125 million. The Bill and Melinda Gates Foundation and the Michael & Susan Dell Foundation have also joined as funders.

“ExxonMobil invests in people and communities around the world because we believe that meeting the world’s economic, energy and environmental challenges requires the development of the world’s most powerful natural resource — the human mind,” said Chairman and Chief Executive Officer of Exxon Mobil Corporation Rex Tillerson. “By focusing on programs that are proven to be effective, NMSI holds great promise in fostering the next generation of scientists and engineers.”

In addition to the AP grants, NMSI will offer funding opportunities to many universities across the nation for UTeach programs, which encourage math and science majors to pursue teaching credentials during their undergraduate education. Recipients of the UTeach grants will be announced in October of this year. Non-profit entities in 28 states applied for this first round of AP grants, and 52 universities have applied for the UTeach program.

“MAP is excited to add teacher training and incentives to its mentoring services,” said Scott Keeney, MAP Board Chair and CEO of nLight, one of the founding partners of MAP. “With the demonstrated training models provided by NMSI, and the business mentoring services already in place, MAP will be able to have a much bigger impact on students’ success in rigorous coursework. The end result will be more Washington students who are prepared to compete in a global economy.”

The grant includes extensive training of teachers, identification and cultivation of lead teachers, additional time on task for students and financial incentives based on academic results.

Research shows dramatic improvement among schools with training and incentive programs. In a five-year study of Texas schools, those with programs for AP and pre-AP courses experienced four and five times more growth in students scoring three or higher on AP exams in math and science, respectively, than those without the programs.

MAP will deliver the training and incentive programs, along with its mentoring program, to selected schools across the state. MAP's supporting partners in this effort include the Office of the Governor, the Office of Superintendent of Public Instruction, Educational Service District 112, the Southwest Washington Workforce Development Council and nLight.

About the National Math and Science Initiative (NMSI)

NMSI is an innovative non-profit organization created to scale programs proven to positively impact math and science education in the United States. For more information about NMSI, please visit their Web site at **www.nationalmathandscience.org**.

About Mentoring Advanced Placement (MAP)

Mentoring Advanced Placement is a unique, business-education non-profit organization that works with school districts, teachers, high school students and professionals from the business world to bring real-world relevance, rigor and relationships to the classroom. Its mission is to challenge high school students to succeed in more rigorous academic subjects to prepare to become future leaders and innovators in the global economy. MAP does this through a combination of student mentoring, teacher training and the provision of incentives. For more information about MAP, please visit their Web site at **www.apmentoring.org**.

<http://www.governor.wa.gov/news/news-view.asp?pressRelease=639&newsType=1>

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STEM Education Example Op-Eds

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STEM EDUCATION EXAMPLE OP-EDS

SUCCESSFULLY COMMUNICATING STEM EDUCATION

(Following are two published op-eds detailing new STEM education initiatives and their impact on the state. Similar pieces, signed by the governor or a business leader in the state, can be effectively disseminated to newspapers throughout the state to advocate for your STEM education efforts. Please note these examples are provided to spur thought and discussion. An effective op-ed will include specific facts, figures, and policies related specifically to the opportunities in your state. Contact the newspaper's editorial page to determine the paper's op-ed submission policies.)

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Example One: Minnesota

Preparing kids for future “STEM” jobs

8/9/2007

by Brian Fitzgerald

Did you know the jobs your 4th grader will hold likely haven't been thought of yet?

For today's junior high student, his or her jobs have neither been defined nor categorized: will they be “high tech,” or “bio-medical.”

These jobs require the education, skills and core knowledge to allow the students to understand the blend of technologies, sciences, mathematics and even engineering.

The Minnesota Department of Employment and Economic Development projects a 20 percent to 33 percent increase in scientific and engineering occupations within the next 10 years and new job growth in professional and high tech industries will demand an extra 10,500 college graduates per year. Two-thirds of all new jobs will require at least some post-secondary education. These statistics have prompted the reforms requiring Minnesota students to take Algebra I by 8th grade, and Algebra II and either chemistry or physics to graduate from high school. Kids in the 4th grade this year fall under this requirement. The goal is to prepare our kids for these undefined future jobs.

In his 2007 State of the State address, Governor Pawlenty introduced some interesting ideas. His “3R” high school plan would require all students to finish a year of college coursework. High schools also would have to offer rigorous courses, help all students earn college credits and give them career-oriented opportunities.

There probably always will be a need for some of us to learn accounting, marketing and other important areas of business. But the vast majority of new jobs being created to meet the need of developing companies' competitive needs will be in science, technology, engineering and math (STEM) fields. These new jobs will be well-paying and allow for career advancement, but require strong math, problem-solving and reasoning skills, as well.

Last fall, the Minnesota High Tech Association (MHTA) and state Department of Education sponsored 13 outstate sessions to increase awareness of the needs of STEM education, and hear from local businesses and community leaders about workforce opportunities. The sponsors invited educators, students, business people and local government to help identify opportunities to build local partnerships between schools, higher education and businesses.

The idea is to begin building community partnerships designed to encourage more students to take STEM courses and pursue careers in STEM fields.

Businesses in the audience at the Duluth session were challenged by Kate Rubin, president of MHTA and Alice Seagren, state education commissioner, to provide career awareness by organizing career days, job fairs, job shadowing, mentoring students and offering tours of their business.

Business people also can participate as guest speakers, tutoring students or teachers, providing apprenticeships or internships, supporting competitions and recognition programs.

Initial survey results across the state show a positive response to the STEM initiative and a marked improvement in awareness.

Overall, people feel K–12 education isn't preparing students adequately for college, that students find the STEM courses more challenging and nearly half do not want tougher classes. Most post-forum survey participants feel advanced STEM course should be high school graduation prerequisites.

Some STEM-based projects in the region are underway.

For example, Lake Superior College is working with local businesses to address their future workforce needs. Some activities have prompted creative ways to meld business with the school. The college is sponsoring engineering programs with UMD, regional manufacturing and working with K–12 schools to develop additional math courses. Better coordination between businesses, business organizations, educators and students will help meet business needs and opportunities of our future.

Rubin also notes “next generation workers need to have the adaptability to survive.

“There are no guarantees in life; studying STEM topics and learning critical thinking skills are necessary to compete in the 21st century.”

I agree. And there's no reason to “wait and see” what jobs will be forthcoming. STEM courses like Algebra II in high school more than double the likelihood a student will earn a four-year college degree.

Far more entry level jobs also will require a two-year degree or certification.

Students better prepared for post-secondary study will have more flexibility in training to the field of choice.

So parents (and grandparents), you can encourage those around you to request more STEM courses at your schools. If you are in a STEM field, get involved with mentoring and lend your support to your school as a speaker

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or support internships in your business. Students, ask questions of educators and businesses to better understand the skills required of the future workforce, and opportunities yet to surface.

Core STEM skills will improve your employability whatever your career choice may be.

Forrester Research anticipates today's youngest workers will hold 12 to 15 jobs in their lifetimes — we can no longer plan for or count on employment for life. I see the combination of STEM studies and lifelong learning practices keeping workers vibrant and competitive at a time when we need to continually make ourselves employable.

At a time when the U.S. is concerned about competition from world powers like China and India, STEM education is one key to keeping the pipeline of talented scientists, engineers and teachers working to keep good paying jobs from leaving the country. Walter Isaacson wrote the biography of Albert Einstein: *His Life and Universe*, [and] he adds to the STEM equation the need to also consider the creative thinking that Americans are known for. He states "Einstein's genius reminds us that a society's competitive advantage comes not only from teaching multiplication tables but from nurturing rebels." [He continues that] "Grinds have their place, but unruly geeks change the world." He notes that Einstein was not a good student, mostly due to his teachers not challenging him and keeping to the rote learning of the day. Einstein was considered lazy and was often dismissed; it would be a shame to lose that creative, challenging attitude. Einstein was quoted as stating "Imagination is more important than knowledge."

Brian Fitzgerald is president of CcureIT (see-cure-eye-tee) in Moose Lake. He assesses risk, creates common sense IT policies, helps to integrate policy into business practices, and tests technology to ensure security of data and other assets. You can reach him at info@Ccurelt.com, or 800.996.8251.

The MHTA/Department of Education forum series was the first step in formally addressing the need to encourage educators and students to pursue more STEM courses. For more STEM information, visit www.MHTA.org; www.MN-STEM.com and www.achieve.org.

BusinessNorth.com; August 9, 2007 <http://www.businessnorth.com/technology.asp?RID=2066>

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Example Two: Hawaii

Innovation will counter legislators' gloomy scenario

Theodore E. Liu

I WAS surprised — no, I was shocked last week when I saw the House Democratic leadership on TV glumly warning about “delayed welfare checks, delayed housing projects and long lines” at state service counters. Where did that come from?

They are forgetting the fact that during the state’s worst recessions of the 1990s, welfare checks were never delayed. They’ve set aside the fact that before this gloomy assertion the newspapers reported on new housing projects in Millilani, Kapolei and Waianae. They ignore the fact that with the state collecting \$150 million more in revenues in fiscal 2007 than 2006, there is ample money to keep state services at the same level, if not increase them.

The legislators were thinking with the perspective of the “bad old days” — the decade-long stagnation of the 1990s. They are working under the fear of the boom-and-bust cycles of the past. So what is different now?

For starters, Hawaii’s economy is healthy, growing at inflation-adjusted 2.7 percent in 2006, and expected to grow 2.6 percent in 2007. For the first five months of 2007, jobs grew by 2.2 percent. Unemployment for this period was 2.3 percent, still among the lowest rates in the nation. Personal income in the state increased 6.1 percent for the first quarter of 2007. General excise tax collections, a broad measure of economic activity, increased 8.5 percent in fiscal year 2007.

As the result of four years of extremely strong growth, prices have risen and we have a tight labor market. These factors will work to slow our rate of growth. But we will still have healthy growth, unless we become pessimistic and stop investing and spending. That might happen if we again think in doom-and-gloom terms of the past. We’ve been there before, but we now have reason to be optimistic.

WHAT IS really different now, and why we have even more reason to be optimistic, is that the state is now launched on the path toward an innovation economy. Innovation is more than invention — and Hawaii has great potential for invention in ocean sciences, aerospace, energy and creative media, to mention a few.

Innovation is the process by which new or better ideas enter our economy and improve what is produced, how it is produced, creates new products and devises better ways of accomplishing tasks.

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By enabling our economy to grow without depleting Hawaii's scarce natural resources, innovation will lead to sustainability.

By supporting the growth of our new science and technology sectors, innovation will lead to economic diversification.

By enabling us to be more productive across all sectors of the economy, innovation will lead to higher wages and standard of living.

By equipping us with adaptability, creativity and problem-solving skills, innovation will enable us to have resilience, to adjust to rapidly changing global events. Innovation will smooth out the historical boom-and-bust cycles of Hawaii's past.

Fundamentally, innovation is based on a belief in Hawaii's people — its human capital — and makes that human capital even more valuable.

THE HAWAII Innovation Initiative has been recognized as a model by prominent national organizations, including the National Science Foundation, the National Governors Association and NASA. All have recently cited Hawaii's innovation economy strategy as the model for the nation to compete in the new global economy.

This gives us great confidence that our innovation strategy is the best way to increase our standard of living for all of Hawaii's people.

Hawaii's best days lie ahead. Not only because our economy is healthy, but because we now have an innovation strategy to build on that health and to enhance that vitality.

I would hope that state legislative leaders take a more forward-looking approach when speaking about an economy that is on the right path — unless, of course, their wish is to return to the old days.

Theodore E. Liu is the director of the state Department of Business, Economic Development & Tourism.

Honolulu Star-Bulletin; July 22, 2007 <http://starbulletin.com/2007/07/22/editorial/commentary3.html>

STEM Education Sample Congressional Testimony

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STEM Education Sample Congressional Testimony

**Testimony of Janet Napolitano, Governor of Arizona
Submitted to the Committee on Education and Labor
U.S. House of Representatives
Wednesday, February 7, 2007**

Chairman Miller, Ranking Member McKeon, and Committee Members, thank you for the opportunity to testify on an issue of great importance to all of us: the role of innovation in enhancing America's competitive standing.

I testify before you today wearing two hats, one as the Governor of Arizona and one as the chair of the National Governors Association, a bipartisan organization representing the nation's governors. My testimony today is both informed by the experiences of my fellow governors and my own work in Arizona.

The Issue

Today's economy is increasingly global and highly competitive. While the United States remains the world leader in innovation, formidable competitors have emerged — and continue to emerge — as technology breaks down barriers and accelerates change. With demographic shifts, the rapid rate of technological advancements, and new methods of communication, Americans no longer solely compete against each other for jobs; they increasingly compete against well-educated and cheaper labor abroad. The only way the United States can compete in this global economy is to out-innovate the competition. Our growth, and ultimately our success, will be driven by our ability to develop new ideas and technologies and translate them into innovations, and to create a strong, agile workforce that evolves with a changing marketplace.

The Challenge

The challenge is upon us. In 2005, American companies received only four of the top ten patents worldwide. Finland, Israel, Japan, South Korea and Sweden each spend more on research and development than the United States as a share of GDP. China has overtaken the United States as the world's leading exporter of information technology products. In 2006, the World Economic Forum's Global Competitiveness Report dropped the United States from first to sixth in rankings of national competitiveness.

The quality of our workforce, moreover, is an even greater challenge. Businesses need employees who think innovatively and are capable of keeping up with the global economy. Yet, our country's 15-year-olds ranked 24th out of

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39 countries in a 2003 examination, which assessed students' ability to apply mathematical concepts to real-world problems. In 2005, in both mathematics and science, less than 2/5 of U.S. 4th and 8th grade students performed at or above a proficient level. These are startling statistics and we are feeling the impact now. In 2004, the United States produced 137,000 new engineers compared to China's 352,000. Simply put, our public education system is not delivering the workforce we need to compete. American students aren't measuring up to other students around the world, and our country is not producing enough skilled professionals to create tomorrow's innovations.

The diminished ability to compete is reflected in real wages. The earnings of workers who have finished college have risen over the past 20 years, while the wages of those with less education attainment have fallen. Too many Americans are falling behind in an economy that is more global and vastly different than ever before.

Some look at these statistics and think not much can be done. I look at this as our nation's wake up call. This is our opportunity to reinvent our system of education and recapture our competitive edge. The answer is innovation, and the solution lies in our states. As governors, we believe states are the engines for change.

What is Innovation?

"Innovation" is a term that deserves a new common definition. In the 1990's, innovation was about technology. Today, innovation is about reinventing strategies, products and processes, and creating new business models and new markets. It's about selecting the right ideas and executing at the right time. Innovation in the 21st century has moved beyond research laboratories, and today, reaches across disciplines. It requires talented people with the skills and resources necessary to compete and thrive in a global marketplace.

But this new form of innovation cannot develop in a vacuum. It requires an education system that is better than those of other nations. It requires first class research facilities, and vibrant communities designed to retain and attract talent. It requires a business climate that encourages and rewards discoveries and entrepreneurship. It requires improved economic development that focuses on our nation's competitiveness. Most important, it requires committed leadership at all levels of government — working with the private sector — to make it happen.

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Why States?

States play a pivotal role in effecting change and creating innovative economies because they are major investors in the essential tools of that change.

Look at any state budget and you will find that more than half of it is dedicated to education — from pre-K through post-secondary. The reality is that in the United States, education is carried out and predominantly funded at the state level. Actualizing change in our system of education will happen in the states.

Likewise, states can be, and often are, the architects of the policies that cultivate innovation.

Given the seriousness of the competitive challenge our country faces, it is critical for governors to develop strategies to accelerate innovative economies within their states.

This is the impetus behind my National Governors Association Chair's Initiative, Innovation America. This initiative brings Governors, business leaders and higher education officials together to develop educational systems and economies that strengthen states' innovative capacity. The Innovation America initiative has three main strategies:

1. Improving science, technology, engineering, and mathematics (STEM) education
2. Enabling the post-secondary education system to better support innovation
3. Encouraging business innovation through supportive state policies

K–12 Science, Technology, Engineering, and Mathematics (STEM) Education

First, states must create the human talent that powers innovation. A workforce of problem solvers, innovators, and inventors who are self-reliant and able to think logically is one of the critical foundations that drive innovative capacity in a state. Yet, as mentioned earlier, there is a growing consensus that American students are not attaining the basic knowledge they need to succeed, especially as it relates to science, technology, engineering, and math. These subjects are the foundation for innovation, and provide students with the skills needed to solve problems, experiment, and increase their awareness about the world around them.

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The Innovation America initiative seeks to improve the rigor and relevance of science, technology, engineering, and mathematics (STEM) education in grades K–12 to ensure all students graduate from high school with the core competencies needed for a 21st century workforce and to motivate more students to pursue careers in science and technology. At the end of this month, as part of the Initiative, we will release the *Governors Guide to Building a K–12 Science, Technology, Engineering, and Mathematics Education Agenda*, to support states' efforts in building a world-class K–12 STEM education system. We will also announce a new program to support state-level STEM education centers to build statewide capacity for improved STEM teaching and learning. Governors are uniquely positioned to address these challenges by establishing rigorous standards, expanding teacher training, and aligning curriculum with real world demands.

In Arizona, we formed the P-20 Council in 2005 to align K–12 and higher education with the needs of the new economy. Our Council, comprised of educators, community college and university presidents, elected officials, and business leaders, is focused on developing a strong foundation in science, technology, engineering and mathematics, and strengthening curriculum and standards to prepare students for post-secondary education and a 21st century workforce.

The result is an education continuum, with classes building on ideas that were taught in years prior, and students better equipped with industry-specific skills in high-growth, high-wage occupations that await them when they graduate.

This year, at the Council's recommendation, I called on the Arizona State Board of Education to raise our standards to require four years of math instead of two, and three years of science instead of two. I also called on our schools to modernize our curricula, and bring 21st century skills into the classroom. We need technology embedded in our schools — to enhance learning and improve students' understanding of it. We need to move away from rote memorization and start teaching understanding and analysis. We need specialized environments for students interested in a particular area of study like Arizona's new Bioscience High School. Located just minutes from Arizona's bioscience hub, this school will connect students with tools, resources and experts from across the country. And we need more out-of-school time, hands-on activities — such as science fairs and robotics clubs — so that students can apply their learning in experiential ways.

Take, for example, Arizona's Carl Hayden Community High School's Science and Technology Club, which brings STEM skills to life through an after-school robotics team. The team entered their first competition in 2004, opting to compete against university vs. high school students.

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Their work paid off and they ended up winning the entire competition, beating top challengers like MIT.

Postsecondary Education

While the American higher education system has long been a centerpiece of the U.S. economy, and the launching pad for the jobs of the future, the skills needed today are far different than the expectations of yesterday. In the past, being well-versed in a single subject made the cut. Today, integrating diverse subject matters is as important as mastering individual ones. Students not only need to be well-rounded, they also need entrepreneurial skills, and the capacity to imagine and adapt to the unknown. Providing students with new skills taught in a new way is the first step toward developing tomorrow's innovators.

The second piece is equally important. Public universities are uniquely positioned to provide the pipeline of innovators for the local economies they surround. For example, the city of Tucson, Arizona has become the 'silicon valley' of optics because of its relationship and partnership with the publicly-funded University of Arizona.

The Innovation America initiative provides strategies to bring our country to the next level of innovation and prosperity. It asks universities to align their work, both the programs they offer to students and their research and development efforts, with the needs of the state's high growth industries. For example, in 2003 when I became governor, the number of health care providers graduating from our universities was simply not keeping pace with our soaring population growth. We worked with these institutions to address this shortage, and today Arizona State University has the largest public nursing program in the country, and we're opening Phoenix's first medical school this fall.

In addition to more effectively matching graduates to high-demand careers, the Initiative seeks to showcase the great work of universities and bring their achievements to market. Some examples from my home state:

Arizona Telemedicine Program

Its Arizona Telemedicine Program (ATP) located at the University of Arizona College of Medicine was created in 1996 with pilot funding from the state, and today, is recognized as one of the premier telemedicine programs in the world, providing telemedicine services, distance learning, informatics training and telemedicine technology assessment to communities throughout Arizona and beyond. Employing high-resolution interactive video imaging, digital photography, computer workstations and other technology, telemedicine allows physicians at distant locations to make diagnoses, conduct consultations and

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recommend treatment plans. Among its many initiatives, ATP piloted a virtual center for diabetes care that reaches out to medically underserved areas that have high incidences of pre-diabetes and diabetes. Its success is gaining national recognition.

In 2005, ATP received \$1.2 million in federal funds for the new Institute for Advanced Telemedicine and Telehealth (THealth), to be located at the new University of Arizona College of Medicine — Phoenix. The institute will conduct research and develop medical simulations, robotics and the design of “next-generation” medical devices.

Biodesign Institute

The Biodesign Institute at Arizona State University is focused on preventing and curing disease, overcoming the pain and limitations of injury, renewing and sustaining our environment, and securing a safer world. To accelerate the pace of discovery, the institute merges formerly distinct fields of research, including biology, chemistry, physics, medicine, agriculture, environmental science, electronics, materials science, engineering and computing. In its short history, the Biodesign Institute has made measurable strides in delivering on its goals. This past year, Biodesign researchers received five patents, filed twenty new patent applications, and launched two spin-out companies. Among the research discoveries being translated to commercial endeavors are a drug with potential to save the lives of stroke victims; new tests to diagnose diseases more quickly and accurately; devices that rapidly detect explosives and biowarfare agents; the use of DNA forensics for law enforcement; and the design of next-generation flexible electronic displays with multiple applications in medicine, industrial processes and defense.

Sarver Heart Center

The Sarver Heart Center at The University of Arizona College of Medicine has pioneered a breakthrough method of cardiopulmonary resuscitation that emphasizes chest compressions and eliminates the need for mouth-to-mouth breathing. Called “continuous chest compression CPR,” the innovative new approach has been shown to dramatically increase survival rates following cardiac arrest, and is easier to learn, remember and perform than standard CPR.

Growing Biotechnology Initiative

The Growing Biotechnology Initiative (GBI) at Northern Arizona University focuses on technology platforms in cancer, neurosciences, bioengineering, infectious diseases and diabetes identified in the Arizona Bioscience Roadmap. The GBI integrates cutting-edge research in these platform areas with nationally competitive undergraduate and graduate degree programs aimed at

developing a highly skilled workforce to meet the demands of the rapidly developing bioscience industry.

Critical Path Institute (C-Path)

The Critical Path Institute (C-Path), an independent, non-profit organization located at the University of Arizona, was created in 2005 to support the U.S. Food and Drug Administration (FDA) in its effort to implement the Critical Path Initiative (CPI). It serves as a “trusted third party,” working with the pharmaceutical industry to safely accelerate the development of and access to new medications. C-Path was recently awarded a national grant to evaluate genetic tests to improve treatment of cardiovascular disease.

InnovationSpace

InnovationSpace is an entrepreneurial joint venture between the colleges of design, business and engineering at Arizona State University that teaches students how to develop products that create market value while serving real societal needs and minimizing impacts on the environment. Interdisciplinary student teams work to define new product offerings, develop and refine product concepts, build engineering prototypes, and create business plans and visual materials to market their products.

BIO5 Institute

The BIO5 Institute at the University of Arizona brings together some of the world’s best scientists across five disciplines to collaborate on complex problems such as how to diagnose, treat, or prevent disease; how to feed a hungry world; and how to sustain our environment. BIO5 provides researchers with state of the art equipment in a setting that allows interaction on important research issues and provides the infrastructure necessary to translate scientific discoveries into tangible human benefit, increased economic development and a better-educated society.

The next step, and the goal of the Innovation America initiative, is to bring these new discoveries, innovations and cures to the marketplace. This leads to the Initiative’s next strategy.

Business Innovation

While we prepare our students for a global economy and build our universities as pipelines for innovation, we must also cultivate a culture of innovation in the private sector.

The Innovation America initiative seeks to give states tools to develop policies that support research and development, enhance their innovation capacity and foster entrepreneurship.

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Specifically, the Initiative is helping governors promote business innovation by 1) assessing each state's economic performance and making policy recommendations for improving performance; 2) providing governors analyses of their state's most promising innovation clusters and a guidebook to cluster-based growth strategies; and 3) compiling and distributing best practices for the management of technology investment funds.

By reducing regulatory barriers, eliminating policies that inhibit the transfer of new ideas from the lab to the market, and creating tax policies that support the growth of innovative industries, states can lead this charge. States can also help entrepreneurs establish linkages with researchers, target workforce training and research and development to the needs of fast growing industries, and enhance opportunities for entrepreneurs to obtain early-stage investments, on which innovative products depend. Enhancing a state's innovation capacity puts its businesses in a stronger position to exploit the opportunities presented by changes in technologies — opportunities to increase productivity, develop new products, and expand into new markets.

States like Arizona have already started this work, accelerating prosperity through incentives for angel investment, which help small businesses and early stage companies attract much needed capital to expand operations and bring new ideas, products and services to market. Arizona's "angel investors" tax credits will spur \$65 million in investment in life sciences and new technology development.

We are also focused on growing Arizona's entrepreneurial companies into globally competitive enterprises through programs leading to the commercialization of the latest discoveries, innovations and technology. Arizona's Innovation and Technology Commercialization Accelerator is a "virtual" pilot program through our state Department of Commerce. This program is designed to assist early-stage technology and bioscience companies, as well as coordinate and effectively deliver technology commercialization services statewide. It offers grants to companies for technology assessment, commercialization feasibility, and assistance with marketing and licensing.

The Charge

Together, the strategies proposed by the Innovation America initiative seek to recapture our nation's competitive edge. By maximizing the potential of our students, we will produce the necessary talent pool. Through targeted investments in research and development and better coordination with the private sector, our universities can develop the workforce and pipeline for innovation. Finally, by developing state policies that foster innovation and encourage entrepreneurship, we can bring new inventions and discoveries to market and ensure the fruits of our labor stay at home.

In Arizona, these strategies are more than ideas on paper; they are our roadmap for success.

Together, working with academia and the private sector, we are taking action to ensure that Arizona not only remains globally competitive, but is a world class leader in innovation.

Take, for example, Arizona's bioscience industry. A few years ago, we determined that we were lagging behind the nation in bioscience research and needed to step up the pace. We developed a Bioscience Roadmap to assess our existing infrastructure and strengths, with the goal of making Arizona a national leader in the field within 10 years. A small, but rapidly growing bioscience private sector already existed, and we built on these efforts through the creation of the Translational Genomics Research Institute (TGen), a non-profit organization focused on developing earlier diagnostics, prognostics and therapies through genetics.

Since its founding in 2002, TGen has announced more than 15 new genetic discoveries including the identification of genes linked to Alzheimer's Disease, ALS, memory performance, prostate and brain cancer. TGen's success lies in both its biomedical research, and its impact on the Arizona economy. A report released in 2006, found TGen produces a nearly four to one return on state-invested funding and is expected to generate more than 3000 jobs and \$202.4 million in total economic impact by 2025.

Efforts like TGen are possible at the state level, because of our ability to bring diverse stakeholders together and leverage resources to make an impact. Modeled after Science Foundation Ireland, we recently forged an unprecedented partnership between government, universities and the private sector to create Science Foundation Arizona, a multimillion dollar nonprofit organization designed to build and strengthen Arizona's scientific, engineering and medical competitiveness. Supported by seed funding from the state, Science Foundation Arizona is working to attract world-class researchers to Arizona to diversify and expand Arizona's high-tech economic sector. Its Small Business Catalytic Funding initiative will be a stimulus for technology development, company formation and high-tech job creation in Arizona. And its largest funding priority, Strategic Research Groups, will fund partnerships between the private sector and universities. Most importantly, organizations like Science Foundation Arizona give states the flexibility to adjust to new paradigms more quickly and efficiently, and stay competitive in a global economy.

Our mission is bold, but we are on the path to success. In Arizona, we are building a premier education system from pre-school through college, and are working hand-in-hand with businesses to make sure our students can meet the demands of the 21st century economy. We made a \$440 million investment in new research facilities at our universities to house world-class

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talent. We created technology commercialization programs to enhance Arizona's science and technology core competencies and promote entrepreneurship. We have maintained a low-tax, business friendly environment, signing a historic business tax relief package into law to spur investment and attract companies to Arizona from around the country and across the globe.

The Innovation America initiative focuses on the actions states can take because, as I have demonstrated here, governors are in the driver's seat when it comes to promoting innovation. At the same time, the federal government has a major role to play in addressing the challenges we face in this increasingly competitive global environment.

As you know, several major reports in recent years have recommended specific changes in federal policy and funding levels. At the heart of the recommendations is the importance of innovation. I am eager to begin a dialogue about how we can engage in complementary activities — maximizing our respective strengths — to enhance our economic competitiveness by creating an innovative nation.

Thank you for giving me the opportunity to testify about an issue that is so critical to the future of our states and our nation. Ultimately, this is not just a local concern, not just a state priority, and not just a federal problem. It is a national challenge. Working together, the public and private sectors can make meaningful progress in identifying educational and economic actions that make life even better for the next generation of American families.

http://azgovernor.gov/dms/upload/NR_020707_Napolitano%20innovation%20testimony.pdf

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