STEM Action Planning Summit

Science, Technology, Engineering & Math

BACKGROUND REPORT

- Summit participants urged to read this report before the event.
- Summit details: November 8-9, Santa Fe, NM

CONVENER

New Mexico Partnership for Math and Science Education

ORGANIZER

New Mexico First

NEW MEXICO FIRST

New Mexico First
P. O. Box 56549
Albuquerque, New Mexico 87187
Phone: 505-241-4813
Website: www.nmfirst.org

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FOREWORD

Purpose of the Event

This report informs the upcoming *STEM Action Planning Summit.* Participants are urged to review it prior to the event. This report also provides valuable context for policymakers, educators, and advocates – informing future STEM policies and practices.

The **New Mexico Partnership for Math and Science Education** will convene the summit and incorporate the resulting action plans into subsequent implementation efforts. The partnership plans to advance targeted implementation efforts for at least one year following the summit. The event builds on a previous math and science town hall, convened in November 2005.

The summit takes place November 8-9, 2012 in Santa Fe, NM.

Convener

The New Mexico Partnership for Math and Science Education (NMPMSE) is a clearinghouse and network for STEM education initiatives in New Mexico. The statewide membership organization aims to promote coherence and quality of STEM education initiatives through dissemination of information, networking, coordination, and collaboration so that New Mexico will become a leader in STEM education.

Key activities include:

- Providing a forum for communication among state government, K-12 and higher education, nonprofit organizations and projects, and private organizations interested in STEM education
- Coordinating STEM education projects and activities in New Mexico
- Providing opportunities for people and projects with similar goals to communicate and to work collaboratively

Organizer

New Mexico First prepared this report and will facilitate the upcoming summit as well as subsequent implementation activities.

The public policy organization engages people in important issues facing their state or community. Established in 1986, New Mexico First offers unique town halls and forums that bring together people from all walks of life to develop their best ideas for policymakers and the public. The nonprofit also produces nonpartisan public policy reports on critical issues facing the state. These reports – on topics such as water, education, healthcare, the economy, and energy – are available at www.nmfirst.org.

The state's two U.S. Senators – Jeff Bingaman and Tom Udall – serve as New Mexico First's honorary co-chairs. The organization was co-founded in 1986 by Senators Jeff Bingaman and Pete Domenici.

Report Committee

This New Mexico First report was prepared by Heather Balas with research support by Melanie Sanchez Eastwood. Reviewers included:

- Terri Nikole Baca, New Mexico STEM Network
- Jack Jekowski, Innovative Technology Partnerships
- Charlotte Pollard, New Mexico First
- Rick Scott, Los Alamos National Laboratory Foundation
- Kurt Steinhaus, Los Alamos National Laboratory
- Kristin Umland, University of New Mexico

Special thanks to the review committee for sharing their time and expertise.

Sponsors

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- Los Alamos National Laboratory and Los Alamos National Security, LLC
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- University of New Mexico
- Intel
- PNM

SILVER LEVEL

- Innovate+Educate
- New Mexico Highlands University
- Santa Fe Community College
- Technology Integrate Group
- Northern New Mexico College
- LANL Foundation

INTRODUCTION

Some people say America is experiencing the "dawn of a new industrial age" with a growing need for highly skilled workers.[1] Here in New Mexico – with our labs, high-tech companies, and energy industries – we know that the "new age" dawned years ago. We have long understood that our students must develop strong science, technology, engineering, and math abilities. We know employers need workers with STEM skills. What people may not know is how urgent these goals are, or how to achieve them.

National Economy

The academic preparation of the past is not adequate for the careers of the future.[2] In order to grow our national and state economies, today's students must achieve a high degree of technical literacy. It is a paradox that America faces high unemployment at the same time that high-tech companies cannot fill the positions they have open. Microsoft has roughly 6,000 open jobs in the U.S., almost half for researchers, developers, and engineers.[3] Their vacancy rate climbed 15% in the last year.

THE GAP

Looking to the future, there are various ways to measure the growing gap.

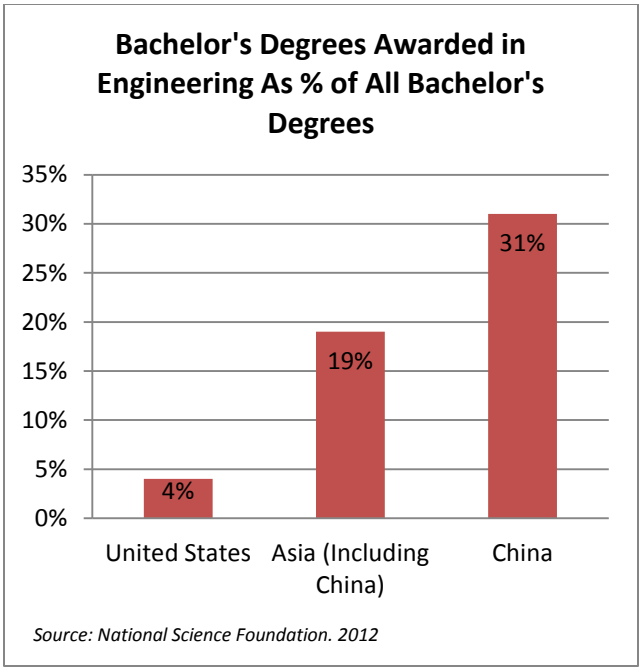
- **Higher skills:** By 2020, labor market research predicts that the American workforce will need 123 million workers for high-skill jobs, but only 50 million Americans are expected to quality for them.[4]
- **Computer science:** Researchers predict that the American economy will create more than 120,000 new computing jobs by 2020; the nation's higher education system currently produces about 40,000 computer science bachelor's degrees a year.[5]
- **Baby boomer retirement:** An estimated 66% of the vacancies to be filled by 2020 will be created by boomer retirement (with many of the retirees educated due to the cold war and space race). Some tech-based companies must replace 100% of their workforces by the end of the decade.[6]

INTERNATIONAL COMPETITION

There is a growing concern that these jobs are migrating to countries that produce more STEM graduates. Not only are U.S. companies outsourcing high-skill, high-pay jobs to Europe, Singapore, or other nations, they are importing STEM talent from abroad using H-1B "specialty occupation" visas.[7] With such a need for qualified people, the president of the Council on Competitiveness said, "Talent will be the oil of the 21st century." [8]

The following table provides one international comparison.

[1] (Gordon 2009, p. 34)
[2] (Feller 2010, p. 9)
[3] (Microsoft 2011, p. 3)
[4] (Gordon 2009, p. 38)
[5] (Microsoft 2011, p. 4)
[6] (Gordon 2009, p. 38)
[7] (Gordon 2009, p. 34)
[8] (Rising above the Gathering Storm Committee 2010, p. 88)



In another example, the nation of Finland emerged in recent years as a "rock star of global education," scoring second in the world in science literacy and reading, and third in math (based on 2009 testing).[9] By comparison, the U.S. ranked 33rd in math and 24th in science, behind less wealthy counties including the Czech Republic and Slovenia.[10] One STEM study estimated that if the U.S. could match the academic performance of Finland's students, America's economy would be 9% to 16% larger, generating between $1.3 to $2.3 trillion a year.[11]

U.S. RESPONSE

The White House recently launched the "Educate to Innovate" campaign that prioritizes industry involvement. "Our strength as a nation depends on strengthening America's role as the world engine of discovery and innovation," said President Obama in conjunction with the campaign's launch. It includes three national priorities: [12]

1) **Great teaching:** Improving STEM education at all grade levels
2) **Inspired learners:** Inspiring student preparation and excitement for STEM, especially among women and underrepresented minorities
3) **A committed nation**: Achieving a sustained commitment to improving STEM education

The focus on STEM is not limited to the current administration. American leaders of all political parties appreciate the importance of this concern. Noted a former Bush-era appointee, "The greatest long-term threat to U.S. national security is not terrorists wielding a nuclear or biological weapon, but the erosion of America's place as a world leader in science and technology." [13]

New Mexico Economy

The state's economy is every bit as dependent on STEM skills as the nation's. "Professional and technical services" is the third largest industry sector in New Mexico, and energy industries generate about a quarter of the state's general fund revenue.[14,15] Healthcare, another key STEM industry, is a critical element of our economy; 40% of New Mexico's general fund goes to health and human services.[16] The economic importance of high-wage jobs cannot be overlooked in a state where one third of children live in poverty.[17]

National experts call for increased work in the frontiers of advanced manufacturing, space exploration, alternative energy, nanotechnology, and healthcare research.[18] Coincidentally, all of these areas were recently prioritized by participants in the *New Century Economy Summit,* sponsored by

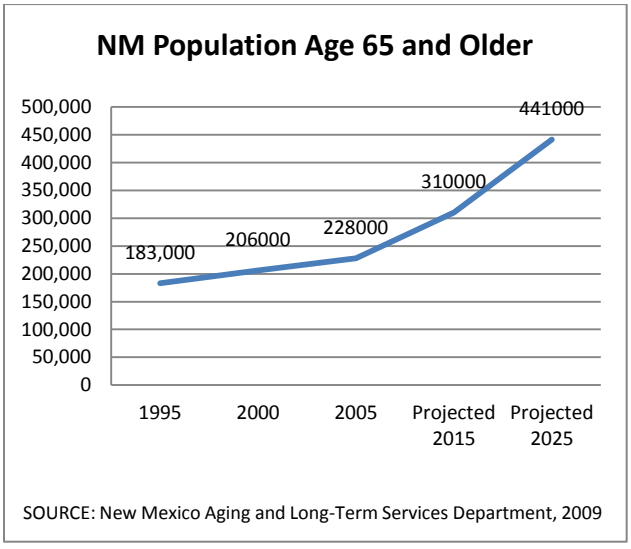
[9] (Levine May 2011)
[10] (Organisation for Economic Co-operation and Development (OECD) 2009)
[11] (Rising above the Gathering Storm Committee 2010, p. 69)
[12] (White House 2010)
[13] (Rising above the Gathering Storm Committee 2010, Gordon Englan, former Deputy Secretary of Defense)
[14] (NMSU Arrowhead Center, New Mexico First 2012, p. 8)
[15] (New Mexico First 2012, Progress Report p. 35)
[16] (New Mexico First 2012, Progress Report p. 10)
[17] (New Mexico First 2012, Progress Report p. 21)
[18] (Feller 2010, p. 8)

the New Mexico Economic Development Department.

The state is pursuing job growth in several technology sectors, building on intellectual resources enabled by the national labs, Intel, Spaceport America, and the research universities.[19] Participants at the economic summit noted that New Mexico's economy and quality of life may also depend on science and technology research devoted to water recycling and treatment – another effort that will require STEM skills.

HEALTHCARE

New Mexico, like the nation, needs a growing healthcare workforce to replace the many doctors, nurses, and other professionals projected to retire in the coming decade.[20] The upcoming retirement of baby boomers not only reduces the healthcare workforce, but simultaneously increases the Medicare roles as people from all careers turn 65. New Mexico's senior population is projected to increase greatly by 2025. The government currently classifies all counties but Los Alamos as having a shortage of healthcare professionals.



SOURCE: New Mexico Aging and Long-Term Services Department, 2009

Collective Impact

Addressing New Mexico's STEM needs will take time, talent, energy, and money. When participants at the upcoming STEM summit begin developing their action plans, they will not just talk about the problem. They will want to make a tangible difference. Research on the Collective Impact model, published by Stanford University last year, may provide guidance for the STEM summit.

The Collective Impact research determined that effective, large-scale social change is more effective when advanced through cross-sector coordination rather than from isolated intervention of individual organizations. It offered five conditions of collective success, excerpted below.[21]

1) ***Common Agenda:*** Collective impact requires all participants to have a shared vision for change, one that includes a common understanding of the problem and a joint approach to solving it. Collective impact requires that differences be discussed and resolved. Every participant need not agree on all dimensions of the problem. All participants must agree, however, on the primary goals for the collective impact initiative as a whole.
2) ***Shared Measurement Systems:*** Developing a shared measurement system is essential to collective impact. It enables participants to hold each other accountable and learn from each other's successes and failures.
3) ***Mutually Reinforcing Activities:*** Collective impact initiatives depend on a diverse group of stakeholders working together, not requiring all participants to do the same thing, but encouraging each participant to undertake a specific set of activities and coordinate with the actions of others.

[19] (NMSU Arrowhead Center, New Mexico First 2012)
[20] (Robert Wood Johnson Foundation 2011, p. 1)
[21] (Kania and Kramer 2011)

4) ***Continuous Communication:*** Developing trust among nonprofits, corporations, and government agencies is a monumental challenge. Participants may need several years of regular meetings to build experience with each other. (Fortunately for the STEM effort, many of the organizations are already collaborating.) Additional structure may help, however. All the collective impact initiatives studied by Stanford held at least monthly meetings among the organizations' CEO-level leaders. Skipping meetings or sending lower-level delegates was not acceptable. Most of the meetings were supported by external facilitators and followed a structured agenda.
5) ***Backbone Support Organizations:*** Creating and managing collective impact requires a separate organization and staff with a very specific set of skills to serve as the backbone for the entire initiative. The expectation that collaboration can occur without a supporting infrastructure is one of the most frequent reasons it fails.

PARTNERSHIPS

New Mexico is in a good position to make a collective impact on STEM education – in large part because the state already prioritizes this work. "We have some incredible teachers in our schools and excellent professors in our universities," noted Kurt Steinhaus of Los Alamos National Laboratory when interviewed for this report. "We also have terrific nonprofit programs supporting our students, as well as a committed, engaged business sector. *Now we need to water the green spots.* Find the great teachers, professors, programs, and companies, and grow our partnership from there." [22]

Partnerships like these have succeeded across the nation. The most effective efforts include schools, business leaders, nonprofits, workforce boards, chambers of commerce, government agencies, and unions.[23] New Mexico and its students stand to gain considerably by tapping the shared wisdom of all these different sectors.

Project 2012 and Survey

One existing statewide partnership is Project 2012, a strategic plan begun in 2006 to improve STEM education in New Mexico. The plan currently contains over 50 specific strategies. Last summer, New Mexico First issued a statewide online survey to help prioritize Project 2012's strategies. Over 150 people answered the survey, and the resulting top priorities are presented throughout this document.[24] **Highlighted in copper**, these strategies will form the basis of the summit discussion.

Structure of Report

The remainder of this report is organized into three sections, each of which will inform a working group at the summit:

- **K-12 teacher preparation and professional development:** Focusing on how colleges train new STEM teachers and how schools support existing teachers.
- **K-12 STEM classroom experience**: Focusing on how to ensure students rigorously excel in math and science, and provide teachers the tools they need to be effective.
- **STEM students in college:** Focusing on how to recruit and retain STEM majors, including an effective transition from high school – and recognizing that women and minority populations are often under-represented in STEM fields.

In the appendix, readers will also find resources on federal initiatives, completed work, and existing NM STEM programs.

[22] (Steinhaus 2012)

[23] (Gordon 2009)

[24] In several cases, the wording of the Project 2012 strategies was simplified to advance group discussion.

Teacher Prep and Professional Development

K-12 STEM EDUCATORS

New Mexico and the nation must recruit great STEM teachers, and we must keep them in the profession. Across the country, about 25,000 math and science teachers leave the profession annually.[25] Overall, almost half (46%) of teachers abandon the profession in their first five years. For this report, we were unable to locate the number of New Mexico STEM teachers who leave the field each year, but it is likely that our state mirrors the nation in this regard.

Recruit

Nationally, research suggests that too many STEM classes are taught by non-STEM trained teachers, and declining achievement scores are tied to that reality.[26] A leading presidential advisory council recommends that the U.S. set a high recruitment target – 100,000 new STEM teachers – in the next decade.[27] They call for both deep content knowledge (including undergraduate degrees in STEM majors) as well as mastery of engaging teaching skills.

A consideration at the upcoming summit is whether New Mexico should set our own target and, if so, how to reach it. Our university system graduates a combined average of 125 new STEM teachers per year.[28] Currently, fewer than half of eighth grade teachers in New Mexico have an undergraduate major in the subject they teach.[29] As of 2008, over 1,100 teachers taught high school math, approximately 900 of whom were fully licensed and subject-matter endorsed.[30] Additional information on recruitment of STEM majors in general is addressed in the *STEM Students in College* section of this report, starting on p. 25.

"I support the idea of setting a state recruitment target for STEM teachers," said Amy Tapia of Sandia National Laboratory. "That is an actionable goal around which we can form a strong public-private partnership – and measure it."[31]

Attributes of a Great STEM Teacher

A presidential report offered qualities of great STEM teachers:[32]

- Deep content knowledge so concepts can be explained from multiple perspectives
- Commitment to staying current on the evolving body of knowledge in their fields
- Ability to make subjects "come alive" to students
- Confidence to encourage tough questions from students, and ability to offer equally challenging questions back to the class
- Ability to explain why concepts exist, rather than just saying, "Because it's a rule…"
- Desire to ignite in students an interest and lifelong study in STEM, rather than just a desire the pass the class
- Strong classroom management skills
- Ability to guide students in scientific inquiry, not just memorization

[25] (President's Council of Advisors on Science and Technology 2010, p. 61)
[26] (Feller 2010, p. 7)
[27] (President's Council of Advisors on Science and Technology 2010, p. viii)
[28] (Eastern New Mexico University 2011, p. 21)
[29] (Change the Equation 2012, p. 3)
[30] (New Mexico Math and Science Advisory Council 2009, p. i)
[31] (Tapia 2012)
[32] (President's Council of Advisors on Science and Technology 2010, p. 59-60)

Teacher Preparation

To develop educators with these attributes, teacher preparation programs at colleges and universities must provide strong STEM content, pedagogical training, effective student teaching experiences, as well as collection of data about teacher retention and teachers' impact on student achievement.[33]

Kristin Umland of the University of New Mexico, interviewed for this report, described the challenges of linking method instruction (*how* to teach) with content instruction (*what* to teach). "A typical college of education student might take her chemistry in a traditional large lecture class. When it comes time to take a methods course, it may be very general and not address chemistry instruction in detail. So she may never see how to apply, for example, active-learning strategies specifically in chemistry, either in theory or in practice. When does she learn how to apply those teaching methods specifically to chemistry? When does she learn how to make chemistry understandable for struggling students?" [34]

INQUIRY-BASED LEARNING

Two of the Project 2012 teacher strategies prioritized inquiry-based learning:

***INQUIRY TRAINING-Strategy 1.2(b)**: Include engaging problem-solving, inquiry-based math and science content and pedagogy in teacher preparation curricula. This action could be aided via additional involvement of university math and science faculty and STEM professionals. Greater collaboration between STEM faculty and education faculty could also support this strategy.*

Inquiry-based learning asks the students to seek knowledge, information, or truth through questioning.[35] It is often tied to project-based or cooperative learning. There are rising concerns that traditional, lecture-style teaching methods are less effective with current generations of students; as a result, many teachers pursue more active forms of instruction. Research supporting inquiry-based learning has shown the following:[36]

- Students learn more deeply when they can apply classroom-gathered knowledge to real-world problems, and when they to take part in projects that require sustained engagement and collaboration.
- Active learning practices have a more significant impact on student performance than any other variable, including student background and prior achievement.
- Students are most successful when they are taught how to learn as well as what to learn.

Active learning is a related educational model. A new study of children ages nine and ten looked at action's affect on learning math. The children were learning about fractions, either with manipulatives (tile pieces) or pictures. The children with the manipulatives learned faster and experimented more. However, both groups required additional instruction on the interpretation of fractions.[37]

Another strategy often discussed is the "**flipped classroom.**" This model enables students to use the internet to watch the lecture portion of the course at home, so that more classroom time can be devoted to interactive or hands-on work.

Another example is the Northern New Mexico Inquiry Science Education Consortium. Deploying inquiry-based science in grade K-6, ISEC serves 29 schools in seven districts serving over 8,000 students. Teachers receive ongoing professional

[33] (President's Council of Advisors on Science and Technology 2010, p. 63)
[34] (Umland 2012)
[35] (Teachnology n.d.)
[36] (Baron and Darling-Hammond 2008, p. 8)
[37] (Martin, Svihla and Smith 2012)

development and coaching. The program began in 2010, and is undergoing rigorous evaluation.

If the Project 2012 strategy on inquiry is advanced, more instruction must be provided by the colleges of education on how to use inquiry effectively. Noted Umland, the problem may be more challenging for math and science majors than other areas, because students learn a lot about how to teach from their own experiences. If their own learning experiences were primarily large-scale science lectures, they are more likely to replicate that style to their own classrooms. This issue may warrant additional consideration during the upcoming summit.

However, some teachers are wary of inquiry-based approaches. High school science teacher Lisa Durkin, interviewed for this report, worried that it is just another trend. She noted that teachers are asked to do more than they ever have, and – in an effort to improve outcomes – reformers frequently offer new "silver bullet" solutions.[38] "Educators can find themselves in a pendulum," Durkin commented. "First there is too much lecture, then it swings to too much project-based work that is often unfocused and slows down the curriculum. We need a happy medium."

Durkin also noted that project-based learning often requires materials and works best in small classrooms. Budget shortages put 35-40 students in a class and leave little room for the purchase of project materials. "It's a herculean effort to teach science or math well with 35 kids in a class – no matter what method you use."

A similar concern was voiced by middle school math teacher Aleli Colon.[39] "The biggest challenge is time. Inquiry-based learning allows students to think critically, but that takes time. It is not that we don't want to do it. We are just pressed for time with the vast list of requirements from the state that we have to cover." Colon said she values the inquiry-based model but has not used it in two years, because she does not have the time to coordinate with a colleague and develop the lesson plan.

SURVEY COMMENTS REGARDING INQUIRY-BASED LEARNING[40]

- *Some universities are already doing a great job of teaching about inquiry, but others need more involvement.*
- *Efforts such as the GK-12 program are a good example. Graduate students from the STEM fields are paired with teachers to enrich problem-solving and inquiry-based initiatives..*
- *I have seen no evidence of inquiry/project-based learning as a regular classroom teacher or as a university adjunct instructor.*
- *Although I have been doing inquiry-based learning, I don't know that it is common, and no one told me I ought to be doing it – that it was an initiative. It would be great if we could round up faculty who teach science courses to help with this effort.*
- *Inquiry-based and project-based learning is just not doable with Common Core and limited teacher time.*
- *Inquiry science professional development must be more in-depth than simply 'training to the kits.' We need more emphasis on professional development to include pedagogy and understanding of science/math concepts.*
- *It would be ideal to have 15-20 students when using the inquiry-based method because it is more manageable. With larger classes, the teacher is policing more that teaching.*

[38] (Durkin 2012)
[39] (Colon 2012)

[40] Survey quotes are included throughout this report. In some cases quotes were amended for brevity or clarity. Not all quotes were preprinted, due to space limitations or duplication.

Student Teacher Competencies

The Project 2012 survey also prioritized the following item:

***STUDENT TEACHERS-Strategy 1.2(c)**: Redesign entry-level math and science content competencies for student teachers at elementary, middle, and high school levels.*

Significant work was done on this strategy in 2009 and 2010. A statewide committee of math educators developed and proposed a framework of skills that student teachers in math would master before licensure. The draft competencies were aligned to the Common Core Math Standards.[41] Simultaneously, a national group – lead by the Conference Board of the Mathematical Sciences – developed a similar set of teacher standards.[42] It is currently undecided how the math teacher competencies will be finalized; it is possible that these two documents can provide a foundation to complete the work.

SURVEY COMMENTS ON STUDENT TEACHER COMPETENCIES

- *Developing these competencies absolutely needs to be high priority, aligned with Common Core State Standards.*
- *This effort was attempted once. If attempted again, the committee must have the authority to implement.*
- *Maybe do this later. Common Core takes priority.*
- *Teachers should be invited to participate in this effort. We have a lot of experience and content knowledge. Often these types of activities are disconnected from the reality of the classroom and needs of students and families.*
- *The focus should also include practices as well as competencies.*

Support New Teachers

As noted previously, almost half of teachers leave the profession in their first five years. The changing demographics of young teachers potentially calls for new management approaches. Project 2012 did not address this issue directly, so the summit planning committee offers the following strategy for discussion:

NEW TEACHERS-Strategy: Create and support school environments that enable new STEM teachers to thrive, feel supported, and remain in the profession for the long-term.

The school environment plays a crucial role in teacher's satisfaction with their jobs. Teacher survey research shows that a positive school environment relies heavily on effective administration. Teachers are obviously happier if they believe their school is well run and feel supported by leadership as well as peers. Many teachers also want to retain control over their classroom, including grading, discipline, and homework.[43]

"In my opinion, keeping a good administrator in the same school would be a terrific policy," said Durkin. "It would create more continuity and stability. Instead, districts seem to move the best administrators from school to school."

Another strategy to support new teachers is shared collaboration time. However, educators are divided about the benefits of this activity. For some, this opportunity enables them to learn from colleagues and align curriculum. For others, the obligation to attend additional staff meetings detracts from their own prep time, syllabus planning, and autonomy.[44]

[41] (Ahlstrom 2011, p. 1)
[42] (Conference Board of the Mathematical Sciences 2012)
[43] (Moore 2012)
[44] (Learning Point Associates and Public Agenda 2010)

GEN Y

Members of "Generation Y" (born between 1977 and 1995) comprise a growing portion of the education workforce. Currently, about 18% of teachers are Gen Y, and the number is growing.[45] This group is characterized as creative, innovative, and accustomed to positive reinforcement.[46] A recent study of Gen Y teachers identified four recurring themes:[47]

1) **Performance pay OK**: Gen Y teachers are more open to rewarding teachers differently for their performance and responsibilities in the classroom than earlier generations; however they are skeptical about using students' test scores to measure such performance.
2) **Performance pay not the *best* solution:** While Gen Y teachers are more likely to support performance pay than their peers, they still see it as a lower priority option for improving teacher effectiveness and retention. They prefer meaningful learning opportunities, reducing class size, and parental involvement.
3) **Remove poor teachers:** Many Gen Y teachers view removing ineffective colleagues from the classroom as a way to boost teacher effectiveness and think that unions sometimes protect poor teachers. However, they still feel it is important to preserve tenure protections.
4) **Give feedback:** Gen Y teachers tend to desire sustained, constructive, and individualized feedback from principles to help them become more effective in the classroom.

Bottom line: a great professional experience is key. Starting salaries for STEM teachers are considerable lower than what they could earn if they used their degrees to pursue careers in physics, computer science, or engineering.[48] These young people choose teaching for reasons other than money, and data shows that – at least near the beginning of their professional lives – they intend to make long-term careers of education.[49] So it is up to schools and administrators to create a rewarding work climate that makes these talented young people want to remain in the classroom. (Note: New Mexico pays teachers reasonably well, by national standards. The average teacher salary was about $52,000 in 2009, ranking us 16th in the nation.)[50]

Improve Professional Development

In addition to retaining new teachers, educators of all ages need ongoing support to remain current in their fields and develop new skills. It can be a challenge, however, to ensure that professional development is a benefit instead of a chore. If teachers are just "checking the box" to fulfill professional obligations, their students may not benefit. Project 2012 contains various recommendations and goals regarding professional development. For the purpose of the summit, the committee offers this combined strategy:

PROFESSIONAL DEVELOPMENT-Strategy: *Provide research-based STEM professional development that is useful for teachers and administrators.*

Across the nation, professional development programs are "a mixed bag" in terms of quality and impact.[51] Some are very useful. While research is limited, potentially effective approaches include:[52]

- Tie training explicitly to the curriculum taught to students.

[45] (Learning Point Associates and Public Agenda 2010, p. 1)
[46] (Learning Point Associates and Public Agenda 2010, p. 1)
[47] (Learning Point Associates and Public Agenda 2010)
[48] (President's Council of Advisors on Science and Technology 2010, p. 67)
[49] (Learning Point Associates and Public Agenda 2010, p. 17)
[50] (Teacher Salary Info 2009)
[51] (President's Council of Advisors on Science and Technology 2010, p. 65)
[52] (President's Council of Advisors on Science and Technology 2010, p. 65)

- Prioritize materials that have already proven effective with other teachers and students.
- Evaluate videos of teachers' own classroom with a facilitator.
- Provide guidance on the role of assessments to understand student progress.
- Have all teachers of the subject participate in the professional development, not just those who self-select into it.

Because time and money are factors, courses with online components may be worth consideration.[53]

Role of Industry in Supporting the Teaching Profession

Industry can play key roles in supporting teacher development.

- **Guest lectures,** such as those offered by Los Alamos National Laboratory, help keep teachers current on scientific development. Engaging content like *Capturing the Light: Scientific Imaging In the Modern World* make science teachers excited to attend.
- **Online professional development programs**, such as *Intel Teach,* can help teachers integrate technology into existing curricula and build critical skills. *Intel Teach* delivers online, blended, or face to face instruction for existing teachers and teachers-in-training. E-tutorial topics include assessment strategies, collaboration in modern classrooms, using inquiry in science classrooms, project-based learning, educational leadership, and thinking critically with data.
- **Teacher tours,** such as those periodically offered by Sandia National Laboratory, can provide teachers the opportunity to see STEM workplaces. Amy Tapia of Sandia notes that there is a perception that only the 'best and brightest' students should be encouraged to pursue STEM fields. "When we brought teachers into our workplace, they saw a wide range of professionals, from hands-on technicians to Ph.D. researchers. They realized there was a continuum of potential STEM jobs for students with different talents."
- **Hands-on lab or field observations** in professional work places give teachers tangible examples to integrate into their lesson plans.

CASE STUDY

Skill-Building for Espanola Teachers

Last summer, 21 K-12 teachers attended a five-day workshop designed to help them better understand and teach earth and space science. Developed and administered by the LANL's Northern New Mexico Math and Science Academy, the workshop was titled "Earth Science in a New Mexico Context."

The sessions included hands-on and computer-based interactive programs that covered everything from phases of the moon, to the evolution of the Earth's crust, to the planet's water cycle. By the end of the sessions, the teachers' own test scores for the subject matter showed improvement.

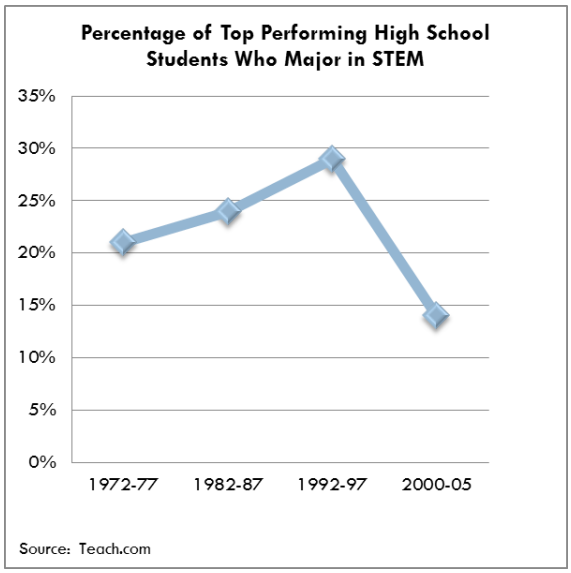
The sessions were designed to give the teachers tools that are readily transportable into their classrooms. With this knowledge, they will be able to help their students break free of misconceptions such as the idea that seasons are caused by the relative distance of the Earth from the Sun, when in actuality, seasons caused by the tilt of the Earth's axis.

[53] (President's Council of Advisors on Science and Technology 2010, p. 65)

K-12 STEM CLASSROOM EXPERIENCE

Why Isn't STEM Cool?

Given our culture's growing love of technology – iPhones, video gaming, Twitter, iTunes – it is puzzling why more students do not thrill to STEM courses in school. Yet during the years that technology use has exploded, student interest in STEM has declined. The following chart shows a 15% drop since the mid-1990s in top performing high school students who chose to major in STEM after graduation.[54]



The decline matters. Nearly four in five STEM college students decide to study science or math in high school or earlier.[55] Research shows that too few students take higher level math and science courses, and thus struggle later if they choose a STEM career like nursing. A 2011 study found that only 45% of U.S. high school graduates were prepared for college-level math, and only 30% were prepared for college-level science. [56]

The problem starts long before high school. Only one in 10 eighth graders are on target to be ready for entry-level college courses in algebra, biology, social science, and writing.[57] However, boys and girls who show interest in STEM in eighth grade can be three times more likely to later pursue STEM degrees.[58]

To reach those future eighth graders, inspiration in STEM must begin much earlier. From pre-school on, students need exciting experiences in the classroom and beyond it. These experiences should reveal to them the satisfaction of solving a problem, discovering a pattern, becoming curious about a puzzling question, or building an invention.[59]

Parents

Parental motivation is a key element of academic success, including in STEM. When parents, guardians, or other family members have high expectations for children, those students are much more likely to devote the time and energy needed to excel. If parents know and understand the relationship between STEM skills and future employment, they can urge their children to work hard, take high-level courses, apply for internships, or consider STEM fields for their careers.[60] "Parents are usually their children's first teachers and can have the greatest impact on their drive to succeed," said Kurt Steinhaus of Los Alamos National Laboratory. "They can also be their children's best advocates – if they know how."[61]

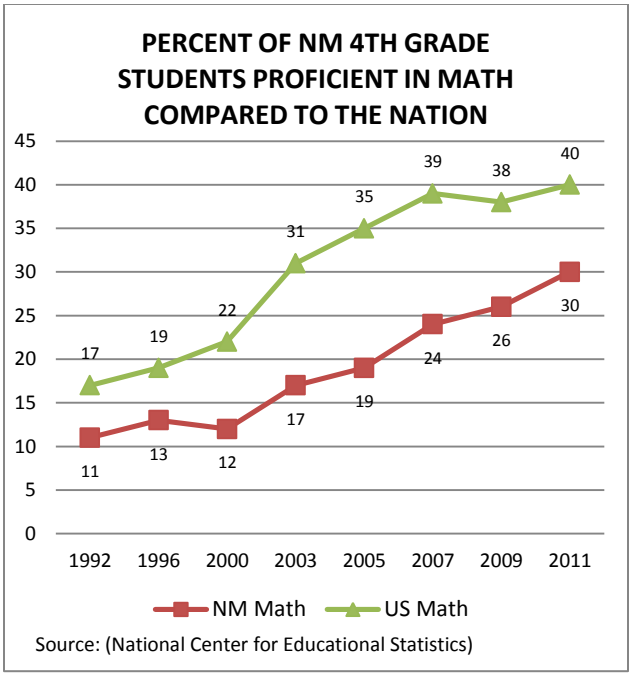
[54] (Teach.com 2011)
[55] (Microsoft (Survey) 2011)
[56] (Microsoft 2011, p. 10)
[57] (ACT, Inc. 2008, p. 2)
[58] (President's Council of Advisors on Science and Technology 2010, p. 87)
[59] (President's Council of Advisors on Science and Technology 2010, p. 20)
[60] (Feller 2010)
[61] (Steinhaus 2012)

New Mexico Academic Performance

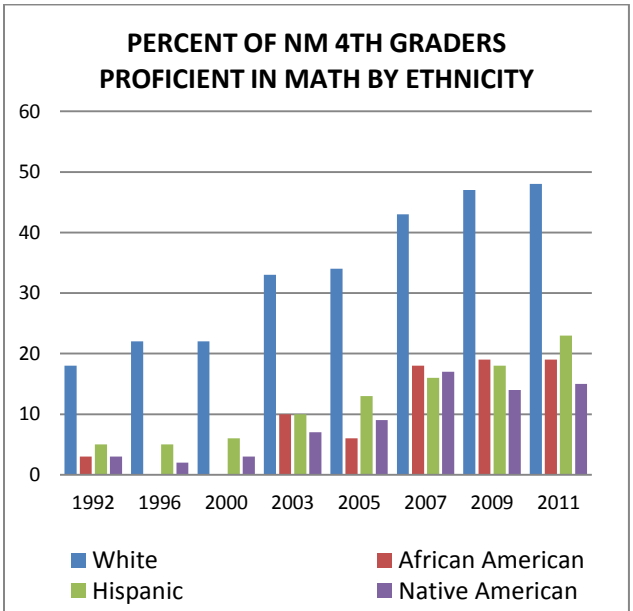
The National Assessment of Educational Progress is one way to measure how students perform over time, compared with other states. Since 2003, eighth grade math scores improved 11 points. Educators agree that is good news, but there is still work to be done.

In 2011, NAEP reported that the average reading score for New Mexico 4th graders was significantly lower than 4th grade reading scores in 46 other states. The following charts compare proficiency with the nation and between different ethnic groups.[62]

While an income chart is not available, it is interesting to note that many researchers now believe that parent income has the bigger impact on academic achievement than race/ethnicity.[63] The Coalition for Excellence in Math and Science Education, however, has found that for New Mexico the combination of both poverty (as measured by Free and Reduced Lunch) and ethnicity significantly outweigh the impact of either of these factors individually.[64]



Source: (National Center for Educational Statistics)



Source: (National Center for Educational Statistics)

[62] (National Center for Educational Statistics 1992-2011)
[63] (Tavernise 2011)
[64] (Coalition for Excellence in Science and Math Education 2012, p. 3)

Classroom Rigor

Multiple reports reviewed for this document called for increased rigor in science and math classrooms.[65] Furthermore, Project 2012 survey respondents prioritized classroom rigor.

RIGOR-Strategy 3.9: *Encourage school polices that increase curriculum rigor. Options might include teaching math every day, teaching science at least every other day, and using homework effectively.*

HOURS

Educators widely agree that the amount of time a school devotes to a subject correlates to student achievement. There is less agreement about whether teaching a subject every day, versus a block schedule that devotes longer periods three days a week, is preferred.[66] What seems to matter is that considerable time is devoted to the subject. For example, some people are concerned that the number of hours per week spent on science in New Mexico first through fourth grades declined by about a third since the mid-1990s.[67]

ADVANCED CLASSES

One strategy offered by a leading science council is accelerated learning. Such learning might be "pull-out" sessions in elementary or middle school for students who want to go beyond the curriculum.[68] The council also spotlighted three promising high school opportunities:[69]

- **Increased use of Advanced Placement courses:** Based on PSAT scores, researchers believe that many more high schoolers are capable of AP work, but for some reason do not take the courses. For example, only about 7,000 Hispanic and African American students currently pass AP calculus each year, but PSAT scores predict that 123,000 should be on track to pass. Even if more of those students took AP courses, however, there are still concerns. Researchers note that AP courses rarely promote inquiry-based science and sometimes move at such a rapid pace that students do not necessarily develop a robust grasp of important concepts. (In a 2011 New Mexico study, educators reported that the expansion of Advanced Placement courses was helping increase academic rigor for a broad student population.)[70]
- **International Baccalaureate:** These inquiry-driven schools make extensive use of project-based learning. At the 11th and 12th grade levels, the IB Diploma Program requires rigorous academic achievement. Students must have studied a foreign language, completed a theory of knowledge class, and taken six challenging examinations. These exams translate into college credit in New Mexico and most other states. There are currently a small number of IB schools in New Mexico, located in Albuquerque, Santa Fe, and Las Vegas. Sandia High School in Albuquerque is currently undergoing IB authorization.
- **College and online courses:** Advanced STEM courses can be taken online, a particularly promising option for students in low-income or rural schools that may not offer higher-level courses. The IDEAL-NM program (Innovative Digital Education and Learning) provides a wide range of online courses. New Mexico was the first in the nation to establish this particular online model, and the program is a joint program of the New Mexico Public Education and Higher Education Departments.

[65] (ACT, Inc. 2008) (Feller 2010) (Microsoft 2011) (President's Council of Advisors on Science and Technology 2010)
[66] (Diaz 2012)
[67] (Change the Equation 2012)
[68] (President's Council of Advisors on Science and Technology 2010, p. 90)
[69] (President's Council of Advisors on Science and Technology 2010, p. 90)
[70] (UNM Center for Education Policy Research 2011, 16)

COMPUTER SCIENCE

Computer science lies at the heart of the modern economy, daily lives, and scientific research. Ironically, as the role of computing has increased in society, the amount of educational time devoted to it has declined significantly. In the last five years, there has been a marked decline across the country in the number of introductory and AP computer courses being taught in middle and high schools.[71]

A "report card" analysis compared computer science policies in all 50 states. For New Mexico, it determined that we have no stand-alone technology standards, but that existing science standards include a strand on "science and society" that includes a few computer science items. It also noted that New Mexico does not have a technology literacy requirement for graduation. Computer science counts as an elective credit for graduation. Currently nine states allow computer science courses to count as required graduation credit for either math or science.

EPSS

Public schools and districts throughout New Mexico are required to develop an Educational Plan for Student Success each year. The EPSS is a continuous improvement strategic plan that includes student achievement data as well as information on attendance, school safety, student wellness, and other topics. Each school reports its progress each quarter. Currently, the EPSS requires academic reporting on reading and math, but not science.

Project 2012 offered the following strategy regarding EPSS:

EPSS-Strategy 3.8b: *Require Education Plans for Student Success (EPSS) to include science as a goal area.*

"I definitely agree that science should be part of the EPSS," said Corrales International School principal

SURVEY COMMENTS ABOUT HOMEWORK AND HOURS OF MATH AND SCIENCE

- *Homework cannot become a burden, but must be "fun."*
- *Homework will only be valuable if the parents value it as a necessary tool.*
- *Homework that supports learning is important, but asking students to do science fair projects is homework for parents.*
- *In-school experiences are more valuable than homework. Homework should be decreased unless it is project-oriented. No more worksheets.*
- *Mastery requires students begin scientific pursuits in elementary schools.*
- *Science every other day would be a vast improvement from the once a month I sometimes see!*
- *How about science every day? It can be taught interdisciplinary, including with language arts and math.*
- *The emphasis on teaching science in elementary schools is severely lacking in schools in the southern parts of the state.*
- *This is a professional development issue, in terms of instructional design. Math and science can be integrated into other assignments to a much greater degree.*
- *Math and science should be completely integrated with literacy, especially at the elementary level, and also integrated with elective classes.*

[71] (Computer Science Teachers Association 2012)

Elsy Diaz, interviewed for this report.[72] "The EPSS helps the school focus its data collection. Schools might tend to focus only on reading and math because that's all they must report on. However, the EPSS is not necessarily the only tool to get schools to focus on science. We voluntarily increased the time students are spending in science and technology, because we know they need the skills."

The national organization, Change the Equation, recommends that New Mexico "make science count" in some way. "New Mexico sets a higher bar than most states for its science test. However, the state should also begin holding schools accountable for their students' performance on its science tests. … When there are no consequences for science achievement, schools can easily give science short shrift."

SURVEY COMMENTS ON EPSS

- *A goal can be put in but until it is assessed and has value in the school grade, there won't be much energy put toward it.*
- *Adding "requirements" or "mandates" without additional support results in a hollow victory. If the only metric is test scores, how do schools quantify science results?*
- *How can science **not** already be on EPSS?!*
- *I definitely say science needs to be added.*
- *This is an excellent goal but rather than more requirements, establish a process where district leadership, principals, and teachers are provided opportunities to learn why this is so important. More mandates don't mean understanding.*
- *With the SBA's focus on reading and math, this would be hard to implement.*

[72] (Diaz 2012)

Academic Standards

A lot has happened in recent years regarding academic standards. As late as 1989, all the STEM classes a student needed to graduate from high school were two units in math (both of which could be at the pre-algebra level) and two units in science. Legislation in 2003 required algebra for high school graduation. Currently the state requires four units in math (at least one at algebra 2 level) and three units of science (two with a lab component).

This year, New Mexico, along with 45 other states, adopted the Common Core State Standards in math and reading. The standards are internationally benchmarked, so states can compare with each other and with other nations.[73] The project was led by the bipartisan National Governor's Association and the Council of Chief State School Officers. In New Mexico, the new standards will be fully phased in by 2015.[74]

A similar set of standards in science education are being developed by a national coalition of experts. The project is managed by Achieve, a bipartisan nonprofit that focuses on student assessment. Like the Common Core, these draft science standards are internationally benchmarked.[75] Currently, 26 states plan to use these Next Generation Science Standards. New Mexico has not announced whether it will take part.

[73] (Microsoft 2011, p. 10)
[74] (New Mexico Public Education Department 2011)
[75] (Microsoft 2011, p. 10)

Quality Materials and Techniques for Teachers

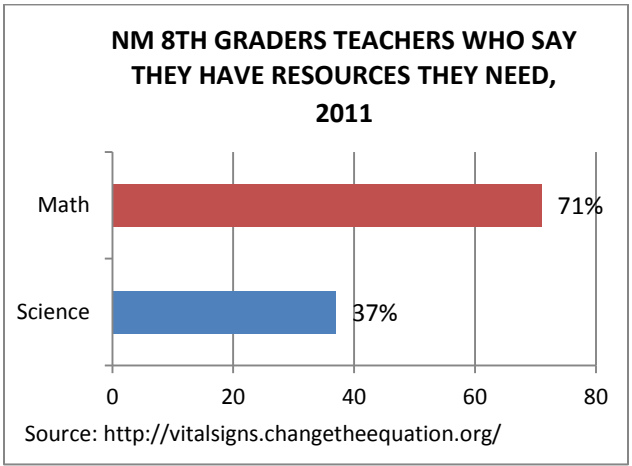
Shared standards create the opportunity to develop improved instructional materials, and the need for those materials to support the new benchmarks.[76] The summit planning committee and Project 2012 offer the following strategies regarding materials:

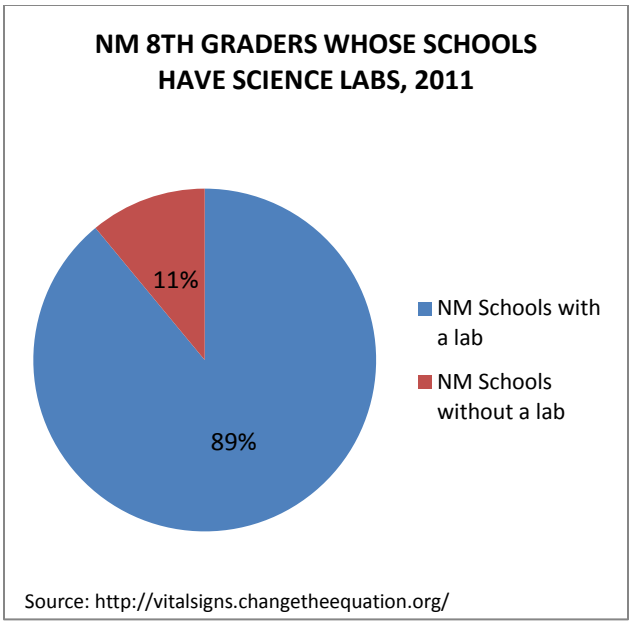
MATERIALS-Strategy: *Leverage the Common Core standards (and potentially the Next Generation Science Standards) to provide common, high-quality curriculum materials to more students, including hands-on experiments and team research projects.*

INQUIRY MATERIALS-Strategy 3.5: *Provide solid professional development and materials for inquiry-based teaching techniques.*

Inquiry-based education may require different materials than traditional teaching models. For context on this question, see p. 13.

Regarding materials in general, it is hard to know whether teachers have the resources they need. There is limited data. However, one study of New Mexico eighth grade educators indicates that math teachers are more likely than science teachers to believe they have adequate teaching tools.





Role of Industry in K-12 Classrooms

There are a number of ways that the private sector can engage with the K-12 system directly.

- **Guest speakers** in classrooms and at school career days provide students important information about the workplace. Among other things, these role models can reinforce the value of higher-level math and sciences courses.
- **Funding** for enhanced activities, such as science materials or other resources schools may lack, can make a difference in the classroom. This strategy can be particularly helpful if funding is designated for specific curriculum-linked activities.
- **Project-based learning** can be difficult for teachers to plan, due to limited time and sometimes limited exposure to industry activities. When teachers and industry representatives work together, the lessons can be more relevant than if the teacher were working alone.

[76] (President's Council of Advisors on Science and Technology 2010, p. 39)

- **Competitions** like science fairs, math contests, computer challenges, or robotics competitions need judges, coaches, organizers, travel support, and funders. Local businesses can step into any number of these roles.

CASE STUDY

nex+Gen Academy

nex+Gen is a magnet for "21st century learning," meaning it uses project-based learning that emphasizes skills and knowledge deemed most essential for succeeding in an increasingly connected world. nex+Gen Academy has a capacity of 400 students in grades 9-12, and is located in Albuquerque. Students are expected to build and demonstrate mastery of standards in core content through collaboration and technology integration. Technology is viewed as a professional tool to advance student work, so every student has a laptop.[77]

A public-private partnership conceived and built the school, including Albuquerque Public Schools, New Technology Foundation, Sandia National Laboratories, Intel, and Technology Integration Group. "The goal is for nex+Gen to be a model school for project-based learning," said Amy Tapia of Sandia. "It is piloting new educational strategies that we hope other schools replicate." [78]

National proposals call for more STEM-focused schools across the country.[79] While nex+Gen is not exclusively a "STEM school," its focus on project-based learning and technology make it an environment where math and science studies are likely to flourish.

(Sources: nex+Gen Academy and APS)

CASE STUDY

Supercomputing Challenge

More than 200 New Mexico students and their teachers participated in the 22nd annual New Mexico Supercomputing Challenge held at Los Alamos National Laboratory last April. The winner was Jordon Medlock from Albuquerque's Manzano High School. He won for his computer algorithm that automates the process of counting and analyzing plaques (substances in the blood such as fat and cholesterol) in magnetic resonance images of persons diagnosed with Alzheimer's disease. The program vastly speeds up the process of identifying the very small and difficult to see plaques.

In all, 60 teams representing elementary, middle, and high schools took part in tours, talks, and demonstrations with Los Alamos scientists and researchers. More than 100 LANL employees worked on the project.

The goal of the year-long competition is to increase knowledge of science and computing, introduce students and teachers to computers and applied mathematics, and instill an enthusiasm for science in the students, their families, and the community. The challenge is project-based learning, geared to teaching participants a wide range of skills, including research, writing, teamwork, time management, oral presentations, and computer programming. Any New Mexico elementary, middle school, or high school student is eligible to enter.

(Source: Los Alamos National Laboratory)

[77] (Albuquerque Public Schools 2011)
[78] (Tapia 2012)
[79] (President's Council of Advisors on Science and Technology 2010, p. 97)

Recruitment and Retention

STEM STUDENTS IN COLLEGE

Note: *All of the discussion strategies in this chapter are offered by the summit planning committee.*

Recruit STEM Majors

This section obviously ties to the previous one. The best way to recruit STEM majors is to engage them when they are young. Regardless when recruited, all projections point to the fact that we simply need more – many more – college STEM majors.

Nationally, a presidential advisory council calls for one million *more* STEM majors in the next decade than our educational system will produce at its current rate.[80] To meet that goal, American colleges and universities need to graduate 34% more STEM majors than they do today. In addition to STEM majors in general, many companies are particularly interested in increasing the number of computer science majors.[81]

Higher education institutions deploy various tools to recruit students to STEM fields, including:

- Recruitment visits to high schools
- Dual credit
- Scholarships (academic and need-based)
- Summer science programs for high school graduates to get them ready for college
- Targeted recruitment of students whose majors are undeclared
- STEM speakers in career planning or other first-year college courses
- Other on-campus recruitment strategies during students' first two years of college

For example, the National Science Foundation announced funding this month for a new pilot program at the University of Central Florida to recruit STEM majors from the entering freshman class. Using SAT scores, the school will determine which freshmen appear to have the potential to do well in science or math. Then the school plans to "inundate them during their first semesters with opportunities to explore what a job in a STEM area might look like." [82] All entering UCF students are also encouraged to take a career planning course that includes information on STEM jobs.

DUAL CREDIT

Another tool, used in New Mexico and other states, is dual credit. In our state, this program allows high school students attending approved schools to earn both high school and college credit for qualifying courses. It essentially gives students a jump-start by letting them earn some college credits before they even finish high school. Recent research indicates that high school educators support dual credit because the courses serve many sectors of the high school student population, including first generation college students. Furthermore, dual credit courses provide opportunities to investigate career options and take career technical courses not available in high school.[83]

"We live in a state where many students will be the first in their families to attend college, and we need to ensure those students feel confident that they are college-ready," said Terri Nikole Baca of the New Mexico STEM Network. "Completion of college credits in high school encourages a seamless transition to post-secondary education, and

[80] (President's Council of Advisors on Science and Technology 2012, p. i)
[81] (Microsoft 2011, p. 20)

[82] (University of Central Florida 2012)
[83] (UNM Center for Education Policy Research 2011)

increases the likelihood of success in earning a high school diploma and a college degree."

While there is clear evidence of the value of dual credit overall, there is very little data on the impact of dual credit on student success in STEM in particular.[84] This is an item that summit participants may want to consider.

Focus on Women and Minorities

Nationally, women and members of minority groups constitute about 70% of college students, but they comprise only about 45% of undergraduate STEM majors.[85] These students make up an "underrepresented majority" that could make a huge difference in the nation's STEM workforce. As of 2008, Hispanics, African Americans, and Native Americans made up 26% of our country's workforce, but only 9% of employees in science and engineering fields.[86] Looking to the future, it is easy to see why so many major technology companies (Intel, Microsoft, IBM, Google) invest in programs that encourage STEM among women and minorities. These populations are just too critical a resource to remain untapped in the growing tech economy.

In New Mexico, the Hispanic population is rising steadily, making up 47% of the state's 2010 population. Hispanics earn about 28% of the STEM degrees and certificates awarded in this state. Women (of all races) earn about 30%. [87]

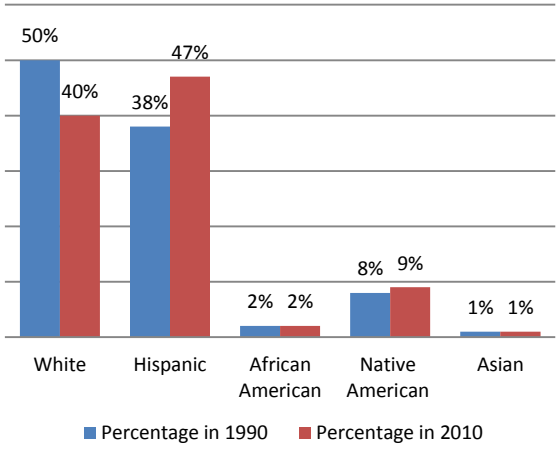
RECRUIT-Strategy: *Pursue multiple approaches to recruit high school students as well as college freshman and sophomores to STEM majors. Include efforts that reach out to girls and minorities.*

[84] (Winograd 2012)
[85] (President's Council of Advisors on Science and Technology 2012, p. 5)
[86] (Microsoft 2011)
[87] (Change the Equation 2012)

Retain STEM Majors

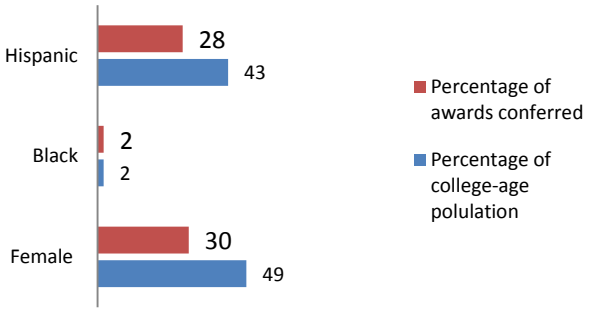
In addition to recruiting students to STEM degrees, colleges and universities must hold on to them. Nationally, fewer than 40% of students who enter college intending to major in a STEM field complete a STEM degree.[88] Completion rates are even lower for women and minorities.

NM Population by Cultural Idenitity, Years 1990 and 2010



Source: New Mexico Department of Finance and Administration,

Percentage of Degrees/Certificates Conferred in STEM, 2009



Source: http://changetheequation.org/sites/default/files/vital-pdfs/NM-CTEq-vital-signs.pdf. Data was not availble for the Native American population.

[88] (President's Council of Advisors on Science and Technology 2012, p. i)

It is hard to know how many STEM majors we retain in our state, according to Dick Howell of the University of New Mexico. "Most students going into education, mathematics, and the sciences at UNM don't declare their major area of studies until their 1st semester, junior year," said Howell. "This means that we only have a rough idea of how many freshman and sophomores are serious about entering the sciences, mathematics, technology and education (math and science education) fields. It is different with engineering, whose students enter that school in the freshman year. We also have gateway courses, like math 120 and 121 and beginning calculus, that stop many students before they even get started. These factors need to be considered in any effort to reform a system of early identification, tracking and monitoring of students in stem fields at UNM." [89]

REMEDIATION

Almost half (46%) of New Mexico college students must take remedial courses in core subjects such as math, literacy, or science before they can begin college-level work.[90] In 2011, a Center for Education Policy Research study of eight New Mexico school districts found that students are more likely to need college remediation in math than in literacy. [91] The same CEPR study found that students who took four or more math courses in high school were less likely to need remedial courses in that subject than students who took fewer.

While remediation is an important tool for improving student skills, it also slows down students' progression through school, costing time and money. It can be a barrier to student advancement, and some advisors urge students to avoid the "remedial trap" at all costs.[92] Educators surveyed or interviewed by CEPR strongly recommended that remediation in college be better defined, practice tests made available, and communication between high schools and higher education strengthened so that fewer students need the basic courses.[93]

On a related note, educators in the study also felt that the lack of alignment in curriculum and assessments between high school and higher education negatively impacts the transition between high school and college.[94]

WHY DON'T STUDENTS FINISH STEM DEGREES?

Students who change majors from STEM do so for any number of reasons including: [95]

- Finding the work more difficult than expected
- Not feeling adequately prepared in high school for college level work
- Not exceling in, or enjoying, lecture style courses
- Not developing positive relationships with professors
- Finances or family obligations
- Not feeling that they belong
- Not enough time for social life
- Wanting to pursue something "more creative" or "more hands-on"

The first two years are a critical time for retaining STEM students. Some professors believe that, if students leave for the reasons above, it is just part of a natural "weeding out" process that keeps the "brightest" students in STEM majors.[96] Others see

[89] (Howell 2012)
[90] (New Mexico Children's Cabinet 2012)
[91] (UNM Center for Education Policy Research 2011, p. 14)
[92] (Jacobs 2012)
[93] (UNM Center for Education Policy Research 2011, p. 17)
[94] (UNM Center for Education Policy Research 2011, p. 17)
[95] (Penn State 2007), (Seymour and Hewitt 1997), (Umland 2012)
[96] (President's Council of Advisors on Science and Technology 2012, p. 30)

the attrition rate as a serious problem that warrants changes to the higher education system.[97]

Faculty Teaching Strategies

Some of these challenges may arise because the college teaching environment is often quite different from the high school culture. Classes are often smaller in high school. In some places – though not all – high school teachers use active-learning approaching with hands-on work like dropping eggs into water to test the first law of motion. That excitement can fade when new college students begin the "math-science death march," as retired engineering professor David Goldberg calls it.[98] College freshmen dive into a barrage of calculus, physics, and chemistry courses in lecture halls with dozens or hundreds of students.[99] After a semester or two, many students change majors. One report asserts that most faculty are unfamiliar with the "vast body of research" showing the impact of evidence-based, active learning models.

"Professors have a lot of autonomy in the classroom and they value their academic freedom. Changes to teaching practice must be voluntary and will not happen unless faculty believe that such changes are worthwhile. This takes a lot of time and opportunity to talk with other faculty members about what they are trying to accomplish in the classroom, and may require professional development," said Kristin Umland of the University of New Mexico. [100]

PUBLISH OR PERISH

Another issue is the university tenure system. Most tenure policies in research institutions place heavy emphasis on research and publishing, sometimes giving it greater weight than teaching. A recent presidential advisory council report called for university presidents and provosts to "galvanize faculty through resources and rewards" for quality teaching. They noted that department chairs would also be essential for enacting changes.

CLASSROOM TECHNIQUES

A team of University of Michigan researchers nationally distributed a series of recommendations for how to "teach for retention" in science, engineering, and math: [101]

1) Create a welcoming and **supportive** learning environment with challenging (not trivial) but manageable (not overwhelming) work.
2) Clearly communicate grading policies and provide frequent feedback on student learning.
3) Encourage students to engage in the scientific method, creating opportunities for them to generate hypotheses and test them, interpret data, draw conclusions, and make predictions.
4) Bring real-world relevance into the classroom and highlight careers in STEM.

***FACULTY TEACHING-Strategy**: Address opportunities and challenges within the university system in order to increase the quality of undergraduate teaching.*

College Support Strategies

New Mexico higher education institutions are already doing many things to retain STEM students. For example, Tim Schroeder directs the STEM Gateway Program at UNM. The project supports undergraduate students through course redesign in core science courses, collaborative learning activities, and referrals to other services. Part of the program's goal is to support underrepresented populations. "Ours is just one of many programs on campus for STEM students," commented Schroeder

[97] (President's Council of Advisors on Science and Technology 2012, p. 30)
[98] (Drew 2011)
[99] (Drew 2011)
[100] (Umland 2012)
[101] (Center for Research on Learning and Teaching 2009)

when interviewed for this report.[102] "Some are designed for honor students, others are culturally-based, and some are promoting student research. Students gravitate to the ones that fit them best."

"There are various networks trying to pull all the programs together, but these efforts often struggle to gain traction, and many are in preliminary phases." Schroeder thinks the STEM programs could coordinate better on individual campuses, and that STEM projects as a whole could coordinate better statewide.

Student support programs can also feed nicely into professional associations, such as the:

- National Society of Professional Engineers
- Society of Hispanic Professional Engineers
- Society of the Advancement of Chicanos and Native Americans in Science
- American Indian Science and Engineering Society
- NM Network for Women in Science and Engineering

COORDINATION

Schroeder believes it is good to have a wide range of programs, but he thinks the efforts could be better coordinated. "There are various networks trying to pull all the programs together, but it's kind of a hodgepodge." Schroeder thinks the programs could coordinate better on individual campuses, and that STEM projects as a whole could coordinate better statewide.

STUDENT SUPPORT-Strategy: *Improve quality and coordination of student support services, e.g., social and cultural support, special-interest learning communities, and academic mentoring.*

Student Research

One way to keep students engaged in STEM is to let them take part in research activities. "We want them to do research because that's the cool, interesting part of STEM. That's what keeps them engaged," said Selena Connealy of NM EPSCoR. "Students are more likely to be excited about hands-on work, and thus they are more likely to complete their degree."[103]

New Mexico Tech runs a range of student research programs. The Interdisciplinary Science for the Environment-A Summer Research Experience Programs at New Mexico Tech allows 12 students to spend nine weeks working on a hands-on summer research project, live on campus free, receive a stipend and earn four college credits. The program is open to students enrolled at any New Mexico college or university.[104]

UNDERGRAD RESEARCH-Strategy: *Increase opportunities for undergraduate research in STEM disciplines.*

Industry Role in Higher Education

Companies in New Mexico have every reason to help increase the number of STEM graduates. For example, Intel has an agreement with Sandoval County to try to select New Mexican for at least 60% of its new hires. The company generally meets the target, but was unable to in 2011, 2009, and 2006.

"As our technology becomes more complex, so does our need for employees with advanced degrees and skill sets," explained Brian Rashap, Intel New Mexico's Site Manager. "About 85% of our new hires last year required a master's in engineering. While our desire is to hire New Mexicans, we, like all our other Intel sites, have to look a little harder

[102] (Schroeder 2012)

[103] (S. Connealy 2012)
[104] (NM Tech)

for the advance degrees. We are having good discussions with our local universities and are piloting some programs to encourage more engineering students to pursue advanced degrees."[105]

There are a number of industry-related strategies for increasing the number of STEM graduates. focus on the first two years of college. Some examples for increasing STEM graduates include:

- **Targeted programs**, such as Intel's "Ultimate Engineering Experience," provide hands-on technical work. Students earn a stipend for participating in the six-week program, and they do tangible projects (like building a robot and developing an app). The program is for college freshman and sophomores.
- **Internships** can take place during undergraduate or graduate years. Sandia National Laboratories hosts 700-900 students interns a year. Last year Los Alamos National Laboratory had over 1,000 interns. And Intel announced this year a national commitment to creating 1,000 additional student intern positions, beyond what it currently runs.
- **Donated technology** or other items can make a difference in the classroom. Some items might still be useable by students. Other things might be interesting to just take apart. "We had an old robot we couldn't use anymore," commented Amy Tapia of Sandia National Laboratories. "We donated it to Highlands University where students are using it to develop senior capstone projects." [106]
- **Professional societies,** such as the student chapter of the Institute of Nuclear Materials Management, coordinate guest lectures from the private sector to engage students and present career information.
- **Curriculum development:** Industry can work with academia to develop materials, industry-specific courses, or advisory committees. These strategies can enhance the rigor and relevance of students' coursework.

JTIP

The Job Training Incentive Program offers one strategy for preparing students for careers in New Mexico. Funding classroom and on-the-job training for newly created jobs, JTIP focuses on expanding or relocating businesses. The program reimburses 40-75 percent of employee wages for up to six months. Custom training at a New Mexico public educational institution may also be covered.[107]

INTERNSHIPS-Strategy: Increase opportunities for industry to engage with the higher education system and with college students directly, including internships, job training, and other tactics.

CONCLUSION

How will New Mexico respond to the growing need for students with strong STEM skills? How will we ensure that our teachers and professors have the knowledge and training they need? And how will we ensure that our industry, small business, government, education, and nonprofit sectors are all collaborating for the greater good?

These questions and others will be addressed by participants at the November 2012 summit. An action plan will be developed and published at www.nmfirst.org.

[105] (Rashap 2012)
[106] (Tapia 2012)
[107] (NM Partnership n.d.)

Appendix A

FEDERAL ISSUES

The primary purpose of the summit is to develop state and local action plans. However, numerous entities around the country are advancing federal reforms on STEM policy. The summit's implementation team may develop a federal platform, informed by the following options. **At this time, none of these recommendations are formally endorsed by the summit or its organizers; the ideas are presented for reference only.**

Teacher Preparation

Recommendations to recruit and prepare the next generation of great teachers include:

- Continue to fund scholarships for college students who commit to five years of teaching after obtaining bachelor's degrees in STEM fields and certification as K-12 math and science teachers.
- Strengthen the skills of 250,000 teachers through summer, master's, Advance Placement, or International Baccalaureate training programs.

K-12 Education

The President's Council of Advisors on Science and Technology released two reports in the last two years, one directed to K-12 education, the other directed to higher education. All of the following suggestions come from PCAST's K-12 report except the final one, which comes from the Gathering Storm committee.[108]

- Set a federal goal of 100,000 new STEM teachers in the next decade.
- Create 1,000 new STEM-focused schools in the next decade.[109]
- "Vigorously support" state-led efforts to develop common standards in STEM subjects, providing both financial and technical support.
- Recognize and reward the top 5% of America's STEM teachers, by creating a STEM master teacher corps. Corp members would receive salary supplements as well as funds for activities in their schools.
- Create an agency for advanced research projects in education, housed in the Department of Education or the National Science Foundation, to develop innovative technologies and technology platforms for learning, teaching, and assessment for all subjects, plus effective "whole-course" curricula for STEM in particular.
- Reauthorize the America COMPETES Act.

Higher Education

Some of the key recommendations PCAST developed for the college and university system follow. [110]

- Advance widespread adoption of empirically validated teaching practices, including active learning, with the goal of training 10% to 20% of nation's 230,000 STEM faculty. Funding for the training/retraining would come from the federal government, academic institutions, disciplinary societies, and foundations.
- Replace standard lab courses with discovery-based research courses, focusing heavily in the

[108] (President's Council of Advisors on Science and Technology 2010), (Rising above the Gathering Storm Committee 2010, p. 17)

[109] The Gathering Storm committee also calls for more STEM schools, but does not quantify it.

[110] (President's Council of Advisors on Science and Technology 2012)

first two years of college. Couple the course remodeling with more independent student research on faculty projects.

- Launch a five-year, multi-campus "national experiment" in college math education to address the skills gap in college math preparedness. The experiment would include a variety of approaches, each evaluated for effectiveness.
- Improve partnerships to diversity pathways to STEM careers, with stakeholders including community colleges, universities, private companies, nonprofits, and others. Include data collection on STEM jobs and promote pathways for underrepresented groups.
- Create a Presidential Council on STEM Education with leadership from the academic and business communities to provide strategic leadership in STEM undergraduate education.

U.S. Business Community

Rebuilding the STEM pipeline will require investments by many sectors. One goal is to encourage more small and large businesses to invest in employee training.[111] Such training may require community partnerships with other companies, community colleges, or local entities. Recommendations to support this effort include: [112]

- Encourage community investments by allowing businesses to depreciate investments in training and education, just as they now depreciate investments in plants and equipment.
- Aim to increase the combined U.S. business investment in training and education from the roughly $53 billion it is today to $100 billion.

Immigration and Visas

Many companies rely heavily on H-1B "specialty occupation" visas to import workers from overseas. Experts predict that the U.S., Europe, and Japan will experience increasing difficulty importing enough of these employees in the next decade because more Chinese and Indian professionals will find good jobs in their own countries.[113] Some companies say they cannot fill the needed position today. Microsoft released at 2012 report with the following recommendations:[114]

- Create a new, supplemental allocation of 20,000 visas annually for STEM skills in short supply.
- Tap prior unused green cards by making another supplemental allocation of 20,000 new green card slots annually for workers with STEM skills. (The U.S. State Department releases green card numbers monthly, based on estimates of the demand in specific employment categories. When not used in the year authorized, the green cards are not available for future use without special legislation.)
- Require an investment, by the company hiring these new workers, of $10,000 for each new visa and $15,000 for each new green card.
- Use the money paid by companies for the visas and green cards (which Microsoft estimates to be up to $500 million per year or $5 billion over a decade) to fund federal STEM education initiatives, hopefully increasing the pipeline of future American workers.

[111] (Gordon 2009, p. 38)
[112] (Gordon 2009, p. 38)
[113] (Gordon 2009, p. 34-35)
[114] (Microsoft 2011, p. 5)

Appendix B

STEM PROGRESS IN NEW MEXICO

The following outcomes and activities were influenced by various STEM education movements.

- New Mexico Public Education Department Math & Science Bureau established, prompted by a New Mexico First town hall, 2006.
- State funding begun for Reading, Math & Science Summer Institutes, 2006.
- New Mexico State University established a website that connects many of the educational resources in the state, 2006.
- University of New Mexico established STEM Education Outreach Programs, 2006.
- Los Alamos National Security implemented a new regional Community Commitment Plan in providing $1M each year for seven years in support of STEM Education and Workforce Development initiatives in northern New Mexico, 2006
- The Math and Science Advisory Council & NM Public Education Department created NM Project 2012, a plan for transformational change in K-12 math and science education in New Mexico (and also prompted by the 2006 town hall), 2007.
- Medical student financial support: aid to repay loans, incentives to stay in NM, 2008.
- The first Math and Science Day at the Legislature was held, 2008.
- A statewide taskforce was created to redesign entry-level math and science content competencies for pre-service elementary, middle, and high school teachers, 2009.
- Passage of HB322, which increased the licensure requirement in math content from six to nine credit hours for elementary school teachers was prompted by Project 2012 and other groups, 2009.
- "On the Road to 2012: Transforming K-12 Math and ScienceTeaching and Learning in New Mexico Conference," was convened by the Los Alamos National Laboratory Foundation and Innovate-Educate New Mexico , 2009.
- The second annual Math and Science Day at the Legislature was held, 2009.
- The Math and Science Advisory Council distrubuted a revisted copy of NM Project 2012 to all New Mexico legislators. The document is available at http://www.ped.state.nm.us/MathScience/index.html, 2009-2010.
- The initial HUB formed under the NM STEM Network launched in September 2010 and works to deliver traditionally out-of-school programs during school time, beginning in middle school, 2010.
- The Council was instrumental in ensuring that the summer institutes in math, reading, and science (FY11) were again funded by the New Mexico legislature. $164,000 was set aside for these teacher development programs, 2011.
- Math and Science Partnerships (MSP) The MSP has been funded by the U.S. Department of Education since 2003. The NM funding targets middle and high school math teachers. One statewide project, Mathematically Connected Communities (MC^2), is currently funded through New Mexico State University with partners spanning much of the state. The grant award for 2010 is $1.4 million, 2010.
- HB53, provides for the inclusion of a financial literacy course as one of the four high school math credits. This financial literacy course is a one-year math course, which must align to the NM 9-12 math standards, 2010.

- The Math and Science Bureau provided training on the RFP (Request for Proposal) requirements of the publishers' participation in the adoption review and the alignment to the New Mexico science content standards, 2010.
- The third annual Math and Science Day at the Legislature was held. Twenty-eight schools were recognized for their achievement on their SBA, 2010.
- A joint memorial (HJM22) supporting the development of a staged, multi-year plan to improve high school science laboratory facilities, as described in New Mexico Project 2012, passed unanimously by the House amd Senate, 2010.
- STEM Database was built by NSF EPSCoR office. http://www.nmstemed.org/ The New Mexico STEM Database provides information about science, technology, engineering and math (STEM) resources for NM students, teachers, parents, counselors, and administrators, 2011.
- The Math and Science Advisory Council distrubuted a revisted copy of NM Project 2012 to all New Mexico legislators. The document is available at http://www.ped.state.nm.us/MathScience/MSAC%20Annual%20Report%202011%20VFinal7%2027%2012.pdf, 2012.

Appendix C

NM STEM DATABASE

Over 48 organizations have registered their science and math programs with the NM STEM Database, hosted by NM EPSCoR. They are all printed in this appendix, which we posted separately for those who prefer to conserve paper. The 20-page document is available at: http://nmfirst.org/events/stem-action-planning-summit. If your organization is not listed, or if you have corrections, please visit http://nmstemed.org/.

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