THE COUNCIL OF CHIEF STATE SCHOOL OFFICERS

The Council of Chief State School Officers (CCSSO) is a nonpartisan, nationwide, nonprofit organization of public officials who head departments of elementary and secondary education in the states, the District of Columbia, the Department of Defense Education Activity, and five U.S. extra-state jurisdictions. CCSSO provides leadership, advocacy, and technical assistance on major educational issues. The Council seeks member consensus on major educational issues and expresses their views to civic and professional organizations, federal agencies, Congress, and the public.

MATHEMATICS AND SCIENCE EDUCATION TASK FORCE

Report and Recommendations

A Policy Statement of the
Council of Chief State School Officers

November 2006

LEADERSHIP, ADVOCACY, SERVICE

CCSSO

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Context

In May 2006, Council of Chief State School Officers (CCSSO) President Valerie Woodruff and the Board of Directors commissioned the creation of a mathematics and science education task force to address a common set of concerns regarding mathematics and science education in the United States. The performance level of U.S. students on international assessments is substantially below that of students in many other nations. One-third of our high school graduates are not prepared to enter postsecondary education or the workforce. The number of U.S. students graduating from mathematics and science advanced degree programs continues to decline. The majority of our mathematics and science graduate students come from countries outside of the United States.

Directly related to student performance is teacher quality. While it is often the case that circumstances compel school administrators to assign inadequately prepared teachers to teach mathematics or science, it is also true that many teacher training programs—particularly elementary education programs—do not require prospective teachers to take challenging coursework in mathematics and science content and pedagogy or coursework commensurate with the level of instruction to be taught. The consensus of the task force members was the need to move forward to provide state-specific solutions for the concerns that had been raised by the broader U.S. community.

Chief state school officers are uniquely positioned to build state capacity to deliver challenging mathematics and science education programs.

Chief state school officers, deputies, and state content specialists partnered with representatives from national science and mathematics organizations and the research and business communities to examine policy and practice to improve mathematics and science education across the P–12 system, particularly at the middle and high school levels. Chief state school officers are uniquely positioned to build state capacity to deliver challenging mathematics and science education programs and impact licensure requirements. Recognizing the diversity of operations for chiefs in the states, territories, District of Columbia, and Department of Defense Education Activity (DoDEA), the method of implementation for any of the following recommendations will likely vary. Yet, within their respective state contexts, chiefs can provide guidance for aggressive improvement, enact policies, and work with other states and other partners to increase achievement for mathematics and science education in their states.

The 2006 report issued by the National Academies of Science, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, outlined recommendations for K–12 education as well the broader scientific community. A recent meeting convened by the National Governors Association offered recommendations for mathematics specifically. In September 2006, the National Council of Teachers of Mathematics issued their *Curriculum Focal Points*. Task force members reviewed all of these documents and used them as the basis to discuss the most effective advice for chiefs.

The approach of the task force included assumptions about the state education systems. The task force members assumed a commitment to clear, challenging standards at the state education agency (SEA) level. They also assumed their peers were committed to engaged relationships with their communities and local governments and were willing to engage those groups on this topic.

Several themes emerged from discussions held between task force members and experts in the fields of mathematics and science education, as well as in smaller groups that identified top priorities for the areas of policy, practice, and professional development. The recommendations below are organized by thematic priorities and points of leverage. The accompanying addendum of references identifies specific work in states and organizations chiefs should find useful in thinking about what can be done in their states. Above all, the task force seeks to underscore the most critical element to improving mathematics and science

learning—the teacher. Thus, teacher development comprises a majority of the recommendations suggested below.

Key Areas of Recommendations

Vision and Leadership:

The most critical task for chiefs is to define and gain consensus on a single statewide vision for mathematics and science education in their states. The surest way to enact changes at the policy level is to work with leaders from various sectors to attain a single shared vision that encompasses what students need to be able to do for entry into continuing education or the workforce. A clear, jointly created vision of the level of mathematics and science education students need and the necessary steps to realize this vision can strengthen the state agency's leadership position in improving student achievement. The following recommendations outline this process and the addendum provides some examples of implemented practices:

- Bring together educators, the private sector, and community members to develop and gain consensus on a clear, single statewide vision that would address what needs to happen to support mathematics and science education to prepare students for entry into postsecondary education and the 21st-century workforce. Ideally, a summit should be convened at which leaders at all levels from the public and private sectors commit to a state vision and articulate measurable goals and actions to improve mathematics and science education and better prepare students for success in a global economy. State leaders should commit to publicly reporting on a regular basis their progress in meeting these goals.

- Convene stakeholders to reach agreement on what it means for students to be college or work ready in science and mathematics education. Determine what specific skills the graduates of our schools are lacking and develop strategies for all students to gain readiness.

- Utilize program approval standards and processes to support quality mathematics and science education programs to facilitate the goal of P–16 alignment.

- Use SEA authority and resources to establish and support state networks of mathematics and science educators or regional ongoing professional development centers for the purposes of professional development and support for teachers.

- Develop education leaders at the district and school levels (teachers, principals, district administrators) who are leaders for learning, particularly in mathematics and science education.

- Build a process and delivery mechanism for the state education agency to continuously gather and make available to school districts new information and resources related to improving learning in the areas of mathematics and science education.

- Establish a process for ensuring state content standards and grade-level expectations are consistent with proven, up-to-date content knowledge in the disciplines of mathematics and science and are aligned with college and workplace expectations.

The most critical task for chiefs is to define and gain consensus on a single statewide vision for mathematics and science education in their states.

- Advocate for state assessments that span the levels of cognitive demand in mathematics and science, recognizing that such a commitment might require funding beyond what is normally allocated for such large-scale assessments for development, administration, and scoring.

- Collectively advocate for reform in large-scale national assessments and their uses. Often the tests that are used for college admissions and other postsecondary learning experiences lack emphasis on the competencies that are needed for success in college and the workplace.

Curriculum, Instruction, and Assessment:

If our students are to succeed in a world of rapid modernization and increasingly sophisticated technology, then it is essential that curriculum, instruction, and assessment be updated to meet

the demands and expectations of the 21st century. State standards and benchmarks must be set against national and international standards. Methods of instruction and the measurement of student learning both should be examined more closely. The development and administration of mathematics and science assessments must be overhauled so that multiple measures and complex items are utilized to measure properly and accurately what students know and are able to do. The following recommendations seek to help identify strategies:

- Align P–16 curriculum, standards, assessments, instructional materials, professional development, and licensing requirements in mathematics and science to enable a high level of student learning.

- Modify, clarify, organize, and place instructional priorities on rigorous standards, indicators, and benchmarks in mathematics and science education to achieve focus and coherence. Standards should have a global perspective to ensure depth of teaching and learning as students progress through grades P–8 and into high school, postsecondary education, and the 21st-century workplace. Standards and grade expectations should be rigorous, aligned with world-class standards, and be subject to regular periodic reviews and updated as necessary. Every effort should be made to support structures that encourage students to connect, apply, and extend what they learn, rather than to gain knowledge of isolated pieces of disconnected information.

Policy and standards revisions will have greater impact if mathematics and science assessments reinforce the state policy agenda.

- Consider the NCTM *Curriculum Focal Points* and the American Diploma Project (ADP) benchmarks when reviewing state mathematics standards. The *Curriculum Focal Points* are based on the NCTM *Principles and Standards for School Mathematics* that most states used as a framework when developing their original standards. The ADP mathematics benchmarks were identified and refined based on research both within and beyond the ADP partner states (Indiana, Kentucky, Massachusetts, Nevada, and Texas) and in conjunction with K–12 educators.

- Provide and encourage the use of rigorous multiple assessment measures within mathematics and science that are appropriate for the intended purposes and that measure the content in appropriate ways. Ensure that assessments are of suitable rigor and are aligned to the scope and depth of the intended standards and curriculum. Policy and standards revisions will have greater impact if mathematics and science assessments reinforce the state policy agenda. State assessments for accountability purposes should include items that require high-level, complex thinking, while classroom-based assessments should contain diagnostic elements designed to aid in improvement of instruction.

- Examine policy at state and/or local levels to determine where regulations are facilitating or inhibiting effective use of learning time, flexible pathways to student success, and performance-based credit. Specific points for examination include graduation requirements, career/technical pathways, grade-level expectations, and appropriate time for student learning.

- Examine mathematics and science course content in light of 21st-century needs and articulate appropriate curriculum at each grade level, especially in light of the critical transition from high school to postsecondary education and into the workplace.

- Advocate for diagnostic resources that demonstrate application and conceptual understanding to inform mathematics instruction as a part of early intervention.

- Establish a mechanism for district and school leaders to exchange ideas and identify best practices to help all students to meet or exceed grade expectations in mathematics and science.

- Collaborate with other states and engage with the publishing and instructional materials industry to improve the quality of mathematics and science education curricula.

Teacher Development and Support:

Teacher development and support recommendations are the most critical element

to improving mathematics and science education reform. Teacher development and support should have a continued focus on developing, implementing, and supporting the most effective programs and instructional strategies. Good pedagogy is inquiry based, hands-on, and focuses on problem solving. A steady investment over time in programs that convey these values and are coordinated and sustained across the P–16 mathematics and science curricula will be of greatest impact and usefulness to teachers. The following recommendations identify qualities and features that should be highlighted in mathematics and science education programs within your state.

Professional Development Design and Support

- Promote the design of professional development in mathematics and science education that is ongoing, school-based, and focused on curriculum and instruction used in the schools. These programs should be continuous and enable teachers to stay current on emerging mathematics and science content and effective instructional strategies for elementary and middle grade levels in particular.

Support professional development programs that teach and promote the appropriate use of technology in instruction and assessment.

- Build or reinforce professional development policies and structures that equip mathematics and science teachers with the knowledge and skills to address students with diverse needs, including those from other cultures, English language learners, students in urban settings, and students with special needs. Continue, within each state context, to focus on using student performance data and research on the most effective models for building effective and ongoing professional development.

- Build policy levers and provide incentives to improve participation in local, state, regional, and national content-specific professional development, particularly for teachers in mathematics and science education. Examples of incentives might include financial, professional, sabbaticals, and relicensure credits.

- Review recruitment, initial certification, and recertification procedures and policies to promote the ongoing growth and development of teachers and principals.

- Support professional development programs that teach and promote the appropriate use of technology in instruction and assessment. Look in particular for programs that offer training for handheld technologies and software applications that can help students develop understandings of abstract concepts.

Pre-service Work and Credentialing

- Require prospective teachers, as part of the licensure process, to take coursework that reflects current and emerging research in mathematics and science education. Work with institutions of higher education to ensure available courses in mathematics and science that will prepare teachers to effectively teach the state standards for their endorsement or level of assignment. Furthermore, because success in higher-level mathematics and science achievement requires an early start, develop credentials and provide support and incentives for mathematics and science specialists in grades P–8.

- Partner with outside organizations, regional agencies, and professional organizations to increase your state's capacity to provide effective professional development and technical assistance for mathematics and science education.

Evaluation

◆ Develop and use evaluation designs to measure effects of increased teacher knowledge and skills on student learning in mathematics and science. Use existing data and assessments systems in evaluation designs when the data are valid for this purpose, or propose improved assessment instruments. Use evaluation results to make decisions on all mathematics and science education programs.

◆ Use research to improve the practice of mathematics and science teaching and professional development. Student, teacher, school, state, and national data should be used to make decisions regarding the focus and structure of professional development programs, beginning with student data that identifies where students are not achieving.

Sustainability and Scalability:

Members of the task force have observed that many of the most effective pilot programs in mathematics and science education tend to remain pilots. However, pilot programs can be helpful in soliciting advocacy for statewide initiatives. In order for legislative and regulatory changes to be enacted, additional investment is required to plan ahead for future scaling up. Success requires advanced planning; therefore, structures and resources need to be built in at the legislative and policy levels in the early stages of pilot program implementation for maximum impact and long-term success.

◆ Promote sustained effectiveness for teachers by identifying professional development designs that focus on research-based practices for mathematics and science education. The following are some effective design characteristics (from Elmore, 2002):

- Contain a well articulated mission/purpose focused on how to teach students
- Be content-based
- Be pedagogically relevant
- Involve active participation both of school leaders and teachers to establish consistency in expectation and practice
- Be attentive to adult learning theory/strategies
- Model effective practice and be, at least in part, school-based with opportunities for authentic practice and descriptive, meaningful feedback
- Sustain the focus over time

◆ Pilot innovative ideas and initiatives in mathematics and science education, evaluate the results, and use the resulting data to support proposals for additional funding to scale up to statewide implementation and sustainability.

Structures and resources need to be built in at the legislative and policy levels in the early stages of pilot program implementation for maximum impact.

◆ Secure long-term financial resources for mathematics and science education and technology within your state's annual budget.

◆ Identify all education initiatives supported by state and federal funding (Title I and II, etc.) that can be used to improve mathematics and science instruction. Seamlessly embed the most efficient and effective initiatives into your state's larger program structure.

◆ Collect appropriate data that will demonstrate improvement in mathematics and science achievement. Regularly assess program impact and make appropriate adjustments.

◆ Use information technology appropriately to efficiently and effectively bring proven models and promising practices in mathematics and science education to scale.

◆ Cultivate grassroots support among all stakeholders for the mathematics and science vision, agenda, and strategy. As much as possible, collaborate with existing organizations such as state and national science and mathematics organizations and education policy groups, and use appropriate resources when crafting messages for particular audiences.

Next Steps

Meaningful progress in P–16 alignment will necessitate long-term collaboration among chiefs, SEAs, communities, and institutions of higher

education. It is evident that mathematics and science education must be reexamined for more rigor and alignment to international standards so our students will be competitive in the 21st century global society. For significant improvement to be possible for our students, a number of steps at various levels need to be taken. Collaborating with other education organizations, the private sector, and local community organizations is the most effective and promising way to accomplish the shared vision for improving mathematics and science achievement. Curriculum and instruction need to be informed, firmly based on research, and aligned to standards which in turn reinforce a high level of rigor. Chiefs are urged to utilize their position to examine and clarify policies, advocate for necessary resources, and create networks for their state education agencies to assist in the recruiting, training, and ongoing development of mathematics and science instructors.

Technology as a content delivery mechanism both in student education and teacher professional development will be instrumental for improving student achievement. The state education agency has a leadership role to play in further integrating technology into the teaching, learning, and assessment of mathematics and science. Professional development in the appropriate uses of technology for instruction and assessment is critical to ensuring students develop the necessary foundations in mathematics and science prior to dependency on the technology. Used appropriately, handheld technologies and software applications can help students to develop understanding of abstract concepts that may not otherwise be accessible to them. Educational technologies also can provide state education agencies with the ability to deliver professional development opportunities to critical masses of teachers and school leaders.

Along with these recommendations to chiefs and their agencies, the task force further recommends the following steps for CCSSO to aid the effort to elevate mathematics and science achievement in our nation as a whole:

- Collaborate with other national organizations to examine mathematics and science curricula at the middle and high school levels.
- Develop issue papers or policy briefs on CCSSO resources for chiefs to utilize the latest research in a specifically policy-oriented manner.
- Synthesize ongoing national discussions and research findings with respect to science, technology, engineering, and mathematics (STEM) to provide feedback to chiefs and alert them to emerging priorities. Convene discussions on STEM with national organizations on behalf of chief state school officers.
- Partner with leaders in the mathematics and science education communities to create an agenda for change that directly impacts instructional materials (printed and electronic) and curricular changes. Explore the development of a mathematics diagnostic instrument.
- Call for a five-year plan to achieve continuous growth in P–12 mathematics and science education that brings U.S. curriculum up to international standards. This initiative should include building strategies for communication, parental involvement and understanding, and the support of the business community and private sector.

Mathematics and science education must be reexamined for more rigor and alignment to international standards so our students will be competitive.

As leaders, we must understand our own roles in education and in today's global society. We must be willing to advocate for and provide the infrastructure for the changes necessary to ensure the educational experiences we offer actually prepare our students for work and citizenship in the 21st century. Our nation's security and economic viability will depend on having not only specialized scientists, mathematicians, and engineers, but on having a scientifically literate populace that can solve problems and advocate for the policies and programs needed to advance our society.

The executive summary and report were made possible by the contributions and work of the CCSSO Mathematics and Science Education Task Force:

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