Executive Summary

Blueprint for Change: Report from the National Conference on the

Revolution

in Earth and Space Science Education

"As our nation deliberates on education policy and funding, we, as leading science educators and scientists, call for legislators, decision makers, and stakeholders to implement all measures that support science education in general and earth and space science in particular.

Fueled by new technologies over the last 40 years, advances in Earth and space science are revolutionizing our understanding of Earth's systems and processes. This growing understanding is increasingly needed to inform political and economic decisions of local, national and global impact.

For this reason, a science-literate citizenry is vital to the nation's well-being and security and will insure our nation's continued leadership in science and technology in the 21st century. To empower the public to make sound and reasoned choices, earth and space science must be taught throughout the United States in K-12 classrooms and be accessible to all students."

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National Conference on the Revolution in Earth and Space Science Education

Earth and space science education is undergoing a remarkable transformation. Long perceived as a "minor" science (in contrast with physics, chemistry and biology), Earth and space science is emerging in both public perception and active science research as a profoundly important field. Our lives and future depend on the depth of our understanding of our home planet. The concept of Earth as a rich and complex system of interconnected components and processes has become a dominant paradigm in science. Furthermore, the Space Age has provided a revolutionary new perspective on Earth, enabling us to see, explore and investigate our world in ways never before possible.

The National Science Education Standards underscore this transformation through a strong emphasis on "Earth and Space Science" as a core domain of science education at all grade levels. The Standards recommend that students experience Earth and space science as a process of inquiry, exploration and discovery. This is an ideal domain for inquiry, as the "lab" is all around us, inviting exploration.

Students should also tap into the power of telecommunications and visualization technologies to see the world from the unique perspective of space and use a wide range of data – just as scientists do. NASA, USGS, NOAA and other agencies have opened their treasure trove of satellite imagery, animations, interactive maps and other visualizations for ready access by schools and the general public. The Internet helps students see how Earth's forces affect their daily lives and provides direct access to news of Earth and space science and links for further exploration. These experiences help students understand Earth as a dynamic system – rather than simply a collection of topics to read about.

The potential impact on our schools and students is not just in Earth and space science, but in the broader applicability of the skills developed by students to related domains of science, math, geography and other fields. These thinking skills include inquiry, visual literacy, understanding systems and models, and the ability to apply knowledge and problem solving to a range of substantive, real-world issues. In short, this revolution in Earth and space science education has benefits for all students and for our relationship with our home planet Earth.

Recognizing the importance of these changes, the National Science Foundation funded the National Conference on the Revolution in Earth and Space Science Education. The conference took place June 21-24, 2001, in Snowmass, Colorado,

with the goal of developing a vision and "blueprint" for K-12 Earth and space science education reform for the next decade. The conference assembled a broad spectrum of stakeholders including K-12 teachers and administrators, Earth and space scientists, university faculty, representatives of educational and scientific organizations, key people from government agencies, and people from allied domains such as biology, chemistry and physics.

The conference featured presentations on educational projects with cutting-edge curriculum, technology and professional development. It also focused on the challenges of large-scale reform in Earth and space science education. It looked at data on the remarkably low numbers of students currently participating in Earth and space science (only 7% of the nation's high school students take Earth and space science – as opposed to 88% that take biology). Working groups looked at ways to change the content and methods of Earth and space science education, and ways to greatly expand the number of students learning Earth and space science at elementary, middle- and high-school levels.

Summary of Recommendations:

Establish state-based alliances to promote Earth and space science education reform. Alliance partners should include educators, scientists, policy makers, businesses, museums, technology centers and others concerned about improving the caliber and scope of Earth and space science education. State alliances should develop and implement concrete plans to achieve the reforms outlined in this report. These alliances should be coordinated nationally.

Develop and conduct an "Annual Snapshot" to gauge progress toward meeting the goals outlined in this report. To measure improvements in Earth and space science education, we need to collect annual data on the current status of Earth and space science education nationally and in each state, including student performance, teacher professional development and curriculum reform, and monitor these changes over time.

Student learning experiences should have a stronger emphasis on inquiry-based learning, use of visualization technologies and understanding Earth as a system. These learning goals and teaching methods build on the National Science Education Standards and the Benchmarks for Science Literacy. They also reflect the nature and current practice of Earth and space science as well as the wealth of Earth visualizations and resources available through the Internet.

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At the high-school level, Earth and space science should be approved as a lab science, with depth and rigor akin to biology, chemistry and physics. Earth and space science has changed dramatically since the time when it was often regarded as a lesser science in the panoply of high-school courses. Now Earth and space science is widely considered an essential element of a science-literate society. As a lab science, Earth and space science offers a rich array of challenging field work, lab experiments and advanced computer-based visualizations.

Develop a national database of high-quality, grade-level appropriate Earth and space science assessments. A national body of scientists and educators in Earth and space science education should create a databank of assessment items organized so teachers and others can construct high-quality measures of student achievement. This database should include not only good multiple-choice and constructed response items but exemplary, performance-based assessments and scoring rubrics for elementary, middle and high school. These assessments should measure student learning of the core concepts and skills identified for Earth and space science in the National Science Education Standards and Benchmarks for Science Literacy.

Create national and state professional development academies in Earth and space science. These academies should offer both summer institutes and school-year offerings, including online learning. They should model best practices in teaching, learning and assessment. Teachers should have an array of high-quality professional development opportunities, helping them experience Earth and space science as an engaging domain for inquiry, exploration and discovery.

In high needs schools, enhance access to high-quality Earth and space science education for students and professional development for teachers. All students should have the opportunity to do inquiry-based investigations of Earth and space whether they live in urban, rural or suburban areas. New curricula should include cultural and place-based perspectives, such as exploring Earth and space science in urban environments. Teacher training opportunities should include working with diverse populations.

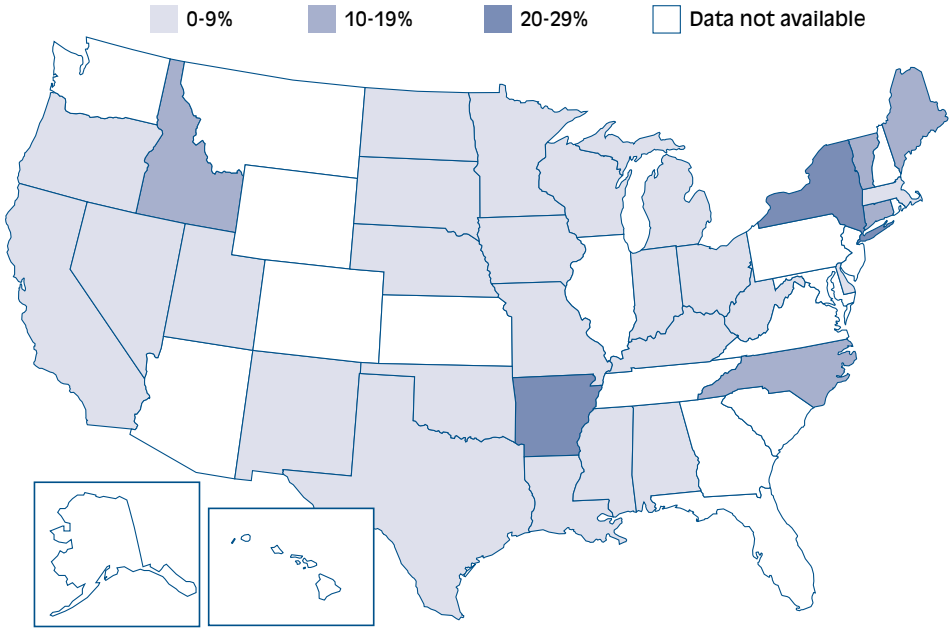
Create new opportunities for students and parents to learn about Earth and space science in informal settings. Education should continue outside the classroom with strong support and involvement from parents and in collaboration with museums, science centers, planetariums and other centers of informal science learning.

Develop a strong research program in Earth and space science education. Research on teaching and learning in Earth and space science education provides the basis for more effective curricula and teaching strategies, the appropriate use of new technologies in classroom and field settings, the professional development of teachers, and high-quality assessments.

The full report will be widely distributed, with the expectation that its recommendations will help shape the agenda, strategies and actions for Earth and space science education reform over the coming decade.

These revolutionary changes represent a timely and essential transfer of new Earth and space science knowledge, paradigms and tools from the science and education research community to the nation's teachers and students. This revolution in Earth and space science education will promote new, more effective approaches to teaching and learning. At a deeper level, this the revolution is essential to our future. A citizenry literate in the Earth and planetary sciences is essential for making informed political and economic decisions on local, regional and global levels.

PERCENT OF HIGH SCHOOL STUDENTS TAKING EARTH SCIENCE IN 1997-1998
Contrast with national average of 88% students taking Biology



AGI National Status Report on K-12 Earth Science Education

Why Earth Science?

Why: The National Strategic Imperative

Earth and space science is of national strategic importance. To understand why, one needs to consider what Earth and space science is. Earth and space science is an integration and synthesis of physics, biology, chemistry, geology, oceanography, meteorology and all other sciences that study life, Earth and the heavens. Fueled by 21st century technologies like data visualizations, analysis tools, remotely-sensed imaging and satellite photography, it consolidates these fields to offer new systemic understandings of Earth's components. Over the last fifty years, Earth and space science has revolutionized how we view and know Earth and its systems.

This accumulating body of knowledge, however, is far from academic. Our quality of life, it is fair to say, depends on the quality of our Earth scientists. This is because understanding the land, air, water and life of our planet gives us the knowledge to best manage the world around us. Earth and space science enables us to learn from the past and prepare for the future. The procurement and use of all major energy sources—fossil fuels, solar, hydro and wind—are the direct result of Earth and space science. The same is true of our water supplies and renewable and non-renewable resources. How we use the land and build our cities, bridges and roadways are all determined by Earth and space science. Earth and space science allows us to forecast the weather, monitor volcanoes and earthquakes, helping us to protect vulnerable populations from the forces of nature, and it informs us about sustaining growing populations, developing adequate food supplies and managing waste. Earth and space science addresses pressing environmental issues such as ozone depletion, global warming and threats to marine life.

From community development to resource planning, from emergency preparedness to energy management, we, as citizens, are increasingly called upon to make vital policy decisions that affect, if not define, our lives, the economy and the national well-being. We must know how to critically evaluate data, investigate the world around us, and assess environmental and economic impacts of our actions. To empower the electorate to arrive at informed and reasoned choices, our educational infrastructure must effectively teach Earth and space science to generation upon generation of students. Whether as citizens or as professionals, we require literacy in Earth and space science to ensure our prosperity.

Earth and space science education offers extraordinary opportunities for teaching scientific inquiry and critical-thinking skills, which have benefits even outside the field. Earth and space science is the most unifying domain in

science and to learn it, students must amalgamate many basic disciplines to see life and nature as comprised of dynamic, interdependent systems. They also must become familiar with models, data analysis, visualizations, technologies and interdisciplinary thinking, all of which are increasingly important in the workplace.

Earth and space science is vital for expanding human knowledge and essential for the nation's future. It is these urgencies that drive the Revolution in Earth and space science education.

Why: The Educational Imperative

Earth and space science education is about the planet we live on, the third planet from the sun and the only known place in our universe where life occurs. It is about four and a half billion years of history involving fantastic stories of climate change, evolution and extinction. It is about a planet alive with fiery volcanoes, sudden earthquakes, slow-moving glaciers and fast moving storms. It is about a planet of rich resources, beautiful natural wonders, and amazing plant and animal species.

Earth and space science education at its most basic level is about observing the world around us and asking questions. As young children we taste, touch, smell, see and listen. We ask questions about rocks and sand, about clouds and rain, about the moon and stars. As we grow older and our questions, observations and sampling techniques become more sophisticated, we learn that Earth and space science education is the study of a complex system of interacting chemical, physical and biological processes, constantly changing, ever surprising.

All of us who live on this planet have the right and the obligation to explore and understand Earth's unique history, its dynamic processes, its abundant resources and its intriguing mysteries. As citizens of Earth, with the power to modify our planet's climate and ecosystems, we also have a personal and collective responsibility to understand Earth so that we can make wise decisions about its and our future. The "Revolution in Earth and Space Science Education" is about ensuring that all citizens have the opportunity to learn the science of their planet from pre-school through college and beyond. We invite you to join us on this 21st century voyage of exploration, discovery and change.

For a free copy of the full report, send an e-mail to:
Communications@terc.edu
or download the report through the Web site:
www.EarthScienceEdRevolution.org

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