

Exploration and Discovery: Essential Elements in Earth and Space Science Literacy

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"The people who were putting up millions of dollars were asking my father, 'So, Captain, what do you expect to find?' and his answer to those people who were about to make major commitments was, 'If I knew, I wouldn't go.'"

Jean-Michel Cousteau, 2005

The wonders of the deep ocean and the mysteries of the universe. Inner Space and Outer Space. Both have historically and inextricably been linked with "exploration" and "discovery" since the beginning of humankind. For ages, people have gazed at celestial objects seemingly floating in the night sky, and as early as 2,000 B.C., the Egyptians were exploring the seas. Astronomers and sailors—explorers driven by the human spirit of discovery and a fundamental "need to know." What drives this quest for knowledge about the natural world, this fundamental "need to know" and understand what makes the planets move and the ocean change color? Can we capture and direct this "fundamental need to know" in novel ways to enhance ocean science literacy?

Even as young infants, humans are indeed, exploring their world. In their book, *The Scientist in the Crib*, Gopnik et al. (2001) write, "The tiny fingers and mouth are exploration devices that probe the alien world around them with more precision than any Mars rover. We are born with the ability to discover the secrets of the universe and of our own minds, and with the drive to explore and experiment until we do. Science isn't just the specialized province of a chilly elite; instead, it's continuous with the kind of learning every one of us does when we're very small."

Developmental psychologists tell us that there are striking similarities in how adult scientists and children learn, a concept that science education professionals come to understand early on in preparation for their careers and a concept that may be new for those in professional technical and/or scientific disciplines. Both children and scientists create and revise theories and construct and reconstruct their own knowledge and understanding based on experiences. Both are searching for understanding of the world around them, and in doing so, are naturally using inquiry to satisfy their own "primordial human urge to explore." In fact, success in scientists' learning has been attributed by some developmental psychologists to the ability to nurture the cognitive skills that evolution designed for the use of children (Gopnik et al., 2001), or the 'genetic engineering' that enables one to explore and discover and thus become more scientifically-literate about one's world, whether it be a new species of bacterium discovered at a hydrothermal vent system or one's own fingers and toes while still an infant in the crib. Steven J. Dick, chief historian of the National Aeronautics and Space Administration (NASA), noted "Even though science may be a motivation for exploration and a product of

it, human exploration is more than the sum of all science. . . . it is individually a primordial human urge. . . ." (2005). Are there implications for science literacy in this "primordial human urge" to explore? We believe that there are, and that they lie within the teaching and learning of Earth and space sciences.

Earth and space sciences are perfect topics in which to use inquiry-based, or 'exploration and discovery-based,' teaching and learning techniques, since students experience or observe the natural environment every day. The *National Science Education Standards* (NSES) (National Research Council, 1996) document that students learn science most effectively through the process of inquiry. Children learn science best by having opportunities to explore and construct their own understandings of scientific processes in the same way that scientists do. They build upon existing knowledge, both knowledge that they themselves have and that which is known by others. They revise and reconstruct their existing knowledge and build new cognitive foundations for understanding the world around them. Add to this the increased accessibility to the Internet and visualization technologies and you have an entirely new way of teaching Earth and space science to learners of all ages—ways that enable them to participate in mindful learning as they explore and discover and construct their own knowledge in an environment facilitated by a skilled and talented teacher. As stated in the NSES (1996), good teachers of science create environments in which they and their students work together as active learners.

The availability of visualizations and real-time and/or near real-time data and other scientific information through the Internet greatly enhances Earth and space sciences content in innovative and engaging ways. The

world has sophisticated technological capabilities that have made inner and outer space more “visible” and more accessible than ever before. Satellite imagery with easy to use viewing software, computer-generated model output and visualizations, interactive maps, and real-time video technologies provide an additional enhancement to teaching Earth and space science to anyone. “NASA, the U.S. Geological Survey (USGS), NOAA, and other agencies have opened their treasure troves of satellite imagery, animations, interactive maps, and other visualizations for ready access by schools and the general public. The Internet helps students see and understand the manner in which the Earth’s forces affect their daily lives and provides links for further exploration. Such efforts should be continued and expanded, including developing related educational materials to help teachers and students take better advantage of these resources” (Barstow, 2002). Clearly, there are unprecedented opportunities to bring the ocean virtually to pre-K-16 classes using marine and space technologies that enable anyone to virtually experience sampling methodologies and exploration techniques very similar to those used by scientists conducting research in inner space or outer space.

Technology enables each advancement made in exploration, from the poles to the deepest reaches of the ocean, to the moon and beyond. Discovery of life at hydrothermal vents was made possible by submersible vehicle technology, and continued enhancements in satellite sensor technologies provide ever-improving discoveries of planetary scale teleconnections like those due to El Niño here on Earth and other planets. It is cutting-edge technology that allows us to expand the boundaries of the known world while engaging the public in these discoveries and providing incentives for students to pursue scientific and engineering careers.

Not everyone who wants to can walk on the moon or dive in a submersible on the Mid-Atlantic Ridge. However, virtual experience technology and real-time telecommunications enables us to “make it real” to all those who want to share in the excitement of exploration and discovery. Perhaps the most significant exploration events of the past few decades were

the discovery of life at deep-sea hydrothermal vents on Earth in 1977, and the arrival of the Exploration Rovers, Spirit and Opportunity, on Mars in January, 2004. In 2004, the NASA portal received nearly 16 billion hits—more than half of these were hits on the Mars-related Web sites, evidence of the interest of the public in exploration and discovery events. Perhaps someday students all over the world will get to explore Mars and the deepest areas of the ocean using mini-rovers and autonomously-operated vehicles (AUVs).

We often associate exploration with individuals such as Magellan, Lewis and Clark, Jacques Cousteau, Amelia Earhart, and Neal Armstrong; however, curiosity and spirituality alone would not have put humans on the moon or in the deepest parts of the ocean. Two additional motivating forces also drive exploration—prosperity and security. The search for resources and the need to expose hidden hazards continue to drive societies to explore the unknown. In this respect, exploration becomes a collaborative venture, not just the dream of one individual. The success of our society is thus linked to the successes of our explorations through planning, teamwork, ingenuity, and leadership. If we fail to recruit the next generation of explorers, we will be lost. The success of our explorations determines our ability to understand the world around us, and how best to adapt to and benefit from our environment.

For the first time in the history of this country, two national-level commissions and two Presidential-level reports have highlighted the critical need for a more ocean-literate public. Further, critical deficiencies and unmet needs in science literacy as a whole are negatively affecting science, technology, engineering, and mathematics (STEM) career entries. The scientific, technological, and economic integrity of our country is at stake. We must capitalize on the inherent human spirit of discovery and the fundamental “need to know” to entice the American public and America’s students into worlds few have ever seen and thereby, enhance the science, or better yet, the STEM literacy of our nation. The universal appeal of exploration can promote learning and literacy as a motivational tool, a pedagogical technique (inquiry), and a source of valuable life lessons.

In their report, *Discovering Earth’s Final Frontier: A U.S. Strategy for Ocean Exploration* (2000), the President’s Panel on Ocean Exploration recommended strategies for a national ocean exploration program in which “discovery” and the “spirit of challenge” were the cornerstones. In January 2004, President George W. Bush announced a new space exploration policy to go to the Moon, Mars and beyond. Titled, *A Renewed Spirit of Discovery*, “exploration” and “discovery” are cornerstones of the new policy. With two Federal agencies launching voyages of discovery into inner space and outer space to fulfill their exploration missions, we see organized, structured measures that when sifted for origins are reduced to that primordial human urge to explore and discover. As Dick (2005) states, “exploration...we should undertake it for the most basic of reasons...Our self-preservation as a creative society.”

“When...we realize the possibilities of deep sea life still unknown to us, every haul of the dredge should be welcomed by an expectant enthusiasm equaled in other fields only by the possible hope of communication with our sister planets.”

*The Arcturus Adventure, 1926,
William Beebe*

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