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THIRD IN A SERIES

eye on*research*

Earth Systems Connections:

Children Study the Earth and Its People—from 400 Miles in the Sky

Dr. Jeff Frykholm, an associate professor in the School of Education, recently completed a four-year, collaborative project funded by NASA titled Earth Systems Connections (ESC). Deemed an "Exemplary" program by NASA's Earth System Education Enterprise, ESC has made a splash at the national level among mathematics and science educators for its innovative integration of mathematics, science, technology, and culture. A series of eight learning modules for learners in the elementary grades, ESC brings to life fundamental concepts in mathematics and science by exposing children to a perspective of the earth that they rarely experience—a view from 400 miles in the sky.

"Most children develop perspectives of the earth—and their place in it—from their own experiences and observations," commented Frykholm. "And most of these observations come from about four feet off the ground. Our goal for this program was to use satellite technology to broaden children's perspectives of the earth—to give them a sense of the ways in which the people, land, animals, water, and living organisms on this planet are all more closely connected than we might first think."

Chairman Michael Powell and Commissioner Jonathan Adelstein of the U.S. Federal Communications Commission show a satellite constructed by third graders studying the ESC curriculum.

Program Background

In the early 1970s, an accomplished meteorologist named Edward Lorenz posed the question, "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" This provocative question symbolizes the vast number of often surprising interconnections that knit our world together. ESC highlights such connections, emphasizing how scientists and mathematicians have learned to think of the earth not as a collection of individual, unrelated objects, but instead as a symphony of interdependent processes linking the water, air, rocks, and life of the planet.

Today, a new generation of spaceships gathers powerful imagery of the earth's surface in more detail, allowing us to study things like the changing of the seasons, the swirling of the clouds, the choppiness of ocean waves, population distribution, and the loss of habitation due to widespread deforestation. Satellites are helping to unlock the unexpected wonders of how our earth works—wonders that are captured in the ESC curriculum program. Did you know, for example, that sands from African deserts can ride the wind all the way to South American rainforests? That some birds follow *identical* migrational paths, over thousands of miles, year after year? That the length of the growing season in Alaska is different than it was 20 years ago? The fundamental challenge of Frykholm and his collaborators on the ESC project was to make these important revelations of modern mathematics and science relevant and accessible to young children.

The Curriculum: Earth Systems Connections

ESC was developed through a collaboration between Frykholm (mathematics educator), Dr. George Glasson of Virginia Tech (science educator), and Dr. Lee Vierling of the University of Idaho (remote sensing scientist). The intent of these authors was to research and develop a curriculum that embraced fundamental issues about the sustainability of the earth. To do so, the authors developed an innovative framework to blend mathematics, science, technology, and culture to help young children cultivate a spirit of curiosity and confidence in themselves as emerging thinkers and scientists who will be responsible for understanding and caring for the earth in the decades to come.

Eight content modules contain over 100 lesson activities and explorations based on the premise that children inevitably learn as they actively explore their environment, share in meaningful activities, and interact with others. Engaging cultural contexts are used to draw students into activities that range from great imaginary adventures, to finding roots in soil, to taking photographs with digital cameras, to using hands-on manipulatives, to developing language arts skills through creative writing prompts, to examining satellite imagery, to tracking animals with satellite technology.

Curriculum Modules Overview

Specific to the curriculum is the notion that mathematics and science (and, indeed, other subjects) should be integrated to show the beauty and utility of connections among the disciplines. Mathematical tools are developed and used to understand scientific phenomena. Science contexts are used to motivate the need and (re)discovery of mathematical principles and procedures. Technology (specifically, satellite imagery) is used to bridge mathematics and science by providing unique perspectives of the earth.

The following two images illustrate this integration of both learning objectives and instructional methods. In two successive lessons titled "Just Around the Bend" and "The Pollution Patrol," students are encouraged to explore these two images, noting ways in which each informs the other. While exploring mathematical concepts such as scale, direction, and the number line, they are also asked to think deeply about the potential impact that pollution in the Missouri River might have on agricultural crops grown with irrigated river water. Later, students see satellite imagery revealing the extent of pollution on another continent, in the Volga River of Eastern Europe, which would be hard to detect by, for example, fishermen on the banks of the river.

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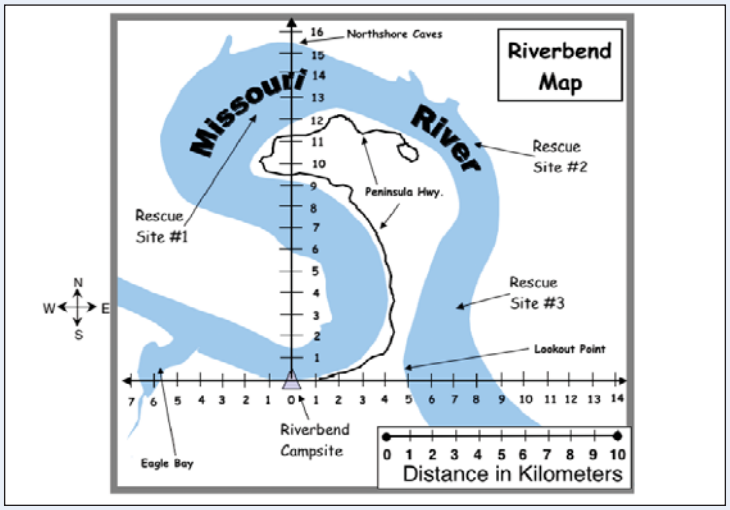

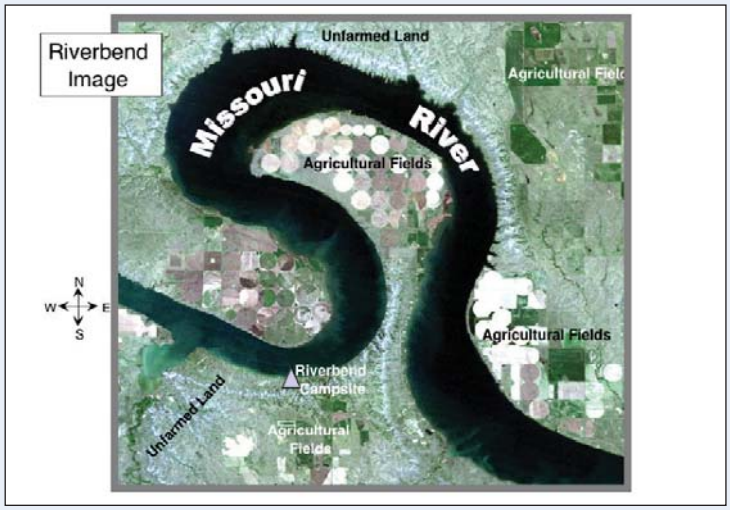

These two pictures illustrate the difference between a human creation—a map—and an actual representation of the earth—an image. In this lesson, children compare the map and image, and use mathematical concepts of scale and direction for environmental science problem solving.

Throughout the curriculum, preference has been given to contexts that not only illustrate the connections across disciplines, but also contain cultural components that help children recognize the relationships that humans have with the environment, the various ways in which different groups of people view the role of humans in the environment, and our responsibility to think carefully about human impact on the earth. Toward this end, some lessons are narrated by Leonard Littlefinger, an elder of the Lakota Peoples of present-day South Dakota. Littlefinger tells stories about his community, his family, his childhood, and the land upon which generations of his people have lived. He offers a perspective about earth system science and the natural world that is not always reflected in the traditional framework of Western modern science.

Remote sensing is a novel, if not abstract, concept for young learners. Pilot research conducted by Frykholm and his colleagues revealed that students were captivated by the notion of "cameras flying in the air," although they had a hard time envisioning what a satellite might be, how it might work, and why it wouldn't "fall from the sky." To allow children to put a face on the unseen, helping to make complex ideas of remote sensing more accessible to young children, ESC features a cartoon character named "Pixel the Satellite." The team developed 10 Pixel the Satellite animated movies designed to excite and inspire students to learn more about satellites and how satellite imagery can be used to study the earth. In his brief narratives, the animated Pixel flies through space, pointing students to interesting phenomenon like flocks of migrating birds, blowing sands of the Sahara Desert, and storms over the Pacific Ocean. Pixel acts as a helpful guide for both students and teachers by raising discussion questions, clarifying directions, and narrating various mathematical and scientific concepts.

Summary

"We are entering a time in history when we must teach learners about the interconnected nature of the earth not because it is fashionable, but because it is actually *necessary* to think about the earth as a system in order to crack the 'inner secrets' of how our world really works," said ESC co-author Vierling. Moreover, as the authors note in their resource materials for teachers, cultivating a new generation of critical thinkers who understand what it will take to sustain the earth is critical. ESC is devoted to heightening the consciousness of young learners so that they will recognize the way that human decisions and actions are changing the planet at an alarming and accelerating rate, a rate so brisk it is unsustainable. As children learn throughout the curriculum, humans have already transformed somewhere close to half of earth's land surface, have added 30 percent more carbon dioxide to the atmosphere since the Industrial Revolution, have used more than half of all available fresh water left on the planet, have overexploited marine fisheries, have pushed extinctions up to 1,000 times their historical rates, and have clearly established human domination on earth as evidenced by the fact that the three most abundant plants on the planet are rice, wheat, and corn. Yet, the Earth Systems Connections curriculum program shows that there are signs of hope as well.

"Young children understand much more about the sustainability of the earth than we may give them credit for," Frykholm reflected. "They are also very concerned about the future of the world. Walk into any elementary school, talk to the children, and you will hear them express their desire to care for the world. There is hope. When my own children catch me—which they always seem to do—putting a container in the wrong recycling bin, I smile, knowing that the earth *will* be in the hands of good and faithful stewards in the years ahead."

Frykholm, J.A. (2005). Integrating mathematics and sciences via satellite. In D. Berlin and A. White (Eds.), *Collaboration for the improvement of science and mathematics education: A global effort.* Columbus, OH: International Consortium of Research in Mathematics and Science Education.

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Leonard Littlefinger, elder of the Lakota Sioux Nation, tells stories in video components of the ESC programs.

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