CRATER A

Use the summer to investigate ways to incorporate NASA projects in the classroom

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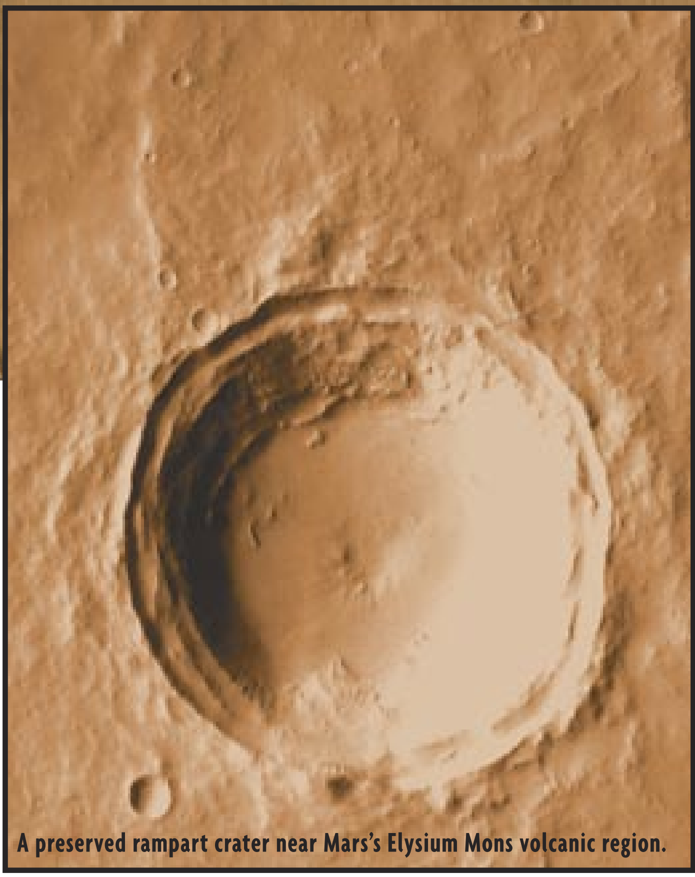

NASA/ASU

A preserved rampart crater near Mars's Elysium Mons volcanic region.

For many years the planet Mars was nothing more than a little red dot in a sea of stars and a blur in many science classrooms. Recent focus on the planet, however, has led to incredible teaching opportunities, such as the Mars Student Imaging Project (MSIP) facilitated by Arizona State University's (ASU) Mars Education Program. The MSIP curriculum serves as an excellent model for scientific inquiry, allowing students to design and carry out a research project. This project provides a unique community context in which teachers and students collaborate with scientists at the NASA/ASU Mars Space Flight Research Facility and online with other teams across the United States.

Mars is very much a mystery in which students are naturally interested. When faced with complex questions such as whether water is present or has ever been present on Mars, students will go to great lengths to find solutions. In this article we describe the design and implementation of MSIP at Westview High School in Avondale, Arizona, where Earth science students studied a crater on the surface of Mars.

Conducting authentic research

MSIP was initiated by Phil Christensen, a Regents professor of geology and NASA scientist at ASU. As a strong proponent of science education, Christensen advocated that students have the opportunity to use his Thermal Emission Imaging System (THEMIS), which is onboard NASA's Mars *Odyssey* orbiter, to conduct authentic science research projects. THEMIS captures visible and infrared images to determine the distribution of minerals on the surface of Mars and decipher the geological record of past liquid environments (Watt 2002). The ASU Mars Education Program developed MSIP curriculum to provide a context for learning the science process using an inquiry-based approach. Through this process, students submit a proposal to use THEMIS and, if that proposal is accepted, collaborate with NASA/ASU scientists (see Figure 1, p. 30, for steps on how to participate in MSIP).

The ASU Mars Education Program is the national training program lead for NASA's Mars Exploration Program and facilitates nationwide teacher workshops each year. We, the authors, met at an MSIP workshop facilitated by ASU's Mars Education Program, which sparked the initial interest in deciding to integrate MSIP into existing Earth science classes at Westview High School. We anticipated that this project would foster in students a solid foundation in inquiry-based science.

The journey to Mars

Engaging more than 150 students together from 5 sections of introductory Earth science in a semesterlong research project was exciting but seemed challenging. This challenge was met by involving students in the planning of the project. A variation of the Group Investigation (GI) model was used to divide students into cooperative learning roles within their class sections (Sharan et al. 1984). These roles included principle investigator, co-investigator, working group leader, mission planner, data archivist, and science team specialist (Watt 2002). Five students (co-investigators) were selected from each section (25 students) to represent their respective classmates throughout the semester during several afterschool meetings.

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In class, students participated in MSIP activities (Watt 2002). As the semester progressed, students generated research questions based on topics such as Mars in society and culture, Mars exploration missions, and similarities between Earth and Mars. The co-investigators met several times after school to discuss outcomes of the initial MSIP activities. These students returned to their respective classmates with a narrower focus, which allowed them to further collaborate with each other in class. This reciprocal process made it easy for students to communicate effectively with one another and decide on a research question.

Initially, students started with broad questions about the possibility of life on Mars. Students concluded that water is essential to living organisms, which led to a focus on the properties of water, the water cycle, and water erosion features on Earth. Students used this information to construct diagrams showing the water landforms' similarities and differences found on both Earth and Mars including tributaries, streams, deltas, lake beds, Oxbow lakes, alluvial fans, and canyon/crater gullies. These diagrams led students to a more narrowed focus on subsurface water and rampart cra-

FIGURE 1

How to participate in MSIP.

1. Submit an application (available at *http://msip.asu.edu/application*).
2. Work with staff at ASU's Mars Space Flight Facility to develop a schedule that will work with your particular classroom situation and time frame.
3. Incorporate hands-on activities that will assist your students in developing their project (available at *http://msip.asu.edu*).
4. Participate in optional monthly teleconferences/videoconferences to increase teacher and student background knowledge about Mars.
5. Submit a proposal to ASU or conduct research using archived THEMIS images (available at *http://themis.asu.edu*).

ters on Mars. Rampart craters are characterized by a thick ejecta blanket formed by muddy slurry, which makes them excellent groundwater depth tools (Hartmann 2003). Students decided that finding evidence of groundwater would be a start in the search for ancient or present life on Mars.

Studying craters

To find the most recent rampart crater, students learned about crater types. They examined photos of barely visible ghost and exhumed craters, heavily eroded modified craters, and preserved craters of a more recent geologic time. Students believed that a closer view of a preserved rampart crater might provide evidence to support their hypothesis of groundwater in surrounding strata. This would be an excellent place for humans to land and search for life in substrata on Mars. Finally, students prepared a written proposal requesting a THEMIS image, which was sent to NASA/ASU.

The proposal was accepted! NASA/ASU sent THEMIS targeting software, which allowed students to track the predicted orbital path of the Mars *Odyssey* spacecraft and locate the perfect crater. Students began searching through hundreds of relatively young, preserved rampart craters in Mars's northern hemisphere. Eventually, a preserved rampart crater near the Elysium Mons volcanic region stimulated their interest (see picture, p. 22). This crater target information was sent to the THEMIS mission planners to be included in commands to the Mars *Odyssey* spacecraft.

Student co-investigators traveled to the NASA/ASU Mars Space Flight Facility for three days to work with the scientists and Mars Education Program team. On the first day, students were given a tour of the facility and learned image processing techniques that could be used to analyze their crater image. On the second day, the newly acquired image was downloaded from the Mars *Odyssey* spacecraft log. You could hear a pin drop as the crater image, section by section, appeared slowly on the screen before students' eyes! Using the techniques learned, students discovered the crater depth, width, and height, and observed geologic features such as gullies, ripples, landslides, and sand dunes that would suggest water had indeed been involved in the shaping of this crater's history. The third day was used to design a presentation and posters to peer tutor their classmates. Students left NASA/ASU with 25 large laminated posters of the crater image named, appropriately enough, *MSIP Westview: Crater on Elysium Mons*.

Teaching their peers

The most remarkable part of the project was in the ways student co-investigators used the posters to teach fellow classmates about image analysis. Students were separated into small groups with a student co-investigator and poster at the helm. Together, students used colored, dry erase markers to label crater image features and measurements. The groups also participated in writing geologic stories, designing charts and graphs, and constructing scale clay models (Figure 2). Some students even compared measure-

FIGURE 2

Student clay model of crater.

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ments of the Barringer Meteorite Crater (northeastern Arizona) and the estimated size of the meteor to their Mars crater image and thus estimated the size of the meteor that formed their crater.

Students put the finishing touches on their research paper and sent it to the Mars team at NASA/ASU. The Mars Education Program highlighted students' accomplishments and featured their crater image and clay model on their website. At Westview, students were honored in a crater image dedication ceremony. The crater image with a photo of the students was framed and mounted on the wall of the attendance office. This academic trophy serves as a reminder of the students' scientific contributions.

Learning outcomes

Student learning during the implementation of MSIP was affected positively in several ways. Student engagement, focus, participation, motivation, and interest increased. This outcome may be attributed to a supportive environment where students were able to facilitate their own learning (NRC 1996, pp. 43–45). In addition, students devoted hours to meeting with each other outside of the classroom and explored ways of doing science by collaborating on a research proposal and carrying it out (NRC 1996, p. 30, 143).

Throughout the process, students demonstrated understanding and growth through authentic performance assessments such as interactive discussions, presentations, demonstrations, written reports, and proficiency portfolios (NRC 1996, pp. 83–84). These ongoing assessments were designed to meet the needs of students within the context of MSIP (NRC 1996, pp. 37–42).

Science education sometimes is thought of as a process in which students are encouraged to participate in existing scientific practices (Brickhouse 2001). However, like scientists themselves, all students may not aspire to do science in the same way. MSIP provided a context for students to participate in some of the same types of activities that NASA/ASU scientists were doing, but in ways that allowed students to really focus on their learning styles, in relation to science (NRC 1996, p. 170).

MSIP curriculum includes a Teacher Guide, Student Handbook, and Resource Manual (all available free of charge online at *http://msip.asu.edu*). For this project, we used activities with an Earth and space science emphasis (NRC 1996, pp. 158–160). However, MSIP is designed to meet many of the National Science Education Standards and can easily be integrated into any science class—Teaching Standards A–E and Content Standards A, B, D–G (NRC 1996, pp. 30–50, 143–154, 158–180, 187–204). Further, teachers and their students participate and build competency together through their research, online collaborations, and participation in optional monthly teleconferences.

The impact

MSIP Westview: Crater on Elysium Mons made a significant impact on students, parents, and the community. Many students were from low-income families and could not imagine a day in the spotlight of science. It was great to see them carrying around articles from the school, local, and state newspapers that had been written about their work researching Mars. In addition, parents were eager to volunteer during the crater image dedication ceremony, and parents helped establish Westview's first "Astronomy Night." During this event, many families from the community attended student astronomy presentations and looked through an array of telescopes. The enthusiasm that was generated may have accounted for a significant increase on the Earth science end-of-course test scores.

Best of all, the collaboration with NASA/ASU fostered a new spirit in the science department at Westview High School. A new science computer lab was developed to further encourage collaborative student projects. A teacher forum was established to discuss future ideas for community projects. Several grant proposals were written and funding obtained to increase the use of technology in science classrooms. And, other science teachers incorporated MSIP into their classrooms.

In the future, MSIP may serve as a stimulus for further scientific investigations. Students could construct a simulated Mars habitat, design rovers, or experiment with hydroponics. These projects provide unique opportunities for students to contribute to the scientific understandings of Mars. For these students, Mars is no longer a little red dot in a sea of stars—the planet now is a brilliant hue, an aspiration, and a destination! ■

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