Spaceward Bound: Training and Inspiring the Next Generation of Space Explorers

Jennifer L. Heldmann[1], Christopher P. McKay[1], Liza Coe[1]

[1] NASA Ames Research Center, Moffett Field, CA 94035 USA

Abstract. Spaceward Bound is an educational program developed at NASA Ames Research Center in partnership with The Mars Society and funded by the Exploration Systems Mission Directorate (ESMD) at NASA Headquarters. The focus of Spaceward Bound is to contribute to the training of the next generation of space explorers by having students and teachers participate in the exploration of scientifically interesting but remote and extreme environments on Earth as analogs for human exploration of the Moon and Mars. Spaceward Bound expeditions have been conducted in 1) the Atacama Desert, Chile, 2) the Mars Desert Research Station in Utah, USA, and 3) the Mojave Desert in California, USA. Plans call for a future Spaceward Bound expedition to Australia.

Keywords: space, exploration, education

1 Background

The generation of students who will become the first astronauts to return to the Moon and explore Mars are currently in middle school. The senior managers and scientists that will plan and organize these missions are now in college and graduate school. In order to fulfill NASA's mission, these students need to learn about exploration science. This training consists of both STEM (science, math, engineering, and technology) education, as well as education that leads to the understanding of exploration concepts and skills. In order to provide the latter, teachers must be trained not only in exploration science content and skills, but also pedagogy and pedagogical content knowledge.

To achieve these objectives, the Spaceward Bound program was established. Spaceward Bound brings both students and teachers into the field with scientists to conduct actual fieldwork. Spaceward Bound expeditions have been conducted in 1) the Atacama Desert, Chile, 2)

the Mars Desert Research Station in Utah, USA, and 3) the Mojave Desert in California, USA.

One of the keys to the success of Spaceward Bound is the training of participants prior to the field expedition via utilization of the NASA Distance Learning Network (DLN) and webcasting. Broadcasting from such remote locales was successfully accomplished thanks to the NASA Ames Education Division. Using a satellite connection, both video and audio were successfully broadcast over the Internet for real-time webcasting. We will continue this aspect of the program for all expeditions. Web broadcasting was also another key to success in terms of significantly increasing the quantity and quality of participation by teachers/students not on the expeditions. While the technical challenges involved in broadcasting from such remote locations is not trivial, successful broadcasting is possible and greatly enhances the Spaceward Bound experience.

1.1 Atacama Desert, Chile

The Atacama component of Spaceward Bound occurred in 2006 and the focus was to involve teachers in authentic fieldwork so that they can bring that experience back to their classrooms and assist in the development of curriculum related to human exploration of remote and extreme environments. In June 2006, seven middle school teachers from around the U.S. teamed with seven teachers from Antofagasta, Chile to work alongside scientists in exploration of the Mars-like soils in the Atacama Desert in Northern Chile (Figure 1).

This expedition was comprised of three components: 1) Education, 2) Science, 3) Technology. The overarching theme that united the three components was exploration. Scientific activities were approached from the perspective of how similar activities would be performed on the Moon or Mars, how research here on Earth could assist the analysis of research results from the Moon/Mars, and what infrastructure was needed to support the research which will, in turn, need to be provided on the Moon/Mars surface. The technology component was approached similarly.

Education activities were guided by the motivation to train teachers to inspire students to be the next generation of explorers. While exploration is often presented in classrooms as a motivational supplement to existing curriculum, and components of exploration are taught, no pedagogy of exploration itself exists.

A true pedagogy of exploration would provide unparalleled experience in affective and cognitive motivations such as curiosity, discovery, bravery, disappointment, tenacity, flexibility, etc. But it also requires a synthesis of currently segregated academic disciplines, i.e. "hard" science, "soft" science, and non-science. In modern schools, curriculum and pedagogy are ill-equipped to embrace this synthesis, and much less able to develop the content, concepts, and skills to teach it.

Fig. 1. View of the University of Antofagasta Desert Field Station in Yungay, Chile, in the hyperarid core of the Atacama Desert.

In a broader sense, however, the contribution of this expedition to the education community as a whole (including research) and to NASA is the creation of a program that enables the amalgamation of the expertise and experience of master teachers with the knowledge, practice, and experience of today's explorers to begin the conceptualization and development of a pedagogy of exploration.

Analysis of the teacher's final reports (posted on the Spaceward Bound website) reveals how this new pedagogy may look. It also provides clear evidence of the intrinsic power of authentic exploration to motivate, engage, frustrate, and thrill.

1.2 Mars Desert Research Station (MDRS), Utah, USA

The focus of the second expedition was to enable students at the upper undergraduate and graduate level to participate as crewmembers in two-week long immersive full-scale simulations of living and working on the Moon and Mars at the Mars Desert Research Station (MDRS), established and operated by The Mars Society (Figure 2). The first Spaceward Bound 2006 crew rotations at MDRS took place between November 2006 and March 2007.

The students were interested, enthusiastic, and came from a variety of schools and backgrounds. At the start of each simulation, a meeting was held to discuss the shape and goals of the Spaceward Bound student activities. The students were very excited by the fact that they were defining and creating this training program through their simulations. Interacting with these students in the field was inspiring for the science PI, as well as for the students.

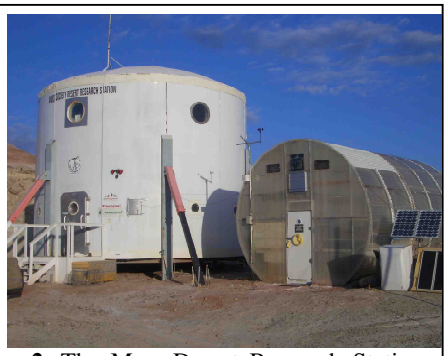

Fig. 2. The Mars Desert Research Station (MDRS) in the desert near Hanksville, Utah, USA.

From these discussions have emerged three particular products that will be used to enhance Spaceward Bound student activities in the future:

1. The MDRS Habitat User Guide and Operations Manual.

2. Spaceward Bound Training Curriculum. There are a range of skills that are essential for field astronauts working on Mars or in Mars-analog field environments on Earth. These include working in bulky suits, mechanical skills, equipment repair, biology and geology skills, greenhouse operations, electronics, navigation, field documentation, ATV operation, etc. We have developed a training course for Spaceward Bound that will train every student in these basic skills.

3. "The Lovely Planet" Guide to Science and Field sites at MDRS. This will be a series of mini-reviews and orientations for each site or topic of research at MDRS, written at the Scientific American-level with images, detailed maps, etc. Note that these three products are being prepared by the Spaceward Bound students.

Students participating in the MDRS Spaceward Bound crews also completed a rigorous science and engineering program. Example science investigations included a survey of hematite concretions surrounding MDRS, landform identification and mapping, biologic studies (including greenhouse plant growth as well as culturing of microbes collected from various field sites), and astronomy investigations using the MDRS telescope. Engineering studies included the installation and testing of a wireless network in the Habitat vicinity, power generation, and the first documented construction project in full simulation spacesuits. Human factors studies investigated the human-machine interfaces to assess the usability of various technological components such as spacesuits, extra-vehicular activity (EVA) transportation vehicles, Habitat instrumentation, etc.

In the fall of 2007, we again plan to sponsor Spaceward Bound student simulations at the MDRS.

1.3 Mojave Desert, California, USA

The third Spaceward Bound expedition (for teachers) occurred March/April 2007 at the California State University Desert Studies Center (CSUDSC) in Zzyzx, California—on the western edge of the Mojave

Fig. 3. Death Valley in the Mojave Desert, California, USA.

National Preserve in Southern California. Figure 3 shows a field site in Death Valley. Teachers worked with scientists and engineers to investigate lunar and planetary surface systems, e.g. extended surface operations, environmental analysis, robotics, radiation protection, spacesuits, and life support. They also investigated human machine interface software and hardware. Some activities included 1) the collection of desert soils for subsequent laboratory analysis to assess the samples for microbial activity, 2) exploration of lava tubes and assessment of detection techniques to search for lava tubes on Mars, 3) study of ancient soils which have been capped beneath previous lava flows, 4) exploration of canyon systems and sedimentary rock deposits, 5) investigation of stromatolite deposits as evidence of ancient life, and 6) remote operation of robotic rovers to conduct field investigations.

1.4 Discussion and Conclusion

Spaceward Bound aims to directly involve students and teachers in planetary exploration. The past three Spaceward Bound expeditions (Atacama Desert, Mars Desert Research Station, and Mojave Desert) have been extremely effective at engaging, inspiring, and training the Spaceward Bound participants. The Spaceward Bound experience begins with live interactive training broadcasts where the expedition leaders provide background content to the students and teachers. Several of these broadcasts are typically planned and participants can watch the webcast and ask questions in real time. These broadcasts are thus useful for both dissemination of relevant information and also team-building. The Spaceward Bound crew is then ready to meet in the field and conduct the expedition. During the expedition, webcasts broadcast live from the field site(s) are conducted to engage those students and teachers that are not in the field. After the expedition, crewmembers are encouraged to share their experiences with fellow students and teachers and to present their findings at relevant conferences and workshops.

These Spaceward Bound expeditions have met and exceeded the intended goals and thus we intend to expand the Spaceward Bound

program to explore additional Mars-analog locales (such as Australia) and to allow more students and teachers to participate in the program.

2 Future Plans

To expand the success of Spaceward Bound, we plan to reach even more students and teachers and continue developing the approach and methodologies for the field training of the next generation of space explorers and those who are teaching them. We also plan to expand the geographic diversity of Mars analog sites where Spaceward Bound expeditions are conducted. One particularly attractive site is the Australian Outback. The feasibility of conducting a Spaceward Bound expedition outside of the U.S. has been successfully demonstrated (through the Atacama Desert expedition in Chile). Australia is uniquely suitable as a Mars-analog environment and the combination of relevant scientific field investigations (geology, chemistry, astronomy, biology, astrobiology) coupled with the active Australian Mars research community makes Australia an especially attractive target site for future Spaceward Bound expeditions.

We plan to continue working with members of The Mars Society Australia to organize and conduct a Spaceward Bound expedition for students and teachers in Australia.

N.B. For more information on Spaceward Bound, please visit our website at http://quest.nasa.gov/projects/spacewardbound/.