THE UNIVERSE IN THE CLASSROOM

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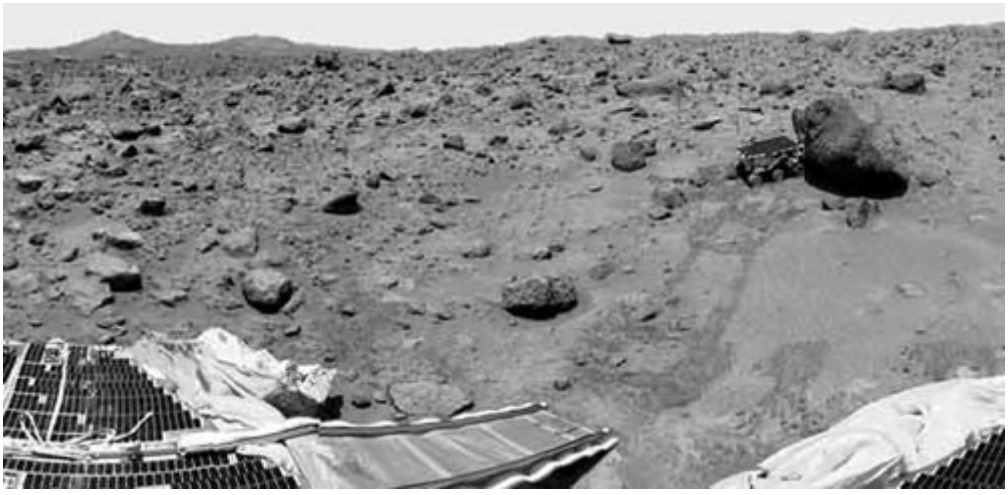
Effecting Global Change

by **Stacy Palen**
University of Washington, Seattle

I was watching a PBS program about John Glenn's 1998 launch on the Space Shuttle when the idea first occurred to me. I realized that this launch meant very little to my Astronomy 101 students, who were not even born the last time we as a species went to the Moon, let alone the first time we went into Earth orbit.

As the program went on to talk about space initiatives and what comes next for NASA, covering topics such as the International Space Station and Mars colonization, I began to realize how common-place some of this must be to my students, nearly all of whom have grown up in the post-Apollo era. An informal poll of them indicated that some think the Space Shuttle goes to the Moon, and that we visit it regularly -- so regularly that it doesn't even make the news!

I was born in 1971. I've never quite gotten over the disappointment of not seeing a man walk on the Moon in "real-time." But things were still happening when I was young. The Space Shuttle was new and tremendously exciting. I recall watching the launches in "homeroom" at school. All of this meant that I knew why I was interested in science. I wanted to go to the Moon, to Mars. I wanted to see Earth from space for myself.



Wandering the Martian plains. In July 1997 the Mars Pathfinder spacecraft landed on the surface of the Red Planet. Soon after its arrival, a small Martian rover named Sojourner left the craft and explored the immediate area. In this image we see Sojourner studying a large rock nicknamed

"Yogi", and roughly a kilometer away are the 30-35 meter tall "Twin Peaks" rising above the rock-strewn plain. Part of the Pathfinder spacecraft is visible in the lower left, and tracks leading to Sojourner are clearly visible. Image courtesy of NASA.

Today's students have no reason to wonder about the Space Station. They have no reason to ask why the Shuttle exists. They have no reason to wonder where we are going next. The whole space program is removed from their experience. For many of them, this launch of the Shuttle carrying Glenn was the first of any spacecraft that they knew about ahead of time. Even Mars Pathfinder was unknown to them before it began to actually transmit images, yet that mission was a good start at getting the general public interested in the space program again. I decided to try to give my students another reason to care about science.

I asked them to terraform Mars. Not literally, of course, but on paper. Why this project? It is often said that Mars is the next great frontier. There is an abundance of literature at middle-school and higher levels about the subject. In fact, it is easy to find a great deal of information if you do a web search on, say, "Mars and colonization" (see "A Selection of Web Resources for Student Activities").

The students in my class, like those everywhere, already knew something about Mars and terraforming from popular science fiction books, movies, and TV. Also, the Pathfinder mission had built some momentum. The students were aware of Mars in a way that no other group of students has ever been. They had seen pictures of this place outside of astronomy class -- they knew what the Martian sky looked like, they had heard the sound of Martian winds, they had an almost tactile memory of Mars as a planet, as a place that we have been to visit more than a few times. But mostly, I chose this project because I thought it would be "cool," and therefore likely to attract and keep their attention.

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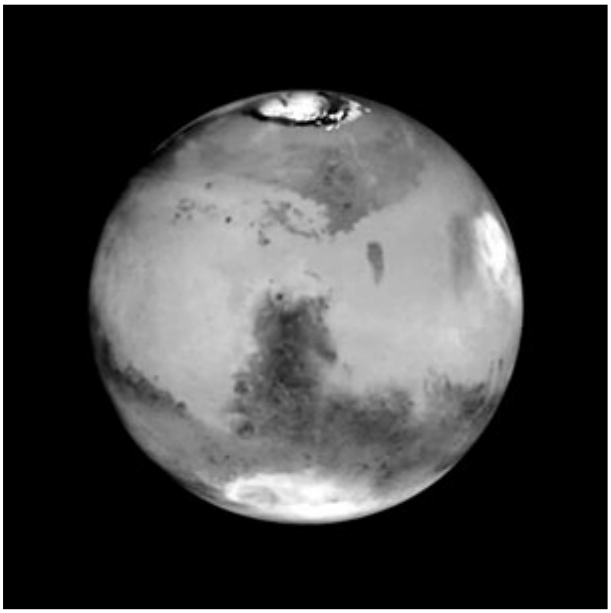
"Your Mission, Should You Choose to Accept It..."

The night after the John Glenn program, I pitched the terraforming idea to my students. I asked them if they'd like to terraform Mars as a big class project; I wanted to throw the idea to them and see how they would react. Already I had a vision of splitting the class into several groups and having each group take charge of a portion of the project. At the end of the quarter, they would all present their results at a Mars party.

In spite of these early ideas, I was nonetheless shocked by their response to the proposal: they were so excited that they jumped out of their seats. College freshmen, no less! Jumping up in excitement about being asked to do extra work. It was astounding and very gratifying. They couldn't raise their hands fast enough. They were full of questions, comments, and ideas. They wanted to start right away, that night. Students were clamoring for attention from all over the room. I felt as though I'd suddenly been transported to a kindergarten class!

Following my initial idea on how to conduct the project, I split the class into six groups, each student choosing his or her group.

- The **ethics** group was in charge of discussing (and arguing!) whether we should go to Mars, whether it's right to impose our will on another planet, whether it's worth the cost, etc.
- The **public relations** group pitched the project to the entire world. This group further split into a government group, a scientist group, a general public group, and a group in charge of "indoctrinating the young."
- The **pre-atmosphere** group had to get us to Mars and set up. They needed to choose landing sites, launch vehicles, communications relays. They also decided who and how many should go before the atmosphere was in place.
- The **atmosphere** group was responsible for the engineering and building of an atmosphere on Mars and then greening the planet.
- The **infrastructure** group considered how to make the most of the Martian landscape and resources to build the colony and fulfill its requirements for shelter and food.
- The **society** group chose the lucky first few colonizers and then decided how the society would be structured once they got there -- particularly how closely the Martians would be tied to the Terrans.



Mars at its Hubble best. This image, obtained by NASA's Hubble Space Telescope, is centered on the dark feature known as Syrtis Major, first seen telescopkically by the astronomer Christiaan Huygens in the 17th century. Many small, dark, circular impact craters can be seen in this region. To the south of Syrtis is a large circular feature called Hellas. Viking spacecraft and, more recently, the Mars Global Surveyor have revealed that Hellas is a large and deep impact crater; HST images further indicate Hellas sometimes fills with surface frost and water ice clouds. Along Mars's right edge, late afternoon clouds have formed around the volcano Elysium. Such interesting planetary activity, and more specifically atmospheric activity, make Mars an interesting world for students (and everyone else, too) to study.

Each group had a little class time each week to meet and work on the project, and the entire project spanned about six weeks. Allowing them to choose which group to join made the multi-disciplinary approach work very well. Surprisingly, most people chose to join one of the true science groups (pre-atmosphere, atmosphere, or infrastructure), where they were asked to learn the most about Mars itself. The society group was the smallest, possibly even understaffed, and the ethics group was a close second.

Due to the spontaneous nature of the project, the assignment was very open-ended. I gave the students very little direction beyond briefly describing the problem and suggesting that a web search might be a good place to start. I made sure to warn them about using references from the web, and mentioned that they should only believe information coming from a place that they trust. For the most part, students are pretty savvy about this — they've seen enough sites with ridiculous claims to censor the web themselves. I made myself available to them during class time each week and often fielded questions about the project before and after class. It didn't take long for their knowledge to far outshine my own, and then they started answering each other's questions. Probably the largest contribution I made to the project was being enthusiastic, interested in the entire thing, and available "on the side" for comments and ideas.

The students became obsessed with the project. Several of them told me that work in their other classes was suffering because they were so fascinated with this topic. Some of the students who had not been paying close attention during lectures began paying attention as the project progressed. It seemed that science and technology became more real and purposeful to them. Of course, it did not capture everyone. Two students complained bitterly about the "extra" work, which was not part of the original syllabus. They did not want to have anything to do with the project. Rather than force them into a group, where they might ruin the experience for everyone, I allowed them to do a more traditional astronomical observing exercise for this portion of their grade. This decision turned out to be correct: they were happier, and the other students did not have to manage less-than-enthusiastic students in their group.

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Changing a World

What did the students learn from all this? For starters, they learned an awful lot about Mars. The University of Washington is on the quarter system, and we usually don't mention the planets at all during the ten weeks of Astronomy 101 (we have another course that deals solely with the planets). The students found this unsatisfactory -- some of them would not be able to fit another astronomy class into their schedules, but they wanted to know about our planetary neighbors, and this project gave them the opportunity to find out without spending valuable class time on the subject.

Giving thought to transforming Mars. Photos courtesy of the author.

The students also learned to learn for themselves, perhaps one of the most important milestones during formal education. Because the project was so free-form, they were obliged to define the problems on their own: they needed to think about them, ask their own questions, and then try to find the answers, all with no formal guidance. My students really responded to the challenge, and most of them found the general problem of terraforming Mars genuinely interesting and even compelling.

The wealth of information on the topic, both on the World-Wide Web and in the library, made their research straight-forward and fun. There was ample room for creative thinking, for the synthesizing of new ideas. The students seemed to feel that they were making an actual contribution to solving an actual problem.

They also learned to make distinctions between science and science fiction, which is not always easy even for those of us who are a part of the science community! The students learned a great deal about what science is, how scientific endeavor proceeds, and who does it. They even learned how scientific information finds its way into the main stream.

As the project progressed, the students became much more skeptical of the news reports that I would have them read (for other purposes entirely). This led to more questions from them, better involvement in classes, and greater demands of proof that the material I presented in lecture was correct. There were days when I was almost sorry I had started the whole thing!

The last day of the project was a rousing success as the students presented their work to the class. Each group chose its own presentation style. The public relations committee, for example, chose to give speeches, while the pre-atmosphere group gave a PowerPoint-based formal lecture on their topic. The ethics committee summed up the arguments on either side and reasoned their way toward approving the mission. The running joke was that they'd better approve, or the other groups would meet them after class! The students brought food, drinks, balloons and streamers, and made a real event of it. Several of them brought friends from the

dorms or from home, and everyone was impressed with the effort of all the groups. The class was patient with groups' various technical difficulties, and with the fact that classtime ran nearly half an hour too long.

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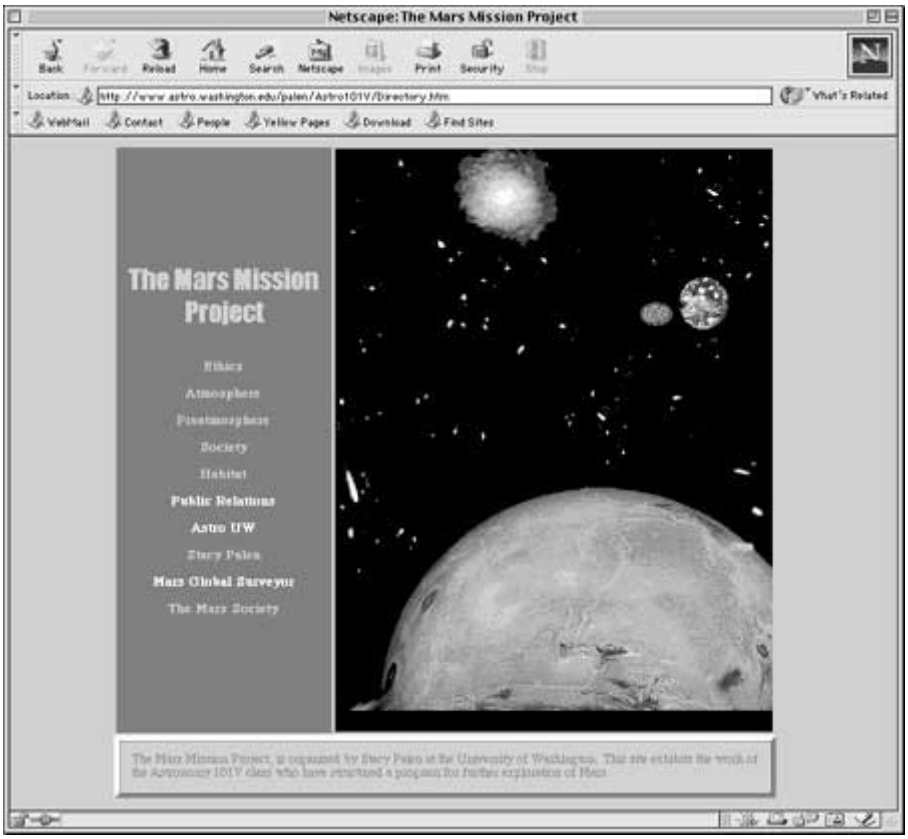
In Hindsight

During and after the project, the student response was tremendous. They really loved it. They felt challenged, interested, compelled to find out more. Many of them said to me afterwards, "You should do this again!" Several of them keep in touch with me about bits and pieces of Mars information that they run into. I am afraid that some of them may be fixated!

I invite you to view what the class did with the terraforming project. All the work there was done by the students - from the website itself, to the artwork, to the content. For some of the groups, I had a hand in converting the work to HTML. For example, the PowerPoint presentation of the pre-atmosphere group required substantial reformatting. These pages contain only portions of the entire project, since some of the presentations were purely verbal, and I was remiss in collecting all the speeches.



The Mars Project student website

Of course, if I were to do it all again or if you decide to try this with your own class, there are a few things I would change.

> *I think that it can be stressful to students to have such a large project to work on when they don't know what it's worth to them. This was something of a problem for me, too, but again, the*

project idea came to me during the term. This difficulty can be avoided by planning on such a project from the beginning of the term (or school year, if you teach at the primary or secondary levels).

On the one hand, having the final product so open-ended made it difficult to assemble the different group projects into a seamless whole. It would be better to have them all write a paper or, say, construct a web page. On the other hand, some of the speeches were really great, and it would be a shame to lose them. I would definitely have the presentations span two class periods, rather than just one, to avoid the class running overtime.

I don't think I would want to do the same project each term. Much of what made this project so successful was the timing -- just after the Mars Pathfinder mission, when Mars was foremost in people's minds. However, this opportunity should continue for several years at least, as NASA has ongoing and upcoming Mars missions (and others to other worlds!).

I was a little frightened the first day that I pitched the idea to my students. I didn't know what was going to happen, and I didn't know if they would respond with enthusiasm or with the typical freshman stare. I was most afraid that an initial enthusiastic response would not carry through to the end of the project. But the students made it work. They were enthusiastic, excited, and involved from the first day to the last.

My experience with grade schools is limited to brief one-day visits, but I think this project would be appropriate for anyone from fourth or fifth grade to college-level. The free-form nature of the project lets students participate to the level of their ability to understand. I would expect that fourth and fifth graders would need a more focused assignment, in order to keep them "on task." I can imagine adapting the project to include an art project (building models of spacecraft and housing on Mars), or to include some mathematics practice (scaling, distance and angular size, etc.), or to exercise language skills (writing speeches or reports). The project is really about building enthusiasm, and the freedom to choose a presentation style makes it highly adaptable.

I was completely impressed with my students' initiative and with the amount of information they managed to pack into their heads in a relatively short period of time. It was like watching 7-year-olds learn about dinosaurs. I think the project may have inspired some of them for the rest of their lives to be curious, and attentive to science, the space program, and astronomy. Perhaps the best way to describe it is in the words of one of the students themselves, as submitted in an anonymous questionnaire at the end of the quarter:

"[The Mars project] provided us with the opportunity to take learning into our own hands and direct the class where we wanted to go."

Stacy Palen is an astronomer at the University of Washington in Seattle. In spite of the rain and the extremely short winter days, she spends lots of time outdoors, riding and training 3-day event horses or backpacking. She may be reached via email at palen@astro.washington.edu.

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A Selection of Web Resources for Student Activities

Terraforming

Terraforming Information Pages

> http://www.users.globalnet.co.uk/~mfogg/index.htm
> A superb source of information on terraforming by Martyn J. Fogg

Terraforming and Ecogenesis

> http://www.reston.com/astro/terraforming.html
> A good collection of information created and maintained by the Astrobiology Web.

Mars Colonization

Mars Millennium Project

> http://www.mars2030.net
> An official White House Millennium Council Youth Initiative that challenges students across the nation to look forward to the year 2030 and design a Martian colony for 100 humans.

Mars Project Phase One

> http://marsproject.com/
> Phase One of a project that is, in fact, an educational simulation of the colonization of the Red Planet in which students experience the trip and the settlement through virtual reality.

The Mars Society

> http://www.marssociety.org/
> An information source to be sure, but the direct aim of the Society is to further the work to colonize Mars.