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Goldilocks and the Three Planets

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Abstract. We have developed a presentation that investigates the differences in the atmospheres of Venus, Earth, and Mars, and how these differences arose. The target audience is elementary school age children. The presentation is a combination of planetary images displayed on engaging spherical displays and visual demonstrations. We recently tested and evaluated our preliminary presentation on the Lawrence Hall of Science's six-foot diameter Science on a Sphere.™ Our future plans include transferring this presentation onto a portable, table-top spherical display system to take into classrooms. We also plan to develop additional presentations targeting older age groups.

1. Introduction

Just after their formation, the atmospheres of Venus, Earth, and Mars are thought to have been very similar. Why are they so different today? We have developed a presentation that investigates the differences in the atmospheres of Venus, Earth, and Mars, and how these differences arose. Our target audience is elementary school age children. We are also developing additional presentations targeting middle school and high school students.

The presentations are a combination of planetary images on engaging spherical displays coupled with visual demonstrations. We recently tested and evaluated our first presentation on the six-foot diameter Science on a Sphere™ at the Lawrence Hall of Science in Berkeley, California. Our future plans include transferring this and future presentations onto a portable, table-top spherical display system for traveling presentations.

This work is part of a larger effort entitled "Seeing the Invisible: Educating the Public on Planetary Magnetic Fields and How they Affect Atmospheres" funded through a NASA Research Opportunities in Space and Earth Sciences (ROSES) Supplemental Education grant. Our collaborators include science and education professionals from the Space Sciences Laboratory, the Center for Science Education, and the Lawrence Hall of Science at the University of California, Berkeley.

2. Presentation, or Goldilocks and the Three Planets

The main goals of the presentation are to communicate to the target audience that the atmospheres of Venus, Earth, and Mars are different and to give the audience some understanding as to why they are different. We employ an analogy with the familiar story of Goldilocks and the Three Bears: Venus is too hot, Mars is too cold, Earth is just right. The initial part of the presentation is an overview of what is an atmosphere and why it is important for life on Earth. Next, the presentation highlights the differences in the atmospheres of the three planets including thickness of the atmosphere, temperature near the surface, composition ("poison content" in audience parlance), and the presence or absence of liquid water. Finally, the presentation addresses why the atmospheres are different focusing on distance from the Sun and the presence and stability of water on the surface. Liquid water was able to remove carbon dioxide ("poison") from the atmosphere of the early Earth. During the presentation, multiple images of the planets and their atmospheres are shown on the Science on a Sphere. At the conclusion of the presentation, there is a demonstration about the phases of matter and how they relate to water at the three planets. A hot plate is used to show how liquid turns to gas (water at Venus), a plate sitting atop a container of dry ice is used to show how liquid turns to solid (water at Mars), and mist condensing to liquid shows how liquid water exists at Earth.

During the spring of 2010, our presentation content was evaluated through the use of test presentations and post-presentation interviews with targeted audiences at the Lawrence Hall of Science. The interviews showed that we did well communicating to the audience that Venus is too hot, Mars is too cold, and Earth is just right for liquid water to exist. The phases of matter demonstration was well received; however, the interviews showed that we did not adequately communicate the connection between the presence of liquid water and the characteristics of the atmosphere. Even though the presentation mentioned that carbon dioxide dissolves in water and is put into rocks, and chalk was shown as an example of such a rock, the idea that the atmosphere is changed by the presence of liquid water was not clearly retained. As a modification to the presentation, we plan to add a demonstration (perhaps at the expense of the phases of matter demonstration) where a piece of carbonate rock (e.g., limestone) is placed in a container of vinegar (weak acid). The resulting reaction releases visible bubbles of carbon dioxide. The hope is that this visual demonstration will help the audience remember that Earth's early carbon dioxide was put into rocks.

3. Future Plans

Our future plans include developing at least two additional presentations. The first presentation will have a middle-school age target audience. This presentation will focus on differences between the magnetic fields of Earth and Mars: Earth has a global dipole magnetic field, while Mars has smaller, weaker magnetic anomalies analogous to buried magnets. Additionally, the presentation will address why the magnetic fields of the two planets are different, which depends upon how the magnetic fields are formed: Earth's magnetic field is generated by motions in the deep interior, while Mars's magnetic field is trapped in magnetized surface rocks. Images that can be displayed on the Science on a Sphere are readily available or can be modified from currently available images with little effort. Additionally, hands-on activities including, for example, mapping

magnetic fields due to a single source versus magnetic fields due to multiple sources can be incorporated.

A second presentation geared toward a high school age audience will also be developed. In addition to the content of the first future presentation, this presentation will stress the effect of differences in the magnetic fields of Earth and Mars. Global (Earth-like) magnetic fields can protect an atmosphere from the solar wind. In the absence of a global magnetic field (like Mars), the solar wind can slowly strip away the atmosphere. The thin atmosphere of Mars today may be due to this effect. The goal of this final presentation will be to show that planetary magnetic fields are important for long-term atmospheric and climate evolution.

As noted above, all of these presentations will be adapted from the six-foot Science on a Sphere format to a portable, table-top spherical display system for traveling presentations. Through this project, in conjunction with other projects at the Center for Science Education, we have purchased a Magic Planet^{TM} portable digital video globe from Global Imagination. This video globe will allow us to take these (and other) presentations into classrooms to reach students who do not traditionally go to the Lawrence Hall of Science.

Finally, our future plans also include constructing rigid, three-dimensional wire models of the magnetic fields of Venus, Earth, and Mars. These display models will be part of the traveling presentations and will show scientifically accurate representations of each planet's magnetic field. These models will be important in communicating the shape of the magnetic field and the scale of the magnetic field in relation to the planet.

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