Educational Use and Effectiveness of an Auditory Display of Mars GRS Data. J. M. Keller[1], W. M. Boynton[1], H. L. Enos[1], D. Hamara[1], D. Janes[1], K. Kerry[1], S. M. Pompea[2], E. E. Prather[3], M. Quinn[4], and T. F. Slater[3], [1]Lunar and Planetary Laboratory, Univ. Arizona, Tucson, AZ 85721 (jkeller@lpl.arizona.edu), [2]NOAO, 950 North Avenue, Tucson, AZ 85719, [3]Steward Observatory, 933 N. Cherry Ave., Tucson, AZ 85721, [4]Quinn Arts, 92 High Rd., Lee, NH 03824 (marty@quinnarts.com).

Introduction: A central issue in science education involves engaging students in the process of scientific discovery. Too often, science is presented as a factual inventory to be memorized rather than an active process of questioning, investigation, and discovery. In addition, scientific data and ideas are most often presented either as text, in tables, graphs, or other visual representations. These modalities are effective and engaging to many, but by no means all, students. In 1983, Howard Gardner [1] proposed a Theory of Multiple Intelligences and argued the need to expand our concept of human intelligence to include logical-mathematical, spatial, linguistic, musical, bodily-kinesthetic, and personal intelligences along with educational materials designed to maximize these intelligences. The scientific community has historically relied more heavily on the first two of these intelligences. Very little work has been done in integrating "musical intelligence" into science and science education materials. Background information on this recent field of research can be found at the website for the International Community for Auditory Displays (ICAD) at http://www.icad.org.

Description of EPO Project: A unique and alternative Education and Public Outreach (EPO) product has been created by members of the Mars Gamma Ray Spectrometer (GRS) team to investigate the use and effectiveness of auditory displays in science education. The product, which allows students to both "see" and "hear" seasonal variations in the hydrogen signal detected by the GRS instrument, consists of a traditional animation of false-color maps of hydrogen concentrations on Mars along with an engaging musical presentation, or sonification, of the same data. The hydrogen signal, which is believed to result from the presence of frozen water ice buried in the first meter of the surface of Mars, varies with season because of changes in the polar carbon dioxide ice caps which mask hydrogen gamma rays. By applying logical algorithms to quantitative data, various instruments have been digitally orchestrated to musically represent the following data elements: average daily solar insolation, planetary latitude, predicted and measured hydrogen gamma ray intensities, and calculated hydrogen concentrations. As will be presented, one can access this data using the visual false-color animation, the aural false-pitched sonification, or both.

Plans for Educational Testing: This EPO product will provide a platform for testing the use and effectiveness of musical data in educational settings. Preliminary research will involve exploratory interviews with university students as they interact with and interpret the data in both representations. Through these interviews, we hope to both uncover fundamental issues related to student use of auditory displays and to develop and revise curricula for implementing the sonification into a classroom setting. The second phase of research will involve presenting the EPO product and related curricula to university students enrolled in an astronomy course for non-science majors. Using multiple sections of this course, data will be collected based upon three different treatments: visual data only, aural data only, and both visual and aural data together. Students will be surveyed following the activity to gauge both the cognitive and affective impacts of these treatments. Followup interviews with a small set of these students may be conducted afterwards. Through this study, we hope to address a number of research questions: Can auditory displays enhance understanding or engagement levels in a science classroom? Is there a correlation between the effectiveness of auditory displays and various learning styles or musical backgrounds amongst students? How can visual and aural presentations be used in tandem to enhance their overall effectiveness? What are key issues in the implementation of musical data into a science education setting?

In addition to providing an engaging and aesthetic presentation for public outreach venues including radio and the internet, this EPO product could also have unique applications with a number of specialized educational settings, including the sight-impaired community, the gifted-and-talented arena, and music and art programs. During the presentation, we will listen to and discuss this unique representation of Mars GRS data.

References: [1] Gardner H. (1983) *Frames of Mind*, New York: Basic Books Inc.

Additional Information: Individuals interested in this or related work are encouraged to contact us at the following addresses:

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