EDUCATIONAL EXPERIENCES FOR K-12 IN THE EARTH AND PLANETARY SCIENCES.

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Introduction: Career opportunities in science, technology, engineering, and math (STEM) are predicted to grow by 17% between 2008 and 2018 [1]. Yet, graduation of STEM college students is expected to fall short of need by 1 million over the next decade [2]. STEM Education and Public Outreach (E/PO) offers an avenue of engaging and exciting the community about STEM topics and careers. Engaging kindergarten through high school (K-12) students in STEM related outreach activities can be the catalyst for students to start, continue, and retain educational and career paths within STEM fields [3]. The work presented here is part of a 10 month project funded by the NASA Nevada Space Grant Consortium to develop a series of engaging, interactive, and educational informal activities targeted at K-12 participants and emphasizing STEM concepts. Our developed outreach activities are expected to become part of a "library" of informal experiences and related supplemental materials for ongoing outreach by the UNLV Department of Geoscience, eventually reaching beyond K-12 to include college undergraduate and graduate students (if interested, please contact Christopher Adcock adcockc2@unlv.nevada.edu).

E/PO Events: Our current project includes three developed E/PO K-12 events. Each event begins with a short presentation, followed by a 30-45 minute group activity, and concludes with a follow-up discussion. Outreach materials are made available for ongoing use by participants and teachers. In addition, the events conclude with an "experience reminder" (an inexpensive souvenir to remind the participant of the event) such as a 3D printed 1"x1" Olympus Mons. The three activities currently developed for this project focus on planetary exploration, planetary volcanism, and solar system scales.

Mission to Planet Alpha Event. The E/PO event applies gamification [4] (i.e. applying game mechanics to non-game contexts such as education) to introduce students to the complexities, tradeoffs, and risks involved with developing and performing unmanned space missions. The event also explores aspects of astrobiology and potential extraterrestrial life.

The event begins with a short presentation on exploring planets and moons, both in our solar system and beyond. The presentation includes instructions on how the game, *Mission to Planet Alpha*, is played. At the end of the presentation, participants break into groups and play a game. The game is table top simulation of an unmanned mission to a fictional planet. The mission objective is to explore the fictional planet and search for signs of life. Each group is assigned a different fictional planet. The simulation includes resources, such as available launch vehicles and science equipment for the mission. There are also limitations, such as weight, energy, and monetary budgets. Participants assemble a spacecraft within the limitations and launch it. During the mission "events" occur that can help or hinder the mission. For example, a game event might include a collision with a micro-meteorite that eliminates an instrument on the probe.

Upon arrival at the planet, participants are presented with an image of their planet and some general facts (see example Figure 1). The mission then "deploys" the science package. Depending on what instruments were chosen, different facts specific to the planet are revealed. Because the participants have no foreknowledge of the planet, there is a possibility that the science package they chose is not well suited for the mission. The activity concludes with a discussion of what life forms might look like on other planets (based on discoveries during the game) and different mission choices that might have been made.

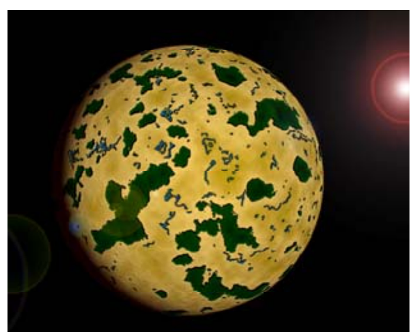

Figure 1. One of five fictional planets in the *Mission to Planet Alpha* game. This planet has a thin atmosphere, large briney lakes possessing a green substance, and a barren desert-like land surface. Image: Chris Adcock 2014

Volcanoes in the Solar System Event. This event begins with a presentation on volcanoes, including a "tour" of volcanoes on other planets or moons (e.g. Enceladus, Io, Mars). The presentation utilizes data or visualizations obtained from the NASA Planetary Data System, Planetary Photojournal, and the Eyes on the Solar System product. After the presentation, samples of volcanic rocks are made available to participants as well as a 3D printed model of Olympus Mons (Figure 2). The event includes a demonstration of pumice floating in water and a model volcano demonstration with participant volunteers. The activities conclude with distributing a 12"x17" volcano poster to participants as well as a larger class size version for the classroom (Figure 3).

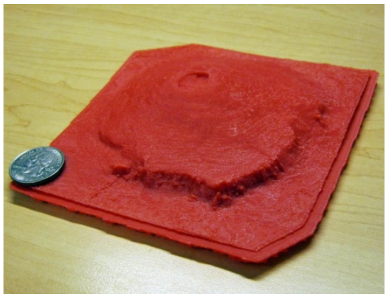

Figure 2. A 5"x5" 3d printed model of Olympus Mons on Mars. Model has 6x vertical exaggeration. Data for models is sourced from MOLA and HIRISE DEMs. Smaller models may be used as experience reminders for E/PO events.

Solar System Scales Event. Like the other events, mission data obtained from the NASA PDS, Planetary Photojournal, and visualizations from the Eyes on the Solar System product are used in a short presentation before a group activity. The activity in this event is an outdoor exercise using a scaled Sun and planets. Participant volunteers play the role of the Sun, planets, and major moons, and each hold a rod with a scaled representation of a planet, moon, or the Sun. The participants stand at distances apart which represent the scaled distance between objects. With the Sun being a 2.5 cm sphere, the distance to Neptune would be roughly 90 meters (Mercury would be represented by the diameter of a section of fishing line). There is also a 1.25 cm Sun option (45 meter solar system). Following this exercise, a second exercise demonstrating the distance from our star to other nearby stars is conducted. The activity concludes with a handout for participants that includes a table of solar system distances based on different size "Suns" from 5 mm to the size of a baseball (~75 mm) and the relative diameters of planets, moons and the Sun.

References: [1] Econ. and Stat. Admin. (2011) Brief #03-11. **3**, 10. [2] Pres. Coun. of Advisor. on Sci. and Tech. (2012): Washington.[3] NASA Office of Education (2014) *About NASA's Education Program*. Available from: http://www.nasa.gov/about/contact/index.html#.U5DsLiim40. [4] Huang and Soman, (2013), *A Practitioner's Guide To Gamification Of Education*, University of Toronto.

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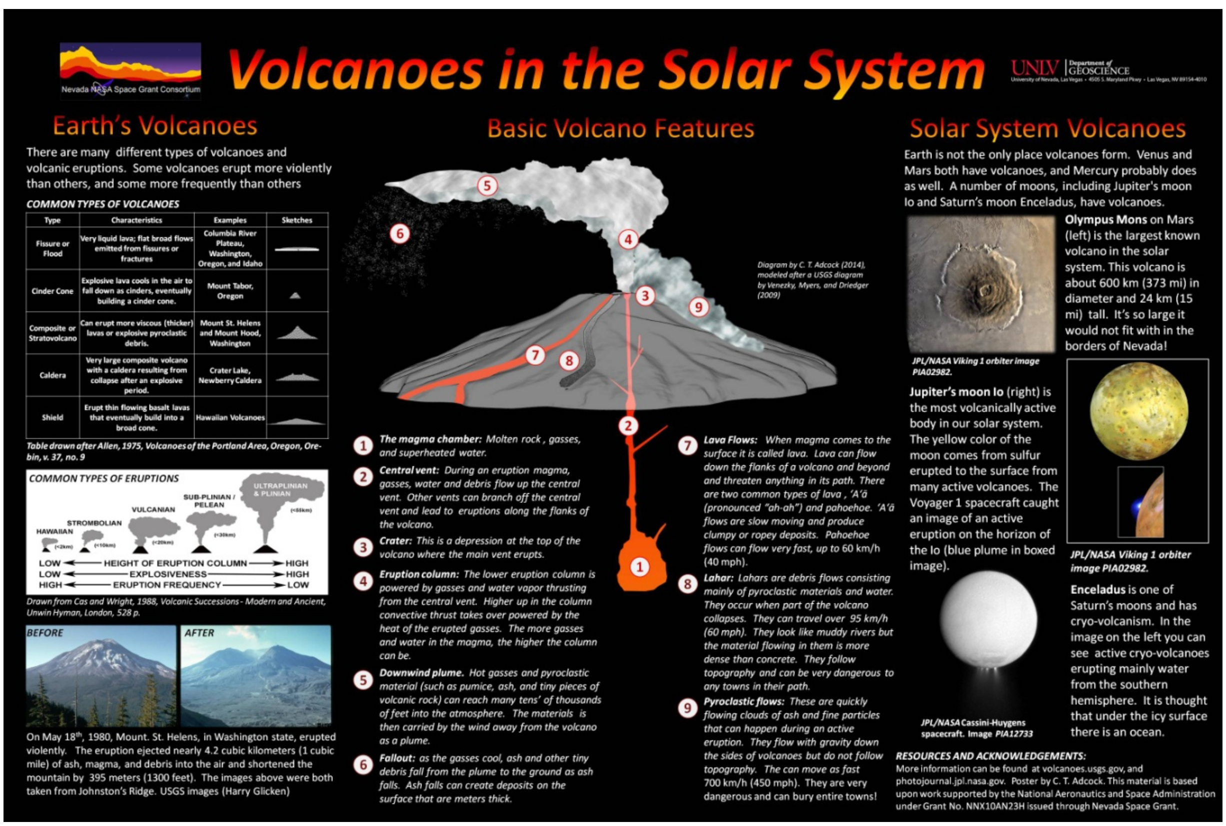

Figure 3. Scaled down image of planetary volcanoes poster used as part of the *Volcanoes in the Solar System* event.