LRO'S LUNAR WORKSHOPS FOR EDUCATORS: A PROVEN MODEL OF EXCEPTIONAL PROFESSIONAL DEVELOPMENT FOR TEACHERS. A. J. P. Jones[1,2], L. V. Bleacher[1], S. Buxner[2], and M. Canipe[2], [1]NASA's Goddard Space Flight Center (8800 Greenbelt Road, Greenbelt MD 20771; andrea.j.jones@nasa.gov), [2]Planetary Science Institute (1700 East Fort Lowell Road Suite 106, Tucson AZ 85719).

Introduction: The Lunar Workshops for Educators is a series of weeklong professional development workshops focused on lunar science and exploration for grade 6–9 science teachers, sponsored by the Lunar Reconnaissance Orbiter (LRO) and conducted by the LRO Education Team [1]. Since 2010, Lunar Workshops for Educators have been held around the country, primarily in locations underserved with respect to NASA workshops and at LRO team member institutions. Since 2013, all workshops in this series have been held at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, MD, where the LRO Project Office and Education Team are based, in response to recommendations from the NASA Education Design Team [2] to leverage local, ongoing educational partnerships, such as with the GSFC Office of Education.

The Lunar Workshops for Educators have been recognized as an exemplary model of teacher professional development by the NASA Office of Education and NASA review panels. The workshops support NASA Science Mission Directorate science education objectives [3] and the 5-Year Strategic Plan outlined by the National Science and Technology Council Committee on STEM Education [4]. The LRO Education Team received a NASA Honor Award for the workshop series in 2014. Since 2010, 259 teachers from 27 states and 3 countries have participated in the Lunar Workshops for Educators.

Workshop Components: The model for workshops in the Lunar Workshops for Educators professional development series incorporates the following components:

Pedagogy. The Lunar Workshops for Educators are designed based on best practices outlined in pedagogical research of science education [e.g. 5, 6, 7]. Facilitators model instructional best practices throughout the trainings. The workshop is designed such that the content and activities flow logically and build throughout the week, leading to deeper understanding. All activities are taught to the teachers as if they were grade 6–9 students, and then discussed as educators. There is a strong emphasis on group learning and learning conversations. Reflective tools and metacognative exercises help facilitate learning and make the learning process more apparent to workshop participants.

Integration of Mission Scientists and Engineers. Mission scientists and engineers are integrated into every workshop in this series. They give presentations, support facility tours and field trips, and have lunch with the teachers in order to interact with them in a less formal setting. The LRO Education Team is able to effectively integrate scientists and engineers into these workshops because we are bridges between the scientific and educational communities. We have backgrounds in both science and education, and close working relationships with the mission scientists and engineers. We know their areas of expertise and their strengths regarding education and outreach, and are able to select the appropriate scientist or engineer for each talk, tour, or other type of workshop participation. We also know the audiences we work with.

We prepare both the scientists and engineers as well as the educators for their interactions. We prepare the scientists and engineers by making sure they are familiar with the audience they will be working with (e.g. the level of scientific understanding that audience will have; we also offer suggestions for how to connect with that audience); we make sure that our goals for their workshop involvement are clear to them; and, we make sure they understand how their contribution fits in with the rest of the workshop. We encourage them to come to the workshop early (so they can see the facilitators interacting with the teachers and get an even better sense of what the teachers are learning, how they are learning it, and what questions they might have in mind), introduce themselves (with at least one personal detail), and engage in conversations with the teachers (instead of just serving as information providers). We then offer honest, constructive, timely feedback to all scientist and engineer presenters, which they can use to prepare for their next interaction with a similar audience.

The teachers also know our goals and expectations for the scientist and engineer interactions ahead of time, and how that part of the workshop fits in with the other activities of the week. They are told about the scientist and engineer presenters before they meet, and they are given 1-page information sheets to help them remember each presentation (which include information about the speakers, the title and abstract for their talk, a picture of the speaker, the speaker's contact information, and space for notes teachers can take during the presentation).

Access to NASA/SMD-Unique Facilities. Where possible, workshops include tours of science facilities

or field trips intended to help participants better understand mission operations or geologic processes relevant to the Moon. Lunar Worksops for Educators hosted at NASA's Goddard Space Flight Center include tours of the clean rooms where LRO was built and tested, and a trip to the LRO Mission Operations Center. Workshops have also included tours of the Laser Ranging Facility at Goddard's Geophysical and Astronomical Observatory, which has helped track LRO in its orbit around the Moon.

Incorporation of Data. Data from LRO and other lunar missions and investigations are incorporated into hands-on activities used in the Lunar Workshops for Educators, and also into scientific visualizations shared with the teacher participants. Teachers learn about the data products and how to share them with their students in ways that are interesting and authentic.

Process of Science and Alignment with Standards. Science education research highlights the importance of teaching science as a process, rather than as a collection of facts; as a creative, collaborative, dynamic field that is constantly advancing with the introduction of new information. Making science education more closely resemble the way scientists think and work is a central tenant in both the Next Generation Science Standards [8] and the Framework for K–12 Science Education [9] upon which the Standards were based. The Lunar Workshops for Educators emphasize the process of science through workshop content, activities, presentations, discussions, and the workshop structure itself.

All activities included in this workshop series have been through the NASA Earth & Space Science Education Product Review [10] and are aligned with the Next Generation Science Standards [8]. Teachers are made aware of which standards each activity addresses. Teachers are given time for planning during the workshop, and for discussing their plans with other teachers and workshop facilitators. All participants leave the workshop with a plan for incorporating information and activities from the workshop into their classrooms.

Addressing Misconceptions. Lunar science misconceptions abound [e.g. 11]. Both students and many teachers hold misconceptions about the Moon. Teachers who do not fully understand lunar science concepts have difficulty teaching them to their students. During the Lunar Workshops for Educators, teachers learn about common student misconceptions about the Moon, and how to address them.

Workshop Follow-Up. 5-day trainings take place during the summer. The LRO Education Team follows up with workshop participants throughout the following school year, and beyond, to keep them informed of new science results and activities, answer questions, provide opportunities for participant discussions, and monitor progress as teachers incorporate workshop information and materials into their classrooms.

Evaluation. The Lunar Workshops for Educators are evaluated by an external evaluation team at the Planetary Science Institute. The LRO Education Team works with the evaluation team to develop evaluation instruments that assess participants' content knowledge and knowledge of student lunar science misconceptions and how to address them before and after the workshop, teachers' motiviations for participation, resources they gained from the workshop, use workshop materials, changes in participants' teaching practice, and the overall quality of the workshop. Evaluation instruments include pre- and post- workshop surveys and assessments, daily surveys at the end of days 1–4, and fall and spring follow-up surveys. Survey responses and other formative assessments used throughout the workshops allow the facilitators to modify the workshops, as needed, throughout the week and the workshop series.

We will present a summary of five years of evaluation results of the Lunar Workshops for Educators professional development series and highlight the strengths of this model for educator professional development, in a program made possible through content and assets unique to NASA's Science Mission Directorate. For more information about the Lunar Workshops for Educators, visit: http://lunar.gsfc.nasa.gov/lwe/index.html

References: [1] Jones A. J. P. (2014) *LRO Education and Public Outreach in the Second Extended Science Mission*, submitted to NASA Headquarters for LRO Senior Review. [2] Education Design Team (2011) *NASA Education Recommendation Report*. [3] NSTC CoSTEM (2013) *Federal STEM Education 5-Year Strategic Plan*. [4] NASA SMD Science Education CAN – Draft Text (2014) Solicitation: NNH15ZDA002J. [5] NRC (2000) *How People Learn.* [6] NRC (2007) *Ready, Set, SCIENCE!* [7] NRC (2007) *Taking Science to School*. [8] NGSS Lead States (2013) *Next Generation Science Standards*. [9] NRC (2012) *A Framework for K–12 Science Education.* [10] Review website: http://nasareviews.strategies.org [11] Keeley P., Eberle F., and Farrin L. (2005) *Uncovering Student Ideas in Science*.