

## **The Nature of Astronomy: Addressing the Nature of Science within NGSS**

Christine Shupla,<sup>1</sup> Sanlyn Buxner,<sup>2</sup> Whitney Cobb,<sup>3</sup> Larry Lebofsky,<sup>4</sup> and Sandra Weeks<sup>5</sup>

<sup>1</sup>*Lunar and Planetary Institute, Houston, Texas, USA*

<sup>2</sup>*Planetary Science Institute, Tucson, Arizona, USA*

<sup>3</sup>*McREL International, Denver, Colorado, USA*

<sup>4</sup>*Planetary Science Institute, Tucson, Arizona, USA*

<sup>5</sup>*Poudre School District, Fort Collins, Colorado, USA*

**Abstract.** The Next Generation Science Standards (NGSS) explicitly calls out the Nature of Science (NOS) to be integrated within science education. NOS topics include understanding that scientific investigations use a variety of methods, that scientific knowledge is based on empirical evidence, that scientific explanations are open to revision in light of new evidence, understanding the nature of scientific models, laws, mechanisms, theories and hypotheses, and much more. Unless these topics are explicitly addressed, students will not be able to apply them to the concepts they are studying. This workshop reviewed the NOS topics and used a variety of astronomical and planetary activities to model how incorporating explicit NOS discussion into the activity can support increased understanding of scientific enterprise.

### **1. Reviewing NOS Standards**

The Nature of Science is included as a list of 8 understandings about science in the Next Generation Science Standards (NGSS Lead States 2013). Some of these are closely associated with science practices, and in discussions with educators, NOS can be confused with science and engineering practices. The first step in determining how to incorporate NOS within astronomy needs to be clarifying what NOS is.

The NGSS understandings about the Nature of Science include:

1. Scientific Investigations Use a Variety of Methods
2. Scientific Knowledge is Based on Empirical Evidence
3. Scientific Knowledge is Open to Revision in Light of New Evidence
4. Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
5. Science is a Way of Knowing
6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems

7. Science is a Human Endeavor
8. Science Addresses Questions About the Natural and Material World

Each of these understandings is broken into statements by grade level within the NGSS, to require a deeper understanding of what science is as a learning progression.

Many of the understandings are related to existing misconceptions about science (Misconceptions About Science 2014); for instance, some students think that theories can “graduate” into laws with sufficient time or evidence. Others assume that scientific theories are facts which can never be revised. Still others don’t realize that science, as a human endeavor, uses creativity and imagination.

## 2. Incorporating NOS into Astronomy

The authors have examined their own practice and ways to incorporate NOS in their activities. Christina Shupla has worked with Dr. Alexandra Matiella Novak to lead summer lunar institutes<sup>1</sup> for high school teachers for many years, and has included aspects of NOS within activities and within the presentations made by scientists. Her initial evaluations discovered that unless the NOS understanding was explicitly discussed, in addition to being modeled within activities and presentations, participants would not demonstrate an increase in their own understanding of NOS within the assessments.

Some of NOS understandings are easier to incorporate into existing activities than others. For example, understanding that science addresses questions about the natural and material world often requires comparisons with a non-science field that is not limited to observation and empirical evidence; attempting this comparison during a specific topic will usually take the discussion far off-topic.

The authors determined that for the workshop, they would focus on the NOS understanding that science is open to revision. They facilitated activities that modeled this concept. In a modified version of “Classifying Objects: How Scientists and Other People Classify Things,” participants classified assorted balls and then were forced to reorganize their systems when new balls were introduced. In “Planet Swap,” they modified predictions on the story underlying a sentence as new words were revealed. They learned about “Dawn—History and Discovery of Asteroids” lessons regarding our changing understanding of the asteroid belt. These activities are all available online.<sup>2</sup>

Rich discussion with the workshop attendees included ways to incorporate this and other NOS understandings within activities and programs.

## 3. Nature of Science Resources

Links to assorted NOS resources described below are available online.

1. *Next Generation Science Standards, Appendix H: This chapter on Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science*

---

<sup>1</sup>Activities and materials from the Unknown Moon Institute are available at <http://www.lpi.usra.edu/education/workshops/unknownMoon/>.

<sup>2</sup>Activities and resources shared during the workshop are available at [www.lpi.usra.edu/education/workshops/NGSS](http://www.lpi.usra.edu/education/workshops/NGSS).

Standards presents perspectives, a rationale and research supporting an emphasis on the nature of science in the context of the NGSS. Additionally, eight NOS understandings with appropriate grade-level outcomes are included as extensions of the science and engineering practices and crosscutting concepts.

2. *Views of Nature of Science Questionnaire: Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science*: This article traces the development of an open-ended instrument intended to provide meaningful assessments of learners' NOS views, outlines the NOS framework used to develop the questionnaire, and presents evidence regarding its validity of the VNOS and uses.
3. *This Is Science*: This article outlines how science is done, the role of critical thinking, evidential reasoning, and judging authority play in science, what scientific knowledge is, and how scientists do science.
4. *Understanding Science 101*: This rich site has a variety of information, activities, and resources on what science is and how it is done. The section on misconceptions about science is particularly useful.
5. *What's In a Word: How Word Choice Can Develop (Mis)conceptions about the Nature of Science*: This article from NSTA's Science Scope describes how words such as "proof," "truth," and "correct" can lead to student misunderstandings about what science is and how it is conducted.
6. *ENSI Papers and Articles*: This has a series of papers on the Nature of Science; the site also has a series of lessons on NOS.

## References

- NGSS Lead States 2013, Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press
- "Misconceptions About Science." *Understanding Science* 2014, University of California Museum of Paleontology. 18 September 2014 <http://undsci.berkeley.edu/teaching/misconceptions.php>