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Cultivating Curiosity with Life in the Universe and WorldWide Telescope

Harry Houghton, Patricia Udomprasert, Susan Sunbury, Erika Wright, Alyssa Goodman, Erin Johnson, and Allison Bishop

Center for Astrophysics, Harvard & Smithsonian, Cambridge, Maryland, USA

Abstract. When students encounter complex topics like the search for extraterrestrial life, questions abound - thoughtful, unpredictable, and often profound. Despite this thriving curiosity, the first step to be able to explore complex questions is developing the capacity to verbalize a meaningful question. The WorldWide Telescope Ambassadors team designed an out-of-school curriculum called Life in the Universe, which engages middle school-aged students in the science and scientific process of the search for distant life. Students practice generating meaningful questions, which will guide them through the science content, as groups of students build to culminating capstone projects. Results from surveys administered to participating students indicate gains in curiosity in science, as well as in seeing oneself as successful in science.

Strand:	Science Education
Audiences:	K–12: Teachers and Students; Informal Audiences at Museums, Parks, Libraries, Afterschool, etc.
Strategies/Practices:	Curriculum Development, Out of School Learning for Children

1. Project Overview

Life in the Universe (LITU) is an out-of-school or expanded-learning-time curriculum designed to engage middle school-aged youth in understanding the search for life elsewhere in the universe. Youth participants explore this topic not only from a scientific angle, but also in consideration of the societal implications of such a discovery.

Over ten 45-minute sessions, students learn the fundamental areas of science necessary to begin exploring this topic:

1. Astronomy basics: *How are we situated in our solar system / galaxy / universe?*
2. Exoplanet basics: *How do astronomers detect planets around other stars? Under what conditions could exoplanets support life? Where are those planets located?*

As students build an understanding of the content knowledge related to the search for extraterrestrial life, they begin to explore deeper questions of social consequence, for which science is not enough to determine an answer.

- *If we found life beyond Earth, how would we communicate with it?*

- *What kinds of life might we find on another planet?*
- *What would we do if we found other life?*
- *Should astronomers be looking for life elsewhere?*

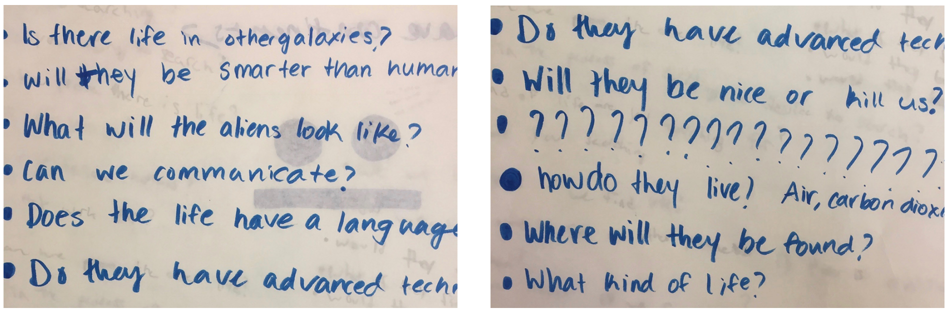

Figure 1. Groups of students write down all the questions they can come up with during a 5-minute question-generation period.

Students develop the skills to generate these open-ended and complex questions themselves, which serve to guide the capstone projects that each student group produces. This process gives the projects personal meaning, and is a fitting culmination of the development of both their scientific comprehension and their ability to ask meaningful questions.

2. Context

The WorldWide Telescope Ambassadors team (Udomprasert et al. 2012) implemented the LITU curriculum at a public school in Boston as an enrichment program during their expanded learning time in 2016 and 2017. Roughly forty students participated in the curriculum each year, drawn from the school's 6th and 7th grade classes. Members of the research team taught all of the lessons, with support from the regular classroom science teachers.

When we taught the curriculum in 2016, classes met once per week for one and half hours. In 2017, classes met every day for 45 minutes. The results reported in Section 4 are based on the 2017 implementation.

3. Curriculum Features

The following three sections detail the three main features of the LITU curriculum: asking big questions; the WorldWide Telescope application; and capstone projects.

3.1. Asking Questions to Cultivate Curiosity

The LITU program gives students an opportunity to generate their own questions to guide their pathway through the curriculum. When driven by their own questions on a topic, students are inherently motivated to explore the topic deeply and search for greater meaning and connection to their own lives.

Asking questions is a skill, but one that is seldom taught in classroom curricula. An even greater skill is asking questions that lack immediate yes-or-no answers, but which drive the pursuit of an answer. Learning to ask questions can help us to better understand what we know, what do we not know, and what information and resources we need to bridge the divide between the two.

The LITU curriculum uses the Question Formulation Technique (QFT), devised by the Right Question Institute, to help students develop the ability to ask good questions. See additional free resources on the Question Formulation Technique at `www.rightquestion.org`. We also highly recommend the book *Make Just One Change: Teach Students to Ask Their Own Questions*, (Rothstein & Santana 2011).

3.2. WorldWide Telescope

Students spend part of the LITU program working within WorldWide Telescope (WWT), a visualization application that allows users to explore a seamless, three-dimensional model of the known universe. Students can manipulate and interact with both Earth- and space-based perspectives of the universe, with views ranging from objects within our solar system to distant galaxy clusters.

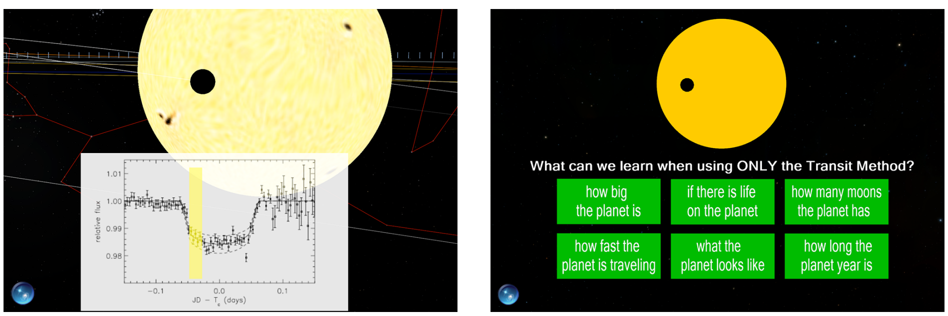

Figure 2. Screenshots of slides from sample WWT tours in the LITU curriculum.

Users can create their own tours within WWT, which are scripted pathways through space that guide the viewer through specific observations and fly-throughs, for storytelling or educational purposes. Instruction for the LITU curriculum is partially delivered through WWT tours created by the research team.

3.3. Student Capstone Projects

Students are placed into small groups according to the types of "big questions" that they expressed interest in. As their knowledge of astronomy grows, they work in these groups to discuss and explore their developing ideas. Their learning experience culminates in a capstone project, for which each group builds a slideshow to examine the intricacies of their big question, and defend a position regarding that question. At the end of the ten days, students present their slideshows to peers and instructors at a final celebration.

Students develop 21st century skills over the course of their participation in LITU: researching a topic; supporting ideas with evidence; and delivering findings through presentation slides.

4. Survey Results

Figure 3 shows Likert results from student surveys before and after participation in LITU. Participants self-reported their level of curiosity, interest, and self-identity in science. In compiling these results, we matched pre-/post- survey data for 35 students. t-test comparisons of pre- and post- data show that students had statistically significant increases for almost every question asked, with mostly moderate effect sizes. (Cohen 1988) defined effect sizes as “small, d = .2,” “medium, d = .5,” and “large, d = .8. Education research projects that achieve medium or large effect sizes are generally considered highly successful). We see especially significant gains in ability to see oneself as successful in science, as well as gains in interest and curiosity in science.

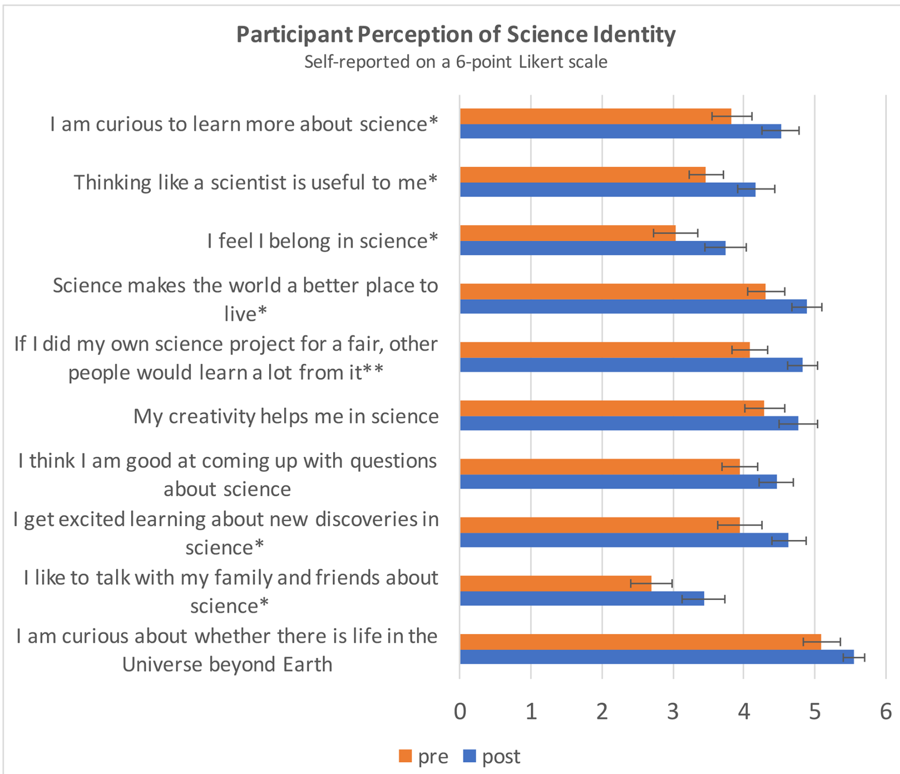

Figure 3. Pre- and post-curriculum Likert results from student surveys following participation in LITU. **p<0.01, **p<0.001*

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