Incorporating Remote Robotic Telescopes into an Elementary Classroom Setting

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Abstract As Next Generation Science Standards (NGSS) are implemented across the nation, engaging and content-specific lessons are becoming an important addition to elementary classrooms. This paper demonstrate how effective hands-on teaching tactics, authentic learning, scientifically significant data, and research in the elementary realm can aid students in self-discovery about astronomy and uncover what it is to be a researcher and scientist. It also outlines an effective, engaging, and integrated classroom unit that is usable in both the scientific community and elementary schools. The lesson unit consists of NGSS science and engineering practices and performance expectations as well as California Common Core Standards (CCSS).

Introduction

Within the undergraduate major, Liberal Studies, at Cal Poly, San Luis Obispo, approximately 6% of the students are concentrating in physical science, 15% in biology, and 17% in mathematics. These three subjects, all STEM disciplines, make up less than half of the total Liberal Studies students' concentrations, while approximately 50% are concentrating in child development. Based on these statistics it is clear that there is a huge gap in physical science content compared to other concentration paths. A concern is that teachers will not be equipped to develop their students' knowledge in the field of physical science. Therefore, this lesson is geared to aid teachers who are less strong in the STEM fields and to illustrate to undergraduate preservice teachers how simple it is to integrate physical science into the classroom.

During fifth grade, students are expected to go into depth about astronomy as they learn about the universe, stars, and Earth's place in the solar system. Astronomy is a relatively unknown but fascinating topic for many fifth grade students. It is a natural science that quickly captures their attention. However, science in general seems to be a scary topic for elementary educators; therefore, it may not be effectively taught in elementary classrooms.

The unit outlined in this paper incorporates diverse California standards and activities that are engaging, content specific, and allow for student discovery. By implementing remote robotic telescope observations into fifth grade classrooms, teachers can expose their students to a hands-on understanding of scientific research. The final assessment to the unit will provide students with the experience of publishing a research paper in a developing research topic: binary star systems. This offers students exposure and insight into careers related to science, like research. Although this process for incorporating research, science, engineering, and basic elementary knowledge is directed toward astronomy content, the process is what is truly important in an elementary classroom. Teachers have the opportunity to use an outline similar to this to apply across all grade levels and science disciplines.

Pedagogy

Hands on Learning

In order to engage students in the Next Generation Science Standards, teachers must introduce hands-on activities and research into their classroom. Traditionally, science was taught straight out of textbooks. It was not experimental and lacked excitement. However, with STEM careers becoming more important in

our society, it is apparent that teachers need to bring the content out in other ways. Lara Triona and David Klahr, authors of Hands on Science: Does it matter what students' hands are on? (2007) state that, "In hands on science, students' concrete, kinesthetic actions are related to abstract concepts and these activities tend to increase student motivation and engagement" (Triona and Klahr 2007). Therefore, by giving students the opportunity to discover the science themselves, students strengthen their possibilities of understanding abstract concepts, scientific inquiry, and observation.

Authentic Learning

Authentic learning is an effective and newly studied pedagogy that can be successfully used in elementary classroom lessons. It "typically focuses on real-world, complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice" (Lombardi 2007). Therefore, the use of authentic learning in an elementary classroom is beneficial for students as they can make connections which offer long term knowledge and higher order learning. It also gives students the opportunity and experience to adapt and apply their learning toward real-world situations, helping them see why the topic is important.

Authentic learning also emphasizes using remote instruments in the classroom to address the approaches in learning. "For students without immediate access to expensive specialized equipment or extremely rare scientific instruments, this approach can open the door to active learning experiences that would otherwise be beyond their reach" (Lombardi 2007). Likewise research in the classroom is effective within this style of teacher because, "...students use data collected by researchers... to conduct their own investigations. They are practicing higher-order analysis on real data sets while contributing to the common knowledge base" (Lombardi 2007). Therefore, introducing the idea of researching a topic, collecting evidence, and publishing a paper is a way for fifth grade students to strengthen their knowledge in the content and prepare them for future research practices. By offering these skills in the classroom, educators are developing students for successful careers once they are out of the K-12 realm.

Lesson Outline

By aligning Next Generation Science Standards and several diverse pedagogies, a unit has been created to teach students about two fifth grade standards, "The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth"; and "The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year" (National Research Council 2007, p174, p176). Students will begin the unit with the encouragement to ask questions to create self-discovery and discussion. They will be given Post-it notes and asked to hang them on a "Question Board" on the wall. As the unit progresses, students will answer their own peers' questions to assist in group learning and, along with the introduction of stars and the universe, students will discuss these to determine their prior knowledge with one another. The unit will go into depth about the Earth's Sun, the stars, and binary systems in the universe.

Earth's Sun

The first sub-unit is about the Earth's Sun. Most students will not consider it to be a star, and therefore, the apparent brightness and observable patterns will need to be discovered. They will observe that it is incredibly bright and gives the Earth heat and light due to the close proximity and rotation of our planet. Along with this unit, students will be introduced to an engineering design lesson that incorporates the engineer practices about defining problems and designing solutions.

Figure 1. Solar Oven Engineering Activity

In this lesson, students will be instructed to design a solar oven, Figure 1, out of cardboard, aluminum foil, tape, and other objects found easily around the home or in a grocery store to heat s'mores. Students in groups will design, create, and implement their oven during a classroom activity. They will determine the best angle for the sunlight to hit their oven, take data on the best time of day, the highest heat their oven will meet, and other data analysis collections. Once this lesson has been taught and implemented, students will have learned that the Sun is apparently bright because of its closeness to the Earth and the Sun changes its position daily and shows observable patterns due to the orbit of the Earth.

The Stars

Once the students have gone into depth about our star, they will be introduced to a better understanding of the stars in the universe. The lesson will begin with students observing the night sky. They will observe the same spot every night for one week and journal about the changes they see. They will be given a map of the sky and asked to hypothesize why they think some of the stars are dim while others are incredibly bright. Furthermore, students will be led to discover that constellation stars are not all in the same part of the sky and their star brightness is due to their distance. Students will participate in an activity called, "Constellation Heroes." The class will create their own constellations by making a logo or image in the sky with a star map. They will integrate their art standards into this unit by "Us[ing] perspective in an original work of art to create a real or imaginary scene" by creating their constellations into an art piece (Grade Five/Visual and Performing Arts 2015).

Common Core State Standards in mathematics will also be incorporated as students will determine the angles of the constellations they have been introduced to in class in "Constellation Math" (Figure 2). This activity will align with the California CCSS, "Students identify, describe, and classify the properties of, and the relationships between, plane and solid geometric figures" which includes learning to, "Measure, identify, and draw angles, perpendicular and parallel lines, rectangles, and triangles by using appropriate tools" and "know[ing] that the sum of the angles of any triangle is 180° and the sum of the angles of any quadrilateral is 360° and use this information to solve problems" (CCSS, 5.2.0).

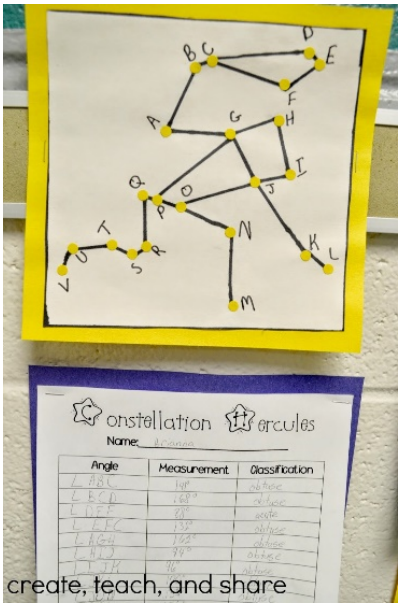

Figure 2. An example of Common Core State Standards' "Constellation Math."

At the end of the subunit on stars, students will be able to determine that stars in the sky have different apparent brightness due to their distance from the Earth. Constellations are not in the same position in the sky and this is apparent due to their brightness. They will also further their knowledge in CCSS mathematics concepts and California State Standards for art.

Binary Stars

Students will learn how to find coordinates for a binary star and will ask for a "star map" of that part of the sky from a remote robotic telescope in the Canary Islands. Students will also research what a remote robotic telescope is and, in groups, present their findings to the class. This will excite the students' curiosity as they will neither know what a binary star is nor the fact that you can send in coordinates and receive back information. By connecting with an outside astronomer, students will see that in the scientific and research community people often must compare results and work together to find information.

After receiving several photos of the sky, the class will hypothesize what a binary star actually is. As they get deeper and deeper into space with their photos from the Canary Islands, it will become apparent that there are two stars gravitationally bound to one another. Students will research further into how many stars they think they see in their sky maps and will continue to research binary systems. After researching what binary stars are, the fifth grade students will understand the diversity of the universe and will have both observational data and science knowledge to create a research paper about their findings.

Research Paper Publication

Students will write a brief research paper about their observations throughout the unit including the Sun, stars, and binary stars. They will write an abstract, discuss their findings, use evidence, and finalize a conclusion on the unit. This end assessment will help students to see the importance of research. It will bring a better understanding of what scientists, mathematicians, engineers, and researchers do every day and will also show how research can relate to both the scientific and educational world. Students will learn that when they are curious, they can simply research a topic and collect evidence and data to find answers for themselves, which encourages problem solving in the classroom. The research papers the

students write will be published in a classroom text for teachers, administrators, and parents. This activity will align with the Common Core State Standard for writing 5.2, "Write informative/explanatory texts to examine a topic and convey ideas and information clearly." The activity will help to develop fifth grade researchers who not only know how to collect and analyze data but also how to observe their surroundings and write an information text about them.

Broad Connections

By incorporating math, art, science, and engineering standards, fifth grade students will strengthen their knowledge in astronomy and make connections to the universe in their lives. Their curiosity of space will open their eyes up to using research in their everyday lives to answer questions, expand observation skills, and explore the world around them. This will bring the idea of research to higher importance in their lives so they can answer their own questions. Furthermore, the class will have a better understanding of how research relates to the educational world through their knowledge in science. Finally, the fifth grade students will connect their new understanding to the Next Generation Science Standards by incorporating their knowledge and findings to see that the universe is a unique and diverse aspect of our lives and Earth is a small planet in the vast universe.

References

Lombardi, M. 2007. Authentic Learning for the 21st Century: An Overview. Educause Learning Initiative. http://net.educause.edu/ir/library/pdf/ELI3009.pdf

National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. http://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts

Triona, L. & Klahr, D. 2007. Hands on Science: Does it matter what students' hands are on? The Science Education Review 6, 126. http://www.psy.cmu.edu/~klahr/pdf/SER.triona&klahr07.pdf

Grade Five/ Visual and Performing Arts: Visual Arts Content Standards. 2015. California Department of Education. http://www.cde.ca.gov/be/st/ss/vagrade5.asp