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Full Length Research Paper

Connecting children internationally for science instruction: Using the internet to support learning about lunar phases

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This study investigated the effect on children's science understanding of Internet-based instruction in which children from around the world in grades 4 to 8 observed the Moon for several weeks and then shared their lunar data internationally to find global patterns in the Moon's behavior. Students in two American and one Australian class took the Comprehensive Moon Phases Assessment as a pre- and post-test. Instruction in the three classes shared some common characteristics such as exchanging data internationally and focusing on finding global patterns in the Moon's behavior. The results showed that overall and in two of the three classes the students' understanding of lunar phases improved significantly. The international exchange of lunar observation reports was effective, although the instruction in each classroom was under the teacher's control and thus varied from place to place.

Key words: Science education, lunar phase, global lunar pattern, moon observation.

INTRODUCTION

Consistent with the argument made subsequent to our study by Lindsey and Davis (2012), we were interested in the general topic of how to engage students internationally in collaborative science inquiry. In that context, the specific issue to be addressed here is the effect of science instruction on Australian and American middle school students who observed the Moon, exchanged descriptions of their observations, and developed their own conclusions about the Moon's appearance around the world. The science topic selected was lunar phases, since (1) the Moon is the sole object that can be readily, safely and freely studied worldwide by all children using no special equipment, (2) children (and their teachers) harbor numerous misconceptions about lunar phases, and (3) as reflected in their science teaching standards, the United States and all of its states expect children to learn about the Moon. Thus, this study investigates the effect of the international exchange of lunar observation reports on students' knowledge of lunar phases.

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BACKGROUND

National and state science standards regarding lunar phases

America's national science education standards [National Research Council (NRC), 1996] expect elementary school students in Kindergarten through the fourth grade to observe change, stating specifically that as students observe changes, such as the positions of the sun and the moon, they will find the patterns in these movements. They can draw the Moon's shape for each evening on a calendar and then determine the pattern in the shapes over several weeks. In grades 5 to 8 students should continue to discover patterns in nature and additionally should attempt to explain the causes of those patterns. With regard to the Moon, the national standards stated that most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the Moon, and eclipses.

Consistent with America's national standards, all states expect their students to enter high school possessing some knowledge of the Moon's phases; but there is no unanimity about what the various states exactly expect their entering high school students to understand (Sherrod, 2009). For example, 49 of the 50 states expect their fifth to eighth graders to learn that the Moon's appearance is not constant from day to day (that is, the Moon has phases) but only 30 of the states explicitly expect these students to be able to explain what causes that change in appearance.

Children's knowledge of lunar phases

Many children harbor various misconceptions about the Moon. Even ideas that could be mastered by regular observation of the Moon elude some students. For example, Trundle et al. (2007) found that about one-fifth of fourth graders believed that the Moon's phases do not appear in a predictable sequence from waxing crescent to first quarter to waxing gibbous and so forth.

Some students are unclear about how long it takes the Moon to complete one orbit of Earth. For example, more than one out of three adolescents believes the Moon orbits Earth once each day; but on the other hand, one in five thought this orbiting of Earth by the Moon took a year to complete (Schoon, 1992).

The cause of the Moon's changing appearance is fraught with misconceptions (for example, clouds or the Earth's shadow covering a portion of the Moon causes daily changes in lunar phases). For example, Baxter (1989) found in a study of 100 nine to 16-year-olds that half of the nine to ten-year-olds thought Earth's shadow caused lunar phases and that percentage grew to 80% of fifteen to sixteen-year olds giving the same explanation for lunar phases.

Some children hold misconceptions about the relationships of the Earth, Moon and Sun in space. For example, Jones et al. (1987) found that 75% of third graders held the pre-Galilean notion that Earth is the center of the universe with the Sun and Moon revolving around Earth; and the other 25% held a heliocentric model of the relationship of Earth, Sun and Moon, although their model might not agree with that of scientists. On the other hand, 63% of sixth graders in the study held a heliocentric view and the remainder believed the Earth to be the center of the universe.

Using the internet for children's science inquiry

The Internet has emerged as a teaching tool to address the growing demands of a new generation of learners that Oblinger and Oblinger (2005) called the "Net Generation" or "Millennials." These digital natives are not entirely like students of former generations (Prensky, 2001). They grew up in a digital world with distinctive learning expectations, styles, and needs as compared to their counterparts who grew up in an analogue world (Skiba and Barton, 2006). Their inclination toward "digital literacy, experiential and engaging learning, interactivity and collaboration, and immediacy and connectivity" (Skiba and Barton, 2006) suggests the adoption of a new teaching-learning paradigm to effectively accommodate their learning needs. A growing body of literature examines how Internet-based instruction has been effectively embraced to enhance motivation, learning, and academic achievement in a variety of academic institutions (Bonk, 2009; Hargis, 2001; Richardson, 2009). Over the last decade, for example, Linn and Hsi (2000), Linn et al. (2004) and Slotta and Linn (2009) have described in a variety of outlets the evolution of their approach to using the Internet to support inquiry within a science classroom. In their Web-based Inquiry Science Environment (WISE) Project, students studied topics such as earthquakes, genetically modified foods, or deformed frogs through an inquiry approach structured by software created by the WISE team to include elements such as collecting and sharing data within their class and taking part with classmates in on-line threaded discussions of the topic.

The MOON Project

Since 2000 the More Observations of Nature (MOON) Project has engaged children in grades four to eight from various countries in lunar observations followed by Internet exchanges of observations and discussions about global similarities and differences in the Moon's behavior (Smith, 2003, 2008; Trundle et al., 2006). The project is repeated twice each year, once in January to April and again in late August to November that correspond with American schools' spring and fall semesters. Each year different students and teachers are involved, but teachers may repeat the project in subsequent years with different students. In spring 2009, fourteen teachers from Massachusetts and Texas in the United States and Queensland and Western Australia in Australia enrolled their 429 students in the MOON Project. Once enrolled, the students were placed in groups that averaged eleven students. Each group was led by a pre-service teacher from Indiana University Purdue University at Columbus or the University of Western Australia. All students in any one group were from different locations. Each student posted an essay of approximately 100 to 200 words that reported observations made when the Moon was a waxing crescent, first quarter, or waxing gibbous moon. After this initial round of essays was shared and examined, the students posted a second essay about global patterns they had found in the reported observations (for example, the same phase is seen on the same day all over the world; but whereas the waxing crescent was on the right or lower right in the Northern Hemisphere, and was seen on the left or lower left in the Southern Hemisphere). After the round of essays about lunar patterns was shared and analyzed, the students posted a third essay that attempted to explain the cause of one of the global patterns. After each essay was posted the college student in the group was tasked with providing feedback to the student about her or his writing and science.

While the MOON Project provided the framework for the investigation of the Moon, as described, what happened in each teacher's classroom varied by number and characteristics of the students (for example, age, nationality, socioeconomic status etc.), amount of time the teacher devoted to the study of the Moon, and lunar studies planned and carried out by each teacher. Thus, while all MOON Project students shared some common features, there was also much variation.

Research question

Within the framework provided by the MOON Project as described, the present study asked about the effect of participating in the MOON Project on students' understanding of ideas about lunar phases expressed in America's 50 states' science standard. This question was applied both to the effect of the instruction in each of two classes in America and one in Australia and overall for the three classrooms.

METHODS

Sample and treatment

All subjects, who were enrolled in one of two American classes or one Australian class, took part in the MOON Project as previously described. The following are descriptions of the three samples and their MOON Project-based instruction.

Australia

The Australian self-contained classroom in a school in a well-to-do urban area in Western Australia had 21 Year Four and eight Year Five students who took part in the MOON Project (Years Four and Five in Australia are comparable to the third and fourth grade in the United States). The children were asked to observe the Moon on a daily basis, and virtually each school day for eight weeks began with 15 min of discussion of the previous day's observations and patterns that were emerging. Each day they arrived at a consensus about the Moon's phase and location at a particular time the previous day and drew this shape with chalk on large pieces of black paper that were hung in sequence around the room. Looking back at their observations and time of their observations for the previous four weeks, the children began to predict the Moon's future behavior. Simultaneously there were formal lessons such as one in which students created reproductions of lunar phases from Oreo cookies and another in which they studied the history of lunar investigations going back to Galileo and working up to human landing on the Moon. There was strong parental involvement that included the parents making lunar observations for their children when the Moon rose after the children's bedtime.

Texas

In a west Texas elementary school with 300 students in an agricultural community of 6500, the MOON Project was carried out for an eight week period for 20 fifth graders in a gifted and talented class that met four times a week for 45 min each time. To begin the program the teacher provided instructions about how to observe the Moon and the MOON Project student handbook was given to each student to record their observations each day. During each class meeting, the students came to consensus about what they had just observed about the Moon's phase and location and found patterns in their observations from their local perspective. During the latter four weeks of this eight week period only a few of the students continued to record their observations; but the students were asked to predict the Moon's future appearance and location and they also had formal lessons about the Moon. For example, the students recreated the phases of the Moon using a Styrofoam ball placed in various positions around a lamp; and they viewed computer animations, available on the Internet, of the Earth-Moon-Sun's changing relative positions and the lunar phase associated with each configuration of the three bodies.

Massachusetts

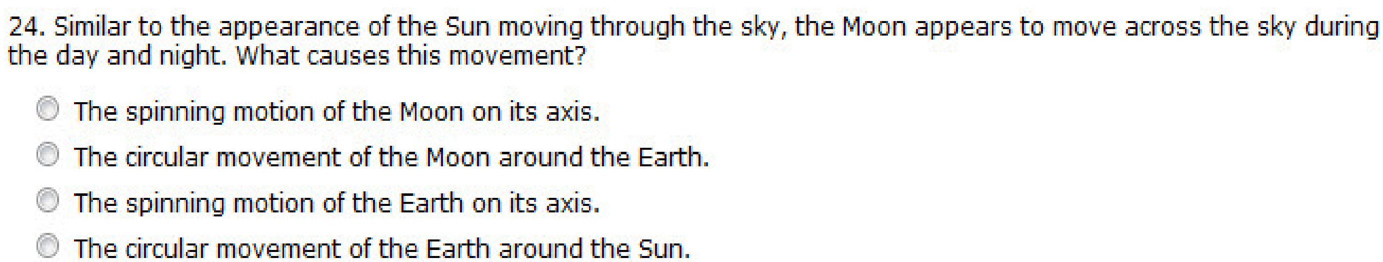
The MOON Project in Massachusetts took place in a middle school of 225 students from primarily low to middle-income families in a north-central Massachusetts town of 6300 residents. Unlike Texas and Australia where the MOON Project was part of the self-contained classroom instruction for all students in those classes, the 14 Massachusetts sixth graders chose to be in a science enrichment class built into their daily schedule; and the teacher chose for these students to be involved in the MOON Project. The students used the MOON Project student handbook as a source of directions for their activities and to record their daily moon observations. The teacher gave directions at a general level to allow students as much leeway as possible to organize their own learning activities, and the teacher answered student questions as they arose. Each day the students used a SmartBoard to arrive at a group consensus about the Moon's appearance the previous day. They constructed a simple cardboard and string astrolabe to measure the Moon's altitude. There were no parents directly involved in the project but the parents did take an interest in the project once the children started their observations.

Data collection

Teachers whose students took part in the MOON Project could choose whether to have their students take the Comprehensive Moon Phases Assessment (CMPA) as only a pre-test or only a post-test, both a pre- and post-test, or not at all. Of the 14 participating teachers, six had their students take the test one or two times and eight chose not to administer the CMPA at all. Of the six teachers who had their students take the CMPA, three teachers - one each in Australia, Texas and Massachusetts as previously described - had their students take the CMPA as both a pre- and post-test. The Australian teacher chose to administer the test to only the Year Five students. Of those eight Year Five students, seven students took the pre-test and five took the post-test (Table 1). The Texas teacher had 20 students eligible to take the test; and of the 20, 16 students took the pre-test and 14 took the post-test. Finally, the Massachusetts teacher had 14 students eligible to take

Table 1. Upper elementary students' understanding of lunar phases prior to and following instruction.

Location	Paired					All					
	N	Pre	Post	F	p	N	Pre	N	Post	F	p
Australia	4	13.8	18.0	4.446	n.s.	7	13.6	5	17.8	18.290	0.002
Texas	12	14.8	20.3	14.545	0.003	16	15.1	14	21.0	14.856	0.001
Massachusetts	10	14.2	16.2	1.029	n.s.	12	14.5	12	16.3	1.139	n.s.
Total	26	14.4	18.4	13.830	0.001	35	14.6	31	18.7	16.765	0.000


24. Similar to the appearance of the Sun moving through the sky, the Moon appears to move across the sky during the day and night. What causes this movement?

- The spinning motion of the Moon on its axis.
- The circular movement of the Moon around the Earth.
- The spinning motion of the Earth on its axis.
- The circular movement of the Earth around the Sun.

Figure 1. Sample item from the comprehensive moon phases assessment (CMPA).

the CMPA; and of those 14, 12 took the pre-test and 12 took the post-test.

The 40 multiple choice questions of the CMPA, which was taken online, were developed and validated by Sherrod (2009) to measure the eleven moon phases domains. Figure 1 shows a sample CMPA item.

RESULTS

Three teachers in Australia, Texas and Massachusetts chose to have their students take the Comprehensive Moon Phases Assessment (CMPA) as a pre- and post-test. Table 1 shows the results of comparing the pre- and post-test scores in each individual class and overall. For the four Australian students who had both pre- and post-test scores, there was no significant difference between the two sets of scores. However, when all pre-test and post-test scores were compared, the CMPA pre-test mean score for seven students was 13.6 and the post-test mean score for five students was 17.8. These two sets of scores were significantly different at the p = 0.002 level. The Australian students performed significantly better after their MOON Project instruction than prior to instruction.

Similarly, there was a significant increase in the Texans' CMPA scores after instruction as compared to their pre-test scores in both the dependent means (p = 0.003) and independent means (p = 0.001) t-tests. However, there was no significant gain in lunar understanding as measured by the CMPA for the Massachusetts students. Finally, when combining the scores for all three classes, the overall post-test mean was significantly higher than the pre-test mean.

DISCUSSION

The positive effect of sharing online essays on the CMPA test scores shows that the MOON Project does provide a mechanism that teachers can adapt to their own setting with confidence that children will generally improve in their understanding of the science topic being studied. In both Texas and Australia the students' understanding of the Moon's phases was significantly better after than prior to the instruction. This finding is especially striking when one considers the particularly small sample size which makes the finding of significant difference especially difficult. In all three classes the students' post-test scores were higher than the pre-test scores; but while the gain was significant overall when all the students' test results were analyzed together, the gain was significantly positive in only two of the three classes. Thus, while the MOON Project provides a vehicle for significant improvement in lunar phase understanding, significantly positive results are not inevitable in all settings.

Using technology in science education would enhance learning experiences and encourage different styles of learning. For example, three-dimensional software (Bell and Trundle, 2008; Barnett and Morran, 2002) have been employed to improve understanding of lunar phase. In addition, an online platform (for example, WISE project) provided a new environment for designing, developing and implementing various science inquiry activities (Slotta and Linn, 2009). Since the MOON project provides scientific activities (that is, predict, observe, explain and reflect) by sharing online essays with students from various countries, it would be another addition to integrate technology in science education.

However, how the MOON Project activities are carried out in the classroom varies from one venue to another, although the MOON Project provides an avenue for children to engage in science inquiry on an international basis. In this iteration of the MOON Project, children in one Australian and two American states studied the Moon; and in turn we investigated their learning about the Moon's phases as measured by the Comprehensive Moon Phases Assessment instrument. What the three classes shared in common was their study of the Moon during the same time period, thus facilitating their sharing of data and finding global lunar patterns, using the MOON Project software. Also, all the students shared use of the MOON Project's student handbook, available at http://worldmoonproject.org, which gave similar structure to the students' collection of data and authorship of essays to be read by their global partners. On the other hand, the make-up of the sample in each location varied in characteristics such as age, socio-economic status, nationality and so forth. Also, the way the instruction was conducted varied from one classroom to another. Thus, we have not attempted to make comparisons in the MOON Project results among the three settings; and we make no comparisons about the effectiveness of this instruction versus other types of instruction.

The Internet provides a means whereby children around the world can connect together in science instruction; and today's New Millennium Learners (Organization for Economic Co-operation and Development, 2008) appear to be well poised for new instructional approaches that engage them collaboratively with their counterparts in other locations. The MOON Project provides a structure teachers can use to immerse their students in new world instruction with some confidence their students will learn science expected by their state's standards while interacting with other children on a global basis.

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