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The Effects of Hands-on Learning Stations on Building American Elementary Teachers' Understanding about Earth and Space Science Concepts

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Research on conceptual change indicates that not only children, but also teachers have incomplete understanding or misconceptions on science concepts. This mixed methods study was concerned with in-service teachers' understanding of four earth and space science concepts taught in elementary school: reason for seasons, phases of the moon, rock cycle, and earthquakes. The participants were 29 second year graduate students in an Urban Master Program at a southeastern American university. The data sources were: an open-ended survey given before and after participation in six hands-on learning stations on earth science concepts and teacher reflections in dialogue journals while participating in the stations. Rubrics were used to score answers to each survey question. Findings indicate that in-service teachers have low conceptual understanding of the earth and space science concepts taught in elementary school. Secondly, paired samples t-tests results showed that participation in hands-on stations on these science concepts changed teachers' understandings of these topics. Finally, dialogue journals contained useful positive reflections, negative reflections, suggestions, and comments on preference to teach the activities in the future. This study has implications for teacher preparation programs, staff development, and conceptual change practices at elementary schools.

Keywords: PISA 2003, private education, public education, comparative study, Finland, Korea

INTRODUCTION

Many of the basic concepts about earth and space science are introduced in elementary school. However, research shows that preservice (Trumper, 2001; Trundle, Atwood, & Christopher, 2002), as well as inservice elementary school teachers (Bulunuz & Jarrett, 2008; Kikas, 2004; King, 2000), have many misconceptions similar to those held by children (Muthukrishna, Carnine, Grossen, & Miller, 1993; Stahly, Krockover, & Shepardson, 1999). Middle and high school teachers generally teach specialized content. However, elementary school teachers need to have a very broad range of scientific knowledge and knowledge of how to teach difficult concepts effectively (Trundle, 1999).

This research study is concerned with inservice teacher understanding of four earth and space science

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State of the literature

The literature on understanding earth and space science concepts suggests the following:

- A limited number of studies on each of the following concepts, the reasons for seasons, phases of the moon, rock formation, and causes of earthquakes, indicate that both preservice and inservice teachers have many misconceptions.
- Research on how both children and adults construct conceptual understandings, suggests that lecture alone is not effective in building understanding and that hands-on experiences are both enjoyable and helpful in clarifying misconceptions.
- Studies on the effects of modeling inquiry methods during teacher preparation helps build understanding of various science concepts.

Contribution of this paper to the literature

This study contributes to the literature by combining elements studied in previous research, i.e., initial conceptual understanding of inservice teachers on earth and space science concepts and the effect of hands-on activities in building conceptual understanding and participant enjoyment of science. The study found the following:

- Inservice teachers had many initial misconceptions similar to subjects in previous research.
- Hands-on activities had a significant effect on teacher understanding of three of the four concepts.
- Analysis of dialogue journals indicated that participants generally enjoyed the activities and felt they were helpful for understanding these concepts.

concepts that are often taught in elementary school: reason for seasons, phases of the moon, the rock cycle, and earthquakes. In the *National Science Education Standards* [*NSES*] (National Research Council, 1996), the *Benchmarks for Science Literacy* (AAAS, 1993), and the recently developed *Georgia [U.S.A.] Performance Standards* [GPS] (Georgia Department of Education, 2006), these concepts are taught at different grade levels in the elementary school curriculum. Table 1 indicates when these concepts should be taught according to the *NSES,* the *Benchmarks*, and the *GPS*.

A number of studies on the conceptual understanding of various earth and space science concepts held by preservice elementary teachers (Atwood & Atwood, 1996; Callison & Wright, 1993; Bayraktar, 2007; Kusnick, 2002; Stofflett, 1993; Trumper, 2001; Trundle et al., 2002) and a more limited number of studies with inservice elementary teachers (Kikas, 2004; King, 2000; Parker & Heywood, 1998) suggest that many preservice and inservice teachers do not have enough scientific understanding to teach earth and space science concepts to students. The following studies examined preservice or inservice teacher understanding of specific concepts.

Atwood and Atwood (1996) surveyed and interviewed preservice elementary teachers on reason for seasons and found that the most common misconception was the proximity of the earth to the sun (distance theory). According to Atwood and Atwood, the thinking seemed to be that when part of the earth is tilted toward the sun, it is closer to the sun and thus gets hotter; and when part of earth is tilted away from the sun, it is farther from the sun and thus gets colder. Other listed examples given by the participants were indicated as “the rotation of the earth on its axis,” “the way the earth positioned on its axis,” and “the part facing the sun is having summer.” Kikas (2004) found in research with inservice teachers that 91% of the elementary and 93% of the science teachers gave scientifically correct answers but that many gave very complicated explanations suggesting that they had memorized explanations and may not have understood them. In addition to distance theory, Parker and Heywood (1998, p. 510) found that inservice teachers had another main alternative conception for the reason for seasons, referred to as “wobbly earth.” They defined wobbly earth as “the oscillation of earth’s axis in summer and winter.”

In the literature, teachers’ misconceptions on the phases of the moon are very similar to the students’ misconceptions. Trundle et al. (2002), focusing on the conceptual understanding held by preservice teachers about moon phases, reported that teachers had alternative conceptions such as: the moon phases are caused by the earth’s shadow on the moon (eclipse) and the earth’s rotation on its axis (day and night). Callison and Wright (1993) investigated preservice teachers’

Table 1. Recommended Grade Levels for Teaching Four Earth and Space Science Concepts in the U.S.A.

	Reason for seasons	Phases of the moon	Rock cycle	Earthquakes
National Science Education Standards	5-8	K-5	5-8	5-8
Benchmarks for Science Literacy	5-8	K-5	9	9-12
Georgia Performance Standards	4	4	3-5	5

conceptions about earth-sun-moon relationships and reported some of the common misconceptions held about what causes the phases of the moon: the earth's shadow, the clouds, the Earth's and the moon's tilt. Parker and Heywood (1998) investigated inservice teachers' misconceptions on the moon phases and found that most teachers thought that the earth's and other planets' shadows onto the moon caused the moon phases. In a recent study, Bayraktar (2007) found that 46% of preservice teachers had misconceptions on phases of the moon, the most common being that phases are caused by the earth's shadow on the moon.

Kusnick's (2002) research with preservice teachers in her geology class noted a number of misconceptions about rock formation. Some of the participants' ideas were as follows: rounded pebbles or rocks found near the rivers must be sedimentary rocks; rocks are formed by sediments sticking together at the bottom of rivers; and sedimentary rocks are formed mainly through catastrophic events, such as earthquakes or explosive volcanic activity. Stofflett (1994) investigated preservice teachers' knowledge about rock cycle processes and found that they understood igneous rocks more easily than sedimentary rocks.

Misconceptions about earthquakes and plate tectonics seem to be common, even among the teachers who teach these topics. In investigating teachers' understandings about plate tectonics and the cross-section of the Earth, King (2000) found that half of the teachers did not give the correct names to the Earth's sections or know their composition. He concluded that teachers would better understand the movement of earth's plates if they had scientific understanding about the states of the Earth's sections.

Hands-on Science Activities

According to the constructivist philosophy of Piaget and Vygotsky, people build conceptual understanding on their experience. Real experiences allow people to construct their own understandings in a meaningful way (Piaget, 1968; Vygotsky, 1978). The common point for these theorists is that learning is an active process requiring physical and intellectual engagement with the learning task. Demonstrations and hands-on activities create "external intrusion" (Piaget, 1968, p. 113) into current thinking and stimulate equilibration, leading to conceptual change. According to Piaget's theory, learning takes place at all ages as people try to "equilibrate" (make sense of) dissonant experiences through the processes of assimilation and accommodation.

Many strategies have been used to improve conceptual understanding, including use of various types of textbooks, concept maps, computer simulations, conceptual change text, field trips, and inquiry activities using learning cycles. This study explores the impact of various hands-on activities on inservice elementary teachers' conceptual understanding about earth and space science concepts.

Research has concluded that students' alternative conceptions are not eliminated by traditional methods involving primarily lecture (Marinopoulos & Stavridou, 2002; Weaver, 1998), and that hands-on activities are an effective way for children and adolescents to acquire knowledge (Costa, 2003). According to Cetin (2003), hands-on activities make students more active learners in science classrooms, especially if they can apply what they learn in school to their daily life situations. Research has also shown that students find science topics more interesting when they are relevant to daily life or experience (Weaver, 1998). According to Crawford (2000), projects involving hands-on experience enhance opportunities for construction of knowledge. In a comparison of traditional and inquiry-based college earth science classes, McConnell, Steer, and Owens (2003) found collaborative hands-on inquiry activities to be more effective in clarifying conceptual understanding. Also their interviews of the students showed that most of the participants enjoyed the inquiry-based class, preferred the hands-on activities to a traditional lecture class, and would recommend this course to their peers.

Some teacher education programs include hands-on activities, not only to clarify concepts but also to model hands-on, inquiry methods. The next section summarizes the findings of some of these studies.

Research with Preservice and Inservice Teachers

Research focused on preservice teachers (Kelly, 2000; Gibson, Bernhard, Kropf, Ramirez, & Van Strat, 2001; Ebert & Elliot, 2002; Plourde & Klemm, 2004), and inservice teachers (Gutierrez, Coulter, & Goodwin, 2002; King, 2000; Parker & Heywood, 2000) demonstrates the effectiveness of hands-on methods. Kelly (2000) found that participation in hands-on activities on light and color, followed by development of their own learning centers for children, increased conceptual understanding. In an introductory physical science course taught using hands-on activities, cooperative group work, manipulatives, and real life applications, Gibson et al. (2001) analyzed preservice teachers' weekly reflective journals and found that the course had a positive impact on their scientific understandings. Ebert and Elliot (2002) concluded that rock and mineral identification activities in a laboratory techniques course for preservice teachers were successful in developing understanding. Plourde and Klemm (2004) found that five learning stations on sound promoted conceptual understanding as well as engagement among preservice elementary teachers.

Parker and Heywood (2000) conducted research on inservice teachers' concepts about floating and sinking and found that through hands-on science activities teachers engaged successfully with difficult and abstract scientific ideas. They also observed that, if teachers were learning by doing, they could identify the characteristics of the learning process itself within specific subject domains. King (2000) conducted Earth science workshops to help teachers clarify their misconceptions and reported great improvements in clarity of understanding after the workshops. Gutierrez et al., (2002) offered a summer workshop to elementary school teachers focusing on earthquakes, volcanoes, floods, hurricanes, and tornadoes and reported that the teachers improved their understanding 31%.

The purpose of the present research was to assess whether or not hands-on centers in a science methods class would help change misconceptions and build accurate content knowledge about earth and space science concepts. For the purposes of consistency and clarity, the teachers in the course will be referred to as students in this paper.

The following research questions guided the study:

1.What initial understandings did the students hold on the following topics: reason for seasons, phases of the moon, rock cycle and earthquakes?

2.Did participation in hands-on learning stations on these earth and space science concepts change student understandings of these topics? If not, what misconceptions did the students still hold?

3.Did student reflections indicate that participation in the learning stations helped build understanding and desire to implement these topics in their own classroom? Did they enjoy the activities?

METHOD

Participants

This research was conducted with inservice elementary school teachers in a science methods course, Fall 2004. The participants were second year graduate students in an Urban Masters Program in the Early Childhood Education Department at a southeastern American university. The purpose of the urban masters program is to prepare excellent teachers for urban high poverty schools with marginalized populations. In the first year of the program, the participants were interns in schools while taking curriculum, child development, and classroom management courses. During the second year, most were first year teachers, although some of the participants came from another urban certification program and were in their second or third year of teaching. In addition to curriculum courses two nights a week, each inservice teacher had a university coach who visited him/her regularly. There were 36 graduate students in the class, but only 29 (4 male and 25 female) of them completed both pre and posttests. The ethnic composition of the class was: 21 European American, 13 African American, and 2 Asian.

Data Sources and Data Collection

Two data sources were used in this study: 1) an open-ended survey about science concepts administered both as a pretest and as a posttest and 2) the students' reflections about the hands-on learning stations in their dialogue journals. A mixed-methods research design was used with the rubric scores of the answers for the open-ended questions analyzed quantitatively and the themes from the students' reflections analyzed qualitatively. All data collection was conducted as a normal part of the class.

Open-ended Survey and its Administration as a Pretest

The second author, who was the class instructor, had previously developed the survey "How well do you understand science concepts?" for use as a teaching tool in her science methods classes. The survey questions assess content knowledge about a variety of science concepts. The concepts were selected based on past experiences with students, and the survey results were used to stimulate class discussions of how teachers can prepare themselves to teach these concepts.

In order to assess students' initial understandings, the survey was administered in the first week of this study. The original survey had 19 open-ended items; however, the researchers focused on only four questions related to earth and space science concepts, which were used as a pre-test in this study. These questions were: 1) why do we have seasons? 2) why do we see the phases of the moon? 3) explain the rock cycle, and 4) what causes earthquakes? The students' answers to these questions provided information about their initial knowledge on these concepts that are currently taught at the elementary level.

Rubric Scoring. The inservice teachers' answers to the open-ended questions were scored according to the level of understanding for each phenomenon. The researchers created scoring rubrics to classify students' responses about these concepts. An answer was coded as 1 if there was no response, an incorrect answer, or a clear misconception, 2 if the answer was partially correct or it had no elaboration, and 3 if the answer was integrated with scientific perspective and clear elaboration (See Appendix A for Scoring Manual). The correctness of the answers scored as 3 was validated by comparisons with textbook explanations and by consultation with a professional engineer having a strong science background. In order to prepare the scoring rubrics, the researchers looked through the answers from past surveys, extracted examples of the answers that would have scored as *1, 2,* or *3*, and created a scoring manual with examples in each coding category. The two raters, authors of the study, scored the survey answers separately and calculated an inter-rater reliability coefficient for each question using the correlation function of SPSS. The inter-rater correlation coefficients were calculated as: (a) reason for seasons, 0.86; (b) phases of the moon, 0.61; (c) rock cycle, 0.89; and (d) earthquakes, 0.72. The same rubrics were used for both the pretests and the posttests. The first author's scores were used in the research.

The concept phases of the moon had the lowest inter-rater reliability coefficient of the four. On this concept, there appeared to be more ambiguity in the answers than reflected in the scoring manual. Most participants thought they knew the answer and responded with a mixture of misconceptions and correct information. Rubric scoring in this concept was clarified for subsequent research through the choice of clearer examples for answers scored as *1, 2*, and *3*.

Hands-on Learning Stations as an Intervention

In each class, the hands-on learning stations were implemented in one class period lasting two and one half hours. On the day of the intervention, the researchers set up six stations with hands-on activities designed to clarify the four earth and space science concepts. Each station had one particular activity with materials and an instruction sheet. Descriptions of the learning stations can be found in Appendix B. For the concepts of "reasons for seasons" and "phases of the moon", there was only one station each. However, two stations each were set up for the "rock cycle" and "earthquake" concepts. The researchers chose more than one activity for those two concepts, giving a better chance for the inservice teachers to understand them. The station activities were adapted from various science activity books and geology class labs. The stations and the sources for the activity ideas were: (a) reason for seasons (Van Cleave, 1991; Smith, 1998), (b) phases of the moon (Couper & Henbest, 1994; Smith, 1998; Zike, 1993), (c) crayon rock cycle (geology lab class), (d) rock sorting, (e) earthquakes (geology lab class), and (f) ocean spreader (Van Cleave, 1991).

To introduce the stations, the researchers gave specific information on the use of some of the materials, reminded participants to read the instructions, and told them to answer the questions in their dialogue journals. They were told that each group would start at a specific station; then after approximately 15 minutes, the instructors would give a reminder followed by a signal to rotate to the next station. Groups of four or five participants were assigned to begin at each station. They rotated through the stations until all groups visited all eight stations.

After reading the instructions at the learning stations, group members worked together to complete the hands-on earth and space science activities. They discussed the questions on the instruction sheets and then tried to answer the questions in their journals. While the students were doing the activities, the researchers observed them, gave extra information as needed, and made sure the participants used the materials appropriately and correctly.

Student Reflections in Dialogue Journals

Upon completion of each activity, the participants wrote about their experience in their dialogue journals. They were asked to write their personal comments, positive or negative reflections, suggestions, and whether or not they would implement the activity in their classrooms (see Table 4). Members of the groups generally talked about their reactions to the activity and shared their own teaching experiences before writing. Given the limited time, they did not have a chance to revise their answers after rotating to the next station.

The dialogue journals were collected at the end of the class period, and the related pages were copied. As is typical in dialogue journals, the course instructor read and made comments in the journals before returning them at the beginning of the next class.

Open-ended Survey Administered as a Posttest

The last week of the study, the researchers asked the students the same four open-ended questions. The students' responses were analyzed quantitatively and evaluated as posttest data in this study.

Data Analysis

To answer the first research question, concerning initial understandings of inservice teachers on the four concepts (the reason for seasons, phases of the moon, the rock cycle, and earthquakes), means, standard deviations, and frequencies using the rubric scores for each question were calculated. Examples of their pretest answers reflecting their conceptual understandings were listed, and examples were identified that illustrated their incomplete understanding or misconceptions

To answer question two, on whether participation in hands-on centers on earth and space science concepts changed student understandings of these topics, paired samples t-tests were calculated comparing pre and posttest scores on each of the questions.

To answer question three, the first author read the students' dialogue journals and separated the answers

Table 2. Frequencies and Percentages of Categorization of Inservice Elementary Teacher's Responses

	Pretest			Posttest		
	Frequencies			Frequencies		
	1	2	3	1	2	3
Reason for seasons	23	6	-	13	15	1
Phases of the moon	24	5	-	20	9	-
Rock cycle	25	4	-	7	20	2
Earthquakes	1	26	2	-	15	14

1= Incorrect answer or No answer
2= Correct or partial answer
3= Correct answer with elaboration

according to whether they were positive reflections, negative reflections, suggestions, or comments on use of the activities in the classroom. Types of responses with numbers of students responding according to type were calculated.

RESULTS

Quantitative Analysis of the Open-ended Questions

To answer the first research question on initial conceptual understanding and question two on the effect of the intervention, the open-ended surveys were analyzed quantitatively. Descriptive statistics were used to determine the frequency of the quality of answers as scored in the rubrics. Table 2 shows the frequencies of the rubric coding on the pre and posttests. An important finding on the earthquake question was that the number of the students' responses categorized as *3* increased from 2 to 14. On the earthquake posttest question, no teacher gave a *1* response. A similar pattern was shown on the rock cycle, with the number of category *1* responses decreasing pre to post from 25 to 7.

In order to determine whether the students improved in conceptual understanding after doing the activities in the hands-on learning stations, means were calculated for the rubric scores on each concept and pretest and posttest scores were compared using paired samples t-tests. Table 3 presents the means and standard deviations for pre and post–test scores.

Posttest scores were significantly higher on three of the four concepts: reason for seasons, $t\ (28) = 4.14, p < .001$; rock cycle, $t\ (28) = 7.89, p < .001$; and earthquakes, $t\ (28) = 4.19, p < .001$. The difference for phases of the moon approached significance, $t\ (28) = 1.684, p = .103$. It is clear that the participation of hands-on science activities had a positive effect on the understanding of the students.

Descriptive Analysis of the Open-ended Questions

Research Question One: Initial Understanding of Earth Science Concepts

Pretest answers were analyzed qualitatively to describe initial understandings on reason for seasons, phases of the moon, the rock cycle, and causes of earthquakes. The types of answers were then tallied. Following are student answers scored a 1 or 2 on the rubric, categorized by whether they represented an incomplete understanding or a misconception.

Reason for seasons. The results of the students' pretest answers indicated that 23 students out of the 29 students had either incorrect understandings or misconceptions about reason for seasons. Some of the students had both incomplete understanding and misconceptions in their answers. Six students had two misconceptions. Seven different misconceptions and two incomplete understandings were extracted from their responses. In incomplete answers, 15 students said the revolution [some said *rotation] of the earth around the sun* caused seasons. The most common misconception was that the *distance/proximity of the earth from/to the sun* caused seasons (9 students). Other misconceptions mentioned by one student each were: *atmosphere changes, our relationship around the sun, the orbiting of the earth on its axis, vernal equinox*, and "how the sun lines up and time changing." Another answer, "to prepare the earth for the preparation of food," tried to explain the usefulness of seasons rather than the cause of seasons.

Before doing the station activities, most students did not understand that in earth's annual journey around the sun, the earth rotates on an axis tilted with respect to the plane of its orbit around the sun. Only six of them mentioned the effect of the tilted axis on the pretest.

Unlike other studies, the most common incomplete understanding about reason for seasons was *the rotation of the earth around the sun* (15 students). The most common misconception was the *distance theory* (9 students), a finding consistent with previous research (Muthukrishna et al., 1993; Schoon, 1992; and Atwood & Atwood, 1996).

Phases of the moon. Pretest results indicated that nine students made little or no attempt to answer the question, 11 students had misconceptions, and nine students had incomplete understanding of the phases of the moon before participating in the activities. The most common answer was the rotation of the moon around the earth (7 students) and the most common misconception was the shadow of the earth on the moon (5 students). This result seems to be consistent with the studies of Rider (2002), Schoon (1992), and Stahly et al., (1999). Another incomplete understanding was the position of sun and moon, (2 students). Three students had the misconception that the rotation of the earth around the sun causes moon phases. The following misconceptions were expressed by one student each: "because of our rotational axis," "whole moon is illuminated by the sun's light," and "sun is exposing itself on different sides of the moon at different times." Instead of explaining causes of the phases, four students wrote the names of the moon phases, and two students made drawings of the phases.

Rock Cycle. Twenty-one students left the answer blank or responded that they did not know. Four students had incomplete understandings about the rock cycle. They described only one aspect of change in rocks with the following answers: "mountains erode and the material that falls off eventually crumbles into many rocks;" "rocks break off mountains and erode and eventually become dirt/sand/soil;" "over the years, dust minerals settle down, under pressure and heat they solidify into rocks." Only three students mentioned three different types of rocks (igneous, sedimentary, and metamorphic) in their answers, and they showed confusion about the relationship among the rock types. For example, one student's response to this question was "sediment comes together to form metamorphic rocks, they break apart and form sedimentary rocks, and pieces come together to form igneous rocks." Five students mentioned sedimentary rocks and their formations in nature. None of the participants mentioned the conversion of one type of rock to another using the phrase "rock cycle."

Causes of Earthquakes. Pretest results indicated that only one student was scored as *1* for this question. Twenty-six students mentioned *the plate tectonics or shifting of plates* as the causes of earthquakes and were scored as *2*. On the other hand, only two students gave more complete answers though none mentioned faults or discussed the effects of pressure between tectonic plates.

Research Question Two: Effect of Participation in Hands-on Learning Stations

Posttest data were analyzed to respond to the second question concerning whether or not participation in hands-on learning stations on these four concepts changed student understanding of these topics. After participating in the stations, students' responses were likely to reflect more scientific understanding of the earth and space science concepts. Although many students changed most of their misconceptions after the activities, some still had conceptions that were either inconsistent with the scientific knowledge or incomplete. The conceptual understanding of the students after the learning station activities are as follows:

Reason for seasons. Although the ultimate goal was to have students give scientific explanations, we considered notable progress toward a scientific understanding to be important. Some of the students' responses had both correct and incorrect pieces for the same question. For example, one student's response to this question was, "The earth rotates on its tilted axis and moves around the sun. Based on angle of the earth and distance from the sun seasons are determined." In this example, in spite of the fact that the student learned that the earth's axis is tilted as it revolves around the sun, she still holds the *distance theory* misconception. Another four students retained the same misconception they had before the intervention. On the other hand, 13 students mentioned the tilted axis of the earth in the posttest, seven students for the first time in the posttest.

The results of the students' posttest answers indicated that seven students had incorrect understanding and seven students still had various misconceptions. In addition to distance *theory,* four other misconceptions were found in their responses: "earth's position in relationship to the sun," "revolution axis of the moon and earth," and "the sun's position in the sky." In incomplete answers, five students said *the rotation of the earth around the sun* caused seasons. Two other students used the term of *the angle of the earth* instead of *the tilted axis of the earth* in their incomplete answers.

As part of the activity, the students examined the concentration of light on a white paper, drawing the area that was illuminated when changing the angle of the flash light. Two students' responses indicated that they were able to understand reason for seasons after this activity. One student's response was, "the way the heat of the sun spreads differently over the earth as the earth rotates [revolves], so there is a different intensity of heat at different parts of the earth." The students

Table 3. Comparison of Means, Standard Deviations for Pre and Post Test Scores

		Pretest		Posttest	
	N	Mean	SD	Mean	SD
Reason for seasons	29	1.20	.41	1.58*	.56
Phases of the moon	29	1.17	.38	1.31	.47
Rock cycle	29	1.13	.35	1.82*	.53
Earthquakes	29	2.03	.32	2.48*	.50

*p<.001

Table 4. Frequencies of Teachers' Reflections about Science Activity Centers

	Positive reflections	Negative reflections	Suggestions	Desire to teach concept in the future
Center 1 Reason for seasons	9	-	9	3
Center 2 Phases of the moon	13	-	7	1
Center 3 Crayon rock cycle	7	4	2	-
Center 4 Rock sorting	10	-	1	2
Center 5 Earthquake model	4	-	1	-
Center 6 Spreader	4	3	1	-

mostly mentioned this part of activity in their dialogue journals rather than in their posttest answers. The dialogue journal reflections suggest that most of the students have the scientific understanding of reason for the seasons after the stations.

Phases of the moon. Many scientific phenomena, including the phases of the moon, are three-dimensional. The research indicates that students, sometimes including adults, cannot easily relate a two-dimensional diagram to three-dimensional astronomical phenomena (Trundle et al., 2002). Therefore, after participating in the stations, most of the students' responses were still likely to reflect some misconceptions and incomplete understandings of the causes of the moon phases. In addition, some of students expressed confusion. Only four students showed improvements in their posttest answers, increasing their scores from *1* to *2*.

The results of the students' posttest answers indicated that seven students had incomplete understandings and said *the moon's rotation around the earth* causes phases of the moon. Similar to the pretest results, the most common misconception was again *earth's shadow on moon* [eclipse] that six students mentioned in their posttest answers. Unlike other studies, three students reported another misconception and that was *Sun's shadow on the moon* [lunar eclipse] causes lunar phases. This means that they were confused between a lunar eclipse and the moon's phases. Other misconceptions mentioned by one student each were: *the angle in which the moon rotates around the sun's light, the sun hits the moon completely,* and *the angle at which the moon reflects the sunlight.* At least one of the students still did not understand that half of the moon is always illuminated by the sun. His/her response to this question was, "the sun hits the moon completely." Some of the students had both correct and incorrect pieces in their answers, such as "we see phases of the moon because of the way the moon orbits the earth. The earth blocks light from the sun at certain times; the sun hits the moon completely." One student's response to this question was an honest *I don't understand this concept.* In addition, two students left the question blank. It is clear that even for teachers, this astronomical concept is very difficult to understand.

Rock cycle. On the posttest, 13 students mentioned the names of the three types of rocks. This result can be considered as great improvement in posttest; however, they still seem to have confusion about the formation process of these three rock types. In other words, how igneous, sedimentary, and metamorphic rocks form and convert to each other does not seem to be clear. Following is one of the responses to this question. "Metamorphic rocks are the result of the breakdown of those rocks. Igneous rocks are formed from heat and pressure." The answer means that this student is still confused about the differences between metamorphic and igneous rocks.

In incomplete answers, two students said "the elements cause the dust to condense and harden" and "layers of earth are pressed together over time." Some of the students described only one aspect of change in rocks with the following answers scored as *1*: "sediments get packed down form rock, wear away and are deposited elsewhere," "wind /rain /erosion," and "weathering and erosion causes rock to break down and get smaller and smaller." Four students mentioned two types of rocks in the posttest but did not mention all three types of rocks or the meaning of the *rock cycle.*

On the pretest, there was no answer that showed a sound understanding of the rock cycle and was scored as *3*. On the other hand, in the post test, two answers were scored as *3*. They mentioned all three types of rock and indicated that the various types were transformed into one another through erosion, heat, and/or pressure.

The results indicated that *pressure, aggregation*, and *weather conditions* are common words repeated in the students' answers about three types of rocks. They mentioned aggregation (such as crushing and compacting of smaller pieces) and weather conditions (such as wind, rain, and erosion, etc.) for sedimentary rocks. Several mentioned pressure but not temperature in the formation of igneous and metamorphic rocks.

Causes of earthquakes. The results of the students' posttest answers indicated that the responses of 14 students (almost 50 %) were scored as *3*. This is the highest percentage correct in this study and suggests that participation in learning station activities promoted clearer conceptual understanding. Although six students mentioned *movement of faults* in their responses, half of the participants understood that there was *movement of tectonic plates in different directions under the ground.*

Three posttest answers were scored as *3*. The following are their answers. "The tectonic plates of the earth shift in various directions causing cracks or rising/falling of the earth." "The plates shift under the ocean land causing parts of the earth to be pushed up & away from each other." "The earth has faults that release pressure underground - pressure causes move to erupt." None of the students' answer was evaluated as *1*.

Research Question Three: Student Journal Reflections about the Learning Stations

The reflections of the students in dialogue journals were sorted according to types of responses, positive reflections, negative reflections, suggestions about the activity, and degree of comfort with using these activities in their classrooms. Since these students had their own classrooms and teaching experience, they pointed out important criticisms and made suggestions about further use of the activities. The frequencies by type of journal response are summarized in Table 4.

Positive reflections. The students expressed positive reflections in their journals about different stations. Ironically, most of these positive reflections were on "phases of the moon." In spite of the fact that there was no significant difference between pre and posttest scores of the students for this question, the students enjoyed the activity. Thirteen students expressed positive comments about it. One student's reflection about this activity was, "this center is a great, interactive way to demonstrate the phases of the moon. Just like the center about reason for the seasons, it makes the concept more concrete and allows students to be able to visualize it easier."

The second favorite station was "rock sorting". Students thought this activity would be very helpful especially for younger children. Some representative positive statements about this station were: "*This is good way to teach sorting to 1st graders. So many different ways to sort.*" "*We looked at the rocks according to color. After the last center, it is interesting to see what each kind of rock looks like.*" and "*Rock sorting is fun activity for younger grades. Children love rocks and they could collect some to sort.*"

Also among positive reflections, some of the students found the support of researchers during the activities to be helpful and mentioned it in their journals.

Negative reflections. A few students also wrote some negative reflections in their journals. Specifically, four negative reflections were noted concerning the crayon rock cycle and spreader. In the crayon rock cycle station, the students used a hot plate to melt crayon pieces to understand the conversion of one type of rock to another. They did not find this activity safe enough to use in their classrooms, and they recommended adult supervision for this station. One student's response was "crayon rock cycle activity is something I would have to show the kids rather than have them do it because of the hot plate."

Another critique was determined for the center "spreader." This center was about the spreading of oceanic crust. One student considered the activity a "large jump for students to grasp, more details and explanation needed to connect with continents splitting." It is clear from his reflection that more detailed information would be necessary for this activity during the rotation.

Suggestions. Because students had one to three years of teaching experience, they had some practical suggestions, especially for the stations on reason for seasons and the phases of moon. Some of them had already tried some of these activities in their classrooms. For reason for seasons and phases of the moon stations, some teachers suggested that we use people manipulatives instead of Styrofoam balls. The following answers have suggestions for the station on reasons for seasons: (a) "we understood the exercise better once we actually recreated the steps with five of us standing in as the sun and the earth in four different locations around the sun." and (b)"using people as manipulative makes understanding the seasons easier." A suggestion for the station on phases of the moon was "Would work better in a darker room and with light bulbs."

Desire to implement these activities in their classrooms . The station the students said they were most likely to implement in their classrooms was the *seasons station.* Because the concept of "reasons for seasons" requires modeling in three dimensions, this concept is not easy to teach in elementary science classrooms. However, some students mentioned that they understood the seasons station and intended to use these activities in their own classrooms.

Two examples indicating their willingness to practice the same stations in their classrooms are (a) "Good activity, I will do it with my class. Good visual about how the earth's tilt causes different seasons" and (b) "Fun activity that could easily be used in the classroom. It is a good way to illustrate the seasons for kids."

While students were doing the station activities, the researchers tried to help clarify how to do the activities. It was understood from their reflections that these clarifications were considered very helpful, especially for the stations on seasons and moon phases. One student said: "Our instructor (the second author) came over and used us as models to demonstrate how the seasons change. She put a person in the middle, sun and four people on the outside tilted forward representing the earth tilted on its axis. Each person rotates counter clockwise representing one of the seasons." Another student stated: "It was difficult at first to observe the moon's phases. After one of instructors (first author) came over, I was able to see the different phases. As the moon rotated around, I saw the crescent moon."

DISCUSSION

As expected from previous research, findings of this research indicated that inservice teachers, without intervention, have limited understanding or incorrect understanding about the reason for seasons, phases of the moon, rock cycle, and causes of earthquakes. These results are similar to the findings of other research with inservice teachers (Bulunuz & Jarrett, 2008; Kikas, 2004; and Parker & Heywood, 1998). The number of incomplete or inaccurate initial conceptions suggests that science method courses ought to include clarification of difficult concepts teachers are required to teach. If teachers do not understand these concepts and they are not aware of these misconceptions, they may simply pass their misconceptions to students, if they teach the concept at all.

The finding that after doing the station activities the students improved in their understanding of three of the concepts indicates that alternative conceptions about earth and space science concepts can be reduced or even eliminated by appropriate hands-on experiences. This finding is consistent with previous research with elementary school teachers (Parker & Heywood, 2000; Gutierrez et al., 2002).

However, the number of continuing misconceptions suggests that either more time be given to the stations or that other activities should be used to make the concepts more clear. The finding that students did not improve in their understanding of the phases of the moon may be the result of a confusing model. The researchers observed that some students who held the Styrofoam ball (the moon) and the walked the moon around the earth (another student) seemed to be confused. (See the details about the stations in Appendix B.) Because the lamplight was directional and small relative to the person representing earth, it was difficult to angle the light so that the "moon" appeared to have phases as seen by the "earth." Probably, not all the students in the group noticed how the lighted part of the ball seemed to change shape.

The diagram that was chosen from the book and scanned onto the instruction sheet was not clear and could have been misinterpreted. Diagrams, figures, and the information in science activity books can create incorrect understandings for students. The authors of books designed for teachers and children must be very careful in selecting the diagrams and figures intended to clarify various concepts. Sometimes, oversimplification can cause misconceptions. The finding that students still had major misconceptions on reason for the phases of the moon caused the authors to improve the instructions, replace the model with two new models, and spend more time on clarifying this concept in subsequent research with a different population (Bulunuz & Jarrett, In press). In that study, participants significantly increased their understanding of phases of the moon.

On the other concepts, the results show that even though students improved their scores on the posttest, many still had incomplete understandings and misconceptions. This finding is very similar to findings of Trundle et al. (2002) and Parker and Heywood (1998). Although science educators try different conceptual change strategies and techniques for modifying misconceptions, the way these teachers were taught as children may cause them to memorize sterile scientific facts without making connections. Studies have shown that misconceptions learned as children are tenacious and resistant to change by conventional strategies even after instruction designed to address them. More importantly, concepts are interconnected and depend on each other for their meanings. Replacing alternative conceptions with scientifically accurate ones is a very difficult process. Science educators need to be aware of their students' incorrect understandings in order to design experiments, demonstrations, hand-on science activities and centers to help students construct correct scientific understandings.

Journal reflections about the learning stations indicated that some of the stations were clearer than others. Some of the students found the activities on the reason for seasons helpful and interesting because they could visualize these three dimensional phenomenon by using models. This finding is consistent with the research by Gibson et al. (2001) and McConnell et al.

(2003) whose students both enjoyed the inquiry-based class and preferred the hands-on activities to a traditional lecture class. The participants in this study suggested adult supervision for the crayon rock cycle station because of dangers in using a hot plate, a suggestion with which the researchers concur. Some students volunteered that they planned to implement some of the activities with their classes. In general, they enjoyed the learning stations and thought the activities improved their understandings.

There are several possible reasons for the continued existence of incomplete understandings or misconceptions after the intervention. First, the time spent at each station might not have been long enough for participants to internalize these concepts. Although general background information about each station was given before they started to do the activities, students might have needed more time to explore the activities and try to understand what they observed. Also the total time (one class period) might not have been enough to change initial understandings about space science concepts, such as reason for seasons or the phases of the moon. Because these concepts are about three-dimensional events, changing with time, and difficult to imagine, students might need more detailed information to change their incorrect understandings. Also, the activities chosen to clarify each concept might not have been the most useful, compared to others that might have been more helpful in building understanding.

To determine the depth of teacher understanding, an assignment to implement some of these learning stations in their classroom could have been given. Observations or videotaping in their classrooms could provide evidence of level of teacher understanding as well as whether these activities develop conceptual understanding in their students. Such an assignment is recommended for future research.

One limitation of this and other studies of earth science concepts is the use of activities focused on observation, visualization, and clarification rather than inquiry. Althogh inquiry was a focus of much of the course, these learning stations provided "cookbook-like" instructions designed to guide the participants to the "correct answer." The authors believe that such activities have a place in the science methods class, especially when many concepts covered in the standards must be clarified in a brief period of time. These earth and space science concepts did not lend themselves to true experimentation. However, such activities should be balanced by other concepts, such as the growth of plants, the effects of magnetism, and the properties of air than can be taught through inquiry.

This mixed-methods study makes several contributions to the research literature on inservice teachers. First, it provides a window into what inservice elementary teachers already know about earth and space science concepts, adding to the limited number of studies on the conceptual understandings of inservice teachers (Kikas, 2004; King, 2000; Parker & Heywood, 1998). Secondly, this research demonstrates the effectiveness of hands-on learning stations for enhancing inservice teachers' conceptual understandings This study shows that enjoyable hands-on activities in a methods class can be useful in clarifying concepts for teachers while modeling activities teachers can use in their classrooms to clarify the same concepts with children. Such activities could be included in: (a) undergraduate science content classes, (b) initial teacher education and training courses, and (c) inservice courses for elementary school teachers as a way to improve both content knowledge and pedagogical knowledge. Thirdly, the teachers' personal reflections in their dialogue journals provided information about their ways of thinking about the hands-on learning stations, especially their level of comfort with teaching these topics and their reflections on whether or not they enjoyed the activities. Such insights are useful for science educators designing hands-on experiences for students. The teachers' common recommendations and constructive suggestions give researchers ideas for revising and improving learning stations for future studies.

Although there are numerous research studies on the *reasons for seasons* and *phases of the moon,* studies focusing on concepts about the *rock cycle* (Kusnick, 2002; Stofflett, 1994) and *causes of earthquakes* (King, 2000) are limited. Researchers generally look at the concepts of rock classification or rock types instead of conversion of one rock type to another. The research on earthquakes investigates conceptions about the cross-section of the Earth or the Earth's composition but not the role of friction between plates in causing earthquakes. The results of the current study present a new set of ideas and practical suggestions for bringing about conceptual change.

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APPENDICES

APPENDIX A

SCORING MANUAL

RUBRIC AND SAMPLE ANSWERS FOR OPEN-ENDED SURVEY

3: Integrated with scientific perspective and clear with elaboration

2: Partially correct or has no elaboration

1: No response, incorrect answer or clearly evident misconception

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Q 1: Why do we have seasons?

Rubric

Scores	Why do we have seasons?
3	• If the response includes two or more of the following ideas: the tilt of the earth's axis, changes in the part of the earth getting more direct sunlight, and the tilt of the earth as it revolves around the sun.
2	• If the response includes a correct idea without elaboration (the amount of the sun's light concentrated on a particular area) or one correct idea, even if combined with one that is not clear (because of the tilt and rotation of the earth).
1	• No response or if the response showed a clear misconception or did not explain the concept, e.g. rotation (revolution) of the earth around the sun, the earth's distance from the sun, our position around the sun, vernal equinox, time changing, changes in the atmosphere.

Sample answers

3:

* Because of the tilt of the earth as it revolves around the sun

2:

* Different parts of the earth have heat & light for different amounts of time.

* The earth revolves around the sun in an oval orbit. The earth's axis is tilted. Greater distance and tilt

* The elliptical path around the sun & the tilt of the earth on its axis effect the changing seasons.

* Because of the Earth's rotation around the sun-it is an ellipse; so sometimes it is farther away from the sun. Also, because of tilt of Earth's axis

* The position of the sun is relationship to the earth causes fluctuations in the number of hours the earth is exposed-affecting temperature and the angle of exposure.

1:

* So that the environment, plants, animals, wildlife can change, and go through the cycles & then restart.

* The earth tilts up and down, making the sun shine bright and warmer depending on tilt.

* Because of the rotation of planets

* Rotation of the earth around the sun can cause temperature changes.

* Because, it is the relation of earth & the sun

* The seasons change because we are closer to and farther from it.

* The earth moves around the universe and your part of the earth is farther from the sun, it is colder …when it is closer it is warmer.

* We have seasons to mark the changes in weather. We go from winter to spring to summer to autumn or fall. We have these 4 seasons for the 4 major changes in the weather. Seasons affect our dress, plants, food, etc.

Q 2: Why do we see phases of the moon?

Rubric

Scores	Question 2 (Phases of the moon) Criteria
3	• Sound understanding (No answer was found in two data sets for this category)
2	• The response includes at least one of the following ideas: the relative position of the sun-earth-moon, the sun's reflection on the moon, the revolution of the moon around the earth, the moon reflects the sun's light.
1	• A response that is clearly wrong, such as "we see the phases of the moon because of the shadow of the earth on the moon, the tilt of the earth, or rotation of the earth."

Sample answers

3: No number 3 answer was found in the previous study. Following is what we looked for in a quality answer, a clear understanding of the reason for the phases of the moon:

* The Moon does not produce its own light, but simply reflects the light of the Sun. The phases of the moon are caused because the orbit of the Moon around the Earth will vary the part of the Moon's reflected light that is visible from earth. In other words, the angle of the moon and earth relative to the sun determines the moon phases.

2:

* Rotation of the earth & moon around the sun & the reflections of them.

* Phases of the moon are caused by the sun position shining on it.

* Because of the relative position (alignment) of the sun – moon-earth.

* What we see is the sun's reflection on the moon.

1:

* Because of the rotations of the earth around the sun

* Because of the tilt of the earth

* Shadow of the earth

* Because the sun cannot reflect light on other sides of moon.

* The sun is getting in the way.

* Shadows of the moon on the earth

* We see different amounts of the moon based on the shadow from the sun.

* Because of the sun

* It depends on where we are in our rotation around the sun how well we see the moon.

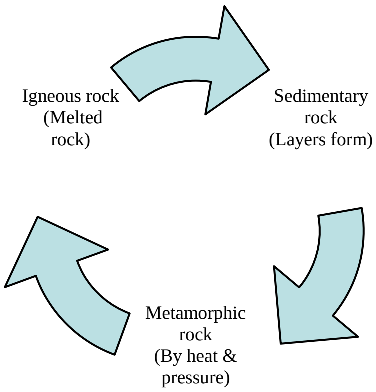
* The earth moves around the moon thus you see different aspects of the moon.

Q 3: Explain the rock cycle
Rubric

Scores	Explain rock cycle
3	• If the response includes all three types of rocks (igneous, sedimentary and metamorphic), their conversion to each other, or their formations (igneous-melted rock, sedimentary-layers form, and metamorphic-heat & pressure).
2	• If the response includes information on just one or two types of rock formation: the rock cycle is formed from sediments, the rock cycle deals with the heat and years and years of weathering, as the earth ages, various layers of rock are formed, probably has to do with the change from superheated core materials pushed upward to the crust.
1	• If the response gives unrelated information, confusing or incorrect information, or no answer was given. For example: material, pressure, and heat can cause the formation of rock, rocks are made from minerals, dirt and sand particles binding together to make one big solid mass, volcanoes produce lava which melts into rock.

Sample answers

3: No number 3 answer was found in the previous study. Following is what we looked for in a quality answer, a clear understanding of the cyclical nature of transformations of one rock to another. A drawing such as the diagram below would have yielded a score of 3 although mention of cross links between rock types would have shown more complete understanding. For example, igneous rocks can be converted to metamorphic rocks and metamorphic rocks can be converted to sedimentary rocks.



2:
* Minerals form rocks; rocks are weathered into sand & soil, as soil builds rocks are compressed together to form larger rocks.
* The rock cycle is formed from sediments that receive heat & pressure & then harden into a rock.
* Particles harden create rocks – rocks erode into particles
* The rock cycle deals with the heat and years & years (billions) of weathering.
* As the earth ages, various layers of rocks are formed.
* Probably has to do with the change from superheated core materials pushed upward to the crust.

1:
* Material-Pressure + Heat = Rock
* Water erodes the rocks and they are carried to soil where phosphorus makes new rocks.
* I don't know besides the fact that rocks are made from minerals
* Dirt or sand particles binding together to make one big solid mass.
* Volcanoes produce lava, which melt into rock.

Q 4: What causes earthquakes?
Rubric

Scores	What causes earthquakes?
3	• If the response includes combinations of ideas giving a clear explanation: shifting of the earth's crust on the fault line, shift in the tectonic plates creating on releasing pressure, the plates of the earth colliding and rubbing against each other, shift in the earth's crust because of the lava inside the earth surface.
2	• If the response includes a correct term or idea, but lacks full explanation or gives a too narrow example: plate tectonics, shift in convergent plates, big plates shift caused by molten rock moving in the middle of the earth, plates shifting due to volcanoes, new lands form.
1	• If the response mentions a clearly evident misconception, mentions a phrase associated with earthquakes but without explanation (e.g. plates in the ocean, friction, the earth moving), or gives no answer.

Sample answers

3:
* Shifting of the earth's crust on the fault line.
* The shifting of the tectonic plates along a fault line.
* Shifts in the Earth's crust because of the lava inside the earth surface.
* Shift in the tectonic plates creating on releasing pressure.
* The plates of the earth colliding &rubbing against each other.

2:
* Tectonic plates (moving of the continents)
* Plate tectonics + pressure
* Plates shifting due to volcanoes, new lands form.
* Heat from the earth moves the plates.
* Shift in convergent plates
* The earth is made up of big plates & they shift caused by molten rock moving in the middle of the earth.

1:
* Plates in the ocean
* Friction
* The earth moving

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Appendix B

DESCRIPTION OF THE HANDS-ON LEARNING STATIONS

1. Reasons for seasons

In this station, a Styrofoam ball, two pencils, flashlight, and a piece of paper were used. As the earth, the students used a pencil that was inserted through a Styrofoam ball with an equator line drawn around it. The students placed the flashlight about from the left then right side of the ball and held the pencil at an angle. They observed where the light struck the ball. Then, the students put the flashlight perpendicular to the white piece of paper and drew the first area on which rays were concentrated. By tilting the paper, they increased the angle between paper and flashlight, and drew the second area again where the light was most intense.

2. Phases of the moon

In this station, a lamp without its shade, a Styrofoam ball, and a pencil were used. The researchers stuck the pencil into the Styrofoam ball and the students used it as a handle for holding the ball. The lamplight represented the sun, the ball represented the moon, and one of the students in each group represented the earth. The student held the ball between the body and the lamp just above the head. Another student was holding the lamp shining on the moon. Following a diagram from a book, one student walked the moon around the lamp in a counter clockwise direction. Students in the group noticed how the lighted part of the ball seemed to change shape, from a thin line, or crescent, to a full moon then it began to get smaller and smaller until they had no reflected light.

3. Crayon rock cycle

In this station, three different color crayons, pencil sharpener, tape, aluminum foil, hot plate, and two boards were used. The students shaved three different colored crayons into the center of an Aluminum foil square to form pretend "sediments." They recorded what it looked like. They folded Aluminum foil into a packet and added pressure by standing on it. They opened packet, removed a bit of stuff, and taped it onto handout as sedimentary rock.

They placed the packet on the hot plate and left until crayons just began to melt. They took foil from heat with a tweezers, removed a bit of stuff and taped to handout as metamorphic rock. They returned the packet to hot plate and left until crayon was completely melted. They observed quickly before the "magma" cooled. After crayon had completely cooled, they taped it to handout as igneous rock.

4. Rock sorting

An assortment of various rocks (igneous, sedimentary, and metamorphic rocks), rocks books and different rock samples were used. There were three tubs on their table. In the first one, the students had different types of rocks to observe, sort, and compare according to color, texture, softness, crystalline shape, and breakage. In the second tub, there were three different kinds of rocks: igneous, sedimentary, and metamorphic. The students tried to differentiate them by using the books and rock guide on their table. In the third tub, there were granite, marble, and pumice samples that they could keep.

5. Earthquake model

In the earthquake center, ratchet, cord, two clamps, belt sander paper, two small bungee cords, spring scale measuring at least eight pounds of tension (fish scale), two bricks, and measuring stick were used. The researchers clamped the sander paper at one end of a table and wrapped a bungee cord tightly around the brick. A second brick was on top for weight and the stacked bricks were placed on the sander paper near the clamp. Later, the researchers hooked another bungee cord to that cord. Starting at the other end of the table, they attached a cord to the ratchet to the table and stretched out the cord and attached a spring scale to the end. At last, they hooked the spring scale to the bungee cord. When the students came to the center, they ratcheted the cord until taut. Each of them predicted how many clicks of the ratchet it will take to move the bricks (cause an earthquake). Then, they checked to see how much tension there was on the spring scale when the earthquake occurred and how far the bricks moved.

6. Spreader

In the spreader station, scissors, shoebox, modeling clay, and sheet of paper were used. The researchers cut two 3 in x 11 in, strips from a sheet of paper. Then they cut out 0.5 in. x 3.5 in. section from the center of the bottom of the shoebox. This shoe box was already prepared before the class. Then, the students put the papers together, ran them through the silt in the box, pulled the strips out about 3.5 in, and fold them back on opposite sides. Later, they pressed a flattened strip of modeling clay about the size of a pencil on the end of each strip. The students held the papers under the box between their index and second finger, and slowly pushed the strips up through the slit, illustrating the flow of magma where the plates are spreading under the ocean.