Teaching for Conceptual
Understanding

Revisiting their initial ideas about the solar system helped students connect newly learned material to their existing knowledge.

By Nam-Hwa Kang and Carrie Howren

One of the most difficult jobs of elementary school teachers is teaching science for conceptual understanding. Conceptual understanding requires students to organize facts and ideas into a meaningful concept in science. Facts and concepts form webs that can help students make connections between the concepts of science and their experiences. Moving beyond rote memorization of facts, conceptual understanding enables students to align intuitive ideas with scientific ones, making meaningful connections. Therefore, students can apply their understanding of concepts to multiple contexts.

Careful lesson planning is required to help students relate their ideas to scientific knowledge and transfer that learning to other contexts. Students often come to class with conceptions that are not scientifically correct. Discussions with other second-grade teachers revealed a majority of our students had difficulty understanding that the Earth is not the center of the solar system. This notion is understandable because students have witnessed many sunrises and sunsets.

Thus, I designed this unit to develop my second-grade students’ conceptual understanding of Earth’s movement. This became the starting point of an educational journey for both the students and me.

Probing Prior Conceptions

I began the unit with a class discussion to find out students’ ideas about the movement of objects in the sky. I started with general questions: “What do you know about the Sun?” “What do you know about space?” and “Have you ever heard of the word planet?” Then I went further by asking specific questions,
such as “What is the shape of the Earth?” Students were thrilled to share everything they “knew” about the planets, space, and the Earth.

Eagerly, each student waited to tell their thoughts and where they obtained this information. Their answers ranged from simply mentioning the names of planets (“I know there is Venus...”) to specific—though sometimes incorrect—descriptions of the solar system: “The Sun is the largest in the solar system...” and “The Sun goes around the Earth and that is why we have day and night.”

Following our discussion, I asked students to divide a piece of paper into four parts, number each square from one to four, and draw a picture based on the topics discussed in each one. They were to draw:

- A picture of “space” in the first square;
- A picture of the night sky in the second square;
- Any movement of objects (such as planets, Earth, Sun, and Moon) in the sky in the third square; and
- A pictorial (or written) explanation of why daytime and nighttime happen.

### Identifying Misconceptions

When I viewed my students’ drawings, I discovered only two of the 17 students thought the Earth revolves around the Sun; 12 students believed “the Sun goes around the Earth,” and three students did not show any movement of planetary bodies in their pictures. The students who indicated movement either used arrows in the drawing or wrote a short description, such as “The Sun goes around the Earth,” or did both. Others only drew some elements—the Sun, the Earth, rockets, astronauts, and stars—as separate entities.

I also learned that most students believed the Sun’s movement to be the cause of day and night. The most prevalent explanation was “The Sun goes down during the night.” Although a couple of students mentioned that the Earth is moving, none of them differentiated the Earth’s revolution and rotation. They seemed to recite what they had read or heard from other resources but the information they remembered was fragmented.

Throughout these introductory discussions, I paid special attention to the ideas from my four English Language Learners and two learning-challenged students. From previous lessons, I had observed that these students frequently relied on other students’ ideas when crafting their own explanations.

For example, in this lesson, one student provided a clear explanation of her conception following word for word what the child before her had said. When she was asked how she came to know what she reported, she was unable to explain it. She seemed to have adopted a compensation strategy of repeating whatever those around her said.

I believe one factor in this behavior is the student’s fear of getting the answer wrong in front of her peers and teacher. To address this issue, I encouraged students to express their ideas frequently in the discussions and to feel comfortable sharing their ideas. In addition, I tried to be aware of how and to whom I asked questions. I also carefully observed students’ actions and facial expressions and attempted to include all students in class discussions and avoid making judgmental comments.

### Role-play

Next, we conducted a role-play in which students modeled the Earth using a globe and demonstrated how they believed the Sun (represented by a flashlight) moved in the sky. I chose this activity to help those students with kinesthetic learning styles as well as to provide students with an opportunity to model their theories in small, heterogeneous groups. Once the students were in groups, they were asked to demonstrate how they thought the Earth and Sun moved in the sky.

In each small group, students tried to show their ideas about how the Sun and Earth moved and observed how the flashlight shined on the globe. An ideal role-
play was for one student to hold the flashlight still while a student holding the globe spun around. By so doing, students would see how the movement of Earth causes day and night. I made sure each group tried both geocentric (the Sun moving around the Earth) and heliocentric (the Earth moving around the Sun) models.

The small-group climate in the classroom seemed to make the students more comfortable with describing their thinking. The students began modeling their ideas, relating the movement of objects in the sky as the other students listened. The students who hadn’t been able to express their ideas through drawing were able to demonstrate their ideas using the flashlight and globe. During the role-play, some of the students explained what they had drawn in the previous drawing activity. A few students began to modify their explanation in light of what the other students demonstrated and explained.

**Space Slideshow**

In the next science class, students visited the computer room for a lesson about the Earth and the Sun. The purpose of this lesson was to present the students with a discrepant event—in order for the children to correct their misconceptions. They needed to have an experience that would challenge their ideas, and this activity would fit the bill.

Using images from NASA’s Solar System Simulator website (see Internet Resources), I had prepared a slideshow of 12 real-time pictures taken of the Earth from space every two hours during a 24-hour period (Figure 1). The students were first shown the pictures and asked only to view them. Next, they were presented with the same slides containing arrows pointing at the portion of the world where the students reside—I was expecting the students to see the movement of the arrows and attribute that change to the movement of the Earth.

I strategically asked the students only what they noticed about the photographs. One of the students indicated that the Earth must have moved because “the arrow moved.” The student proceeded to explain that the “arrow was off of the Earth in one picture and on the Earth in the other.” By discussing the change in the topographical features of the Earth, as noticed by another student, I was able to guide the discussion to create a discrepant event.

At this time, I questioned students to determine if they were beginning to internalize this understanding of Earth’s movement. Further discussion indicated that the students were seeing that the Earth moves. The fact that the photographs were showing movement of the Earth did not fit into their preconceived notions. Thus, their ideas needed to change. Through guided discussion about the change in the photographs, students were able to reconstruct their ideas.

The students pointed out that in some of the pictures the Earth was illuminated on one half in some pictures and then on a smaller portion in other pictures. I repeated the slideshow to focus students’ attention on the transition of sections of the Earth from daylight to darkness. When asked to provide evidence for the Earth’s rotation, students began to describe the change in terms of what section of the Earth was light, by means of being turned toward or away from the Sun.

Although the slideshow demonstrated only the Earth’s rotation as the cause of day and night, the activity helped prepare the students to accept the idea that the Earth revolves around the Sun, a topic we addressed next. Once students had begun to realize the
Earth’s rotational movement, they were more willing to accept the Earth’s revolution around the Sun when suggested by me through direct instruction.

Students as Self-Evaluators

The unit’s culminating activity was to revisit students’ initial ideas and let them evaluate their learning. This activity would help me confirm students’ conceptual understanding by providing an opportunity for students to reflect on their own thinking (Wittrock 1994).

Students discussed their beliefs at the onset of the unit and how they had changed over time. One example of this was when a student stated in writing that he originally thought the Earth “stayed still” but when he saw the pictures he “changed his mind.” Next, I asked students to pretend they were teachers and make comments on the drawings they had composed on the first day of the unit. They identified whether their ideas were correct or incorrect in relation to what they had learned. For example, one student wrote to herself:

You think the Sun goes around the Earth. You are wrong. The Earth goes around the Sun. That is called orbit. And you know that the Earth spins around when it goes around the Sun and that is why we have day and night. It looks like this…

This response was typical of the students’ self-evaluations.

Despite the language barrier, the English Language Learners were able to use the pictures, by viewing and by drawing, both as a catalyst for change and to demonstrate a change in thinking. For the students identified as learning-challenged, however, reliance on classmates may still have been a factor in their conceptual change. For this type of student, it may be necessary to ask students for explanations of the reasons for their ideas at many times in the lesson to get a better sense of what they know.

Positive Outcomes

I was pleased with the results of the series of teaching strategies used to introduce students to these ideas about the Earth and Sun. Throughout the unit, students were excited about sharing their ideas, making pictorial representations of their ideas, role-playing, and evaluating their original thoughts.

In particular, having students compare past and current ideas seemed to be the most critical part of the lesson. Revisiting their ideas allowed students to connect new ideas to their existing knowledge and replace misconceptions with scientific ideas. It also informed me about the effectiveness of my teaching, by allowing me to see each student’s growth in terms of correcting their misconceptions in many different forms, such as drawing and role-play.

The success of this unit suggests the importance of starting lessons by identifying what students know and challenging students’ naïve ideas with various activities. Most of all, letting students evaluate their learning by examining how their ideas have changed is a critical aspect of students’ meaningful learning. With these factors, students will conceptually understand scientific ideas and truly know what they know.

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Resources


Internet

NASA Solar System Simulator

space.jpl.nasa.gov