NGSS FOR ALL STUDENTS

OKHEE LEE • EMILY MILLER • RITA JANUSZYK

EDITORS

NSTA press
National Science Teachers Association

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NSTApress
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Arlington, Virginia

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19 18 17 16 5 4 3 2

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Library of Congress Cataloging-in-Publication Data
NGSS for all students / [edited by] Okhee Lee, Emily Miller, and Rita Januszyk.
pages cm
ISBN 978-1-938946-29-5 -- ISBN 978-1-68140-158-4 (e-book)
1. Next Generation Science Standards (Education) 2. Science—Study and teaching—United States. I. Lee, Okhee, 1959- editor of compilation.

LB1585.3.N53 2015
507.1'073—dc23

2015001209

Cataloging-in-Publication Data for the e-book are also available from the Library of Congress.
e-LCCN: 2015012818

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Okhee Lee is a professor in the Steinhardt School of Culture, Education, and Human Development at New York University. Her research areas include science education, language and culture, and teacher education. Her current research involves the scale-up of a model of a curricular and teacher professional development intervention to promote science learning and language development of English language learners. She was a member of the writing team to develop the *Next Generation Science Standards* (*NGSS*) and leader for the *NGSS* Diversity and Equity Team through Achieve Inc. She is also a member of the Steering Committee for the Understanding Language Initiative at Stanford University.

Emily Miller is a practicing teacher and a member of the *Next Generation Science Standards* (*NGSS*) Elementary and Diversity and Equity writing teams. She has taught science as an ESL/bilingual resource science specialist at a Title I school for 17 years. She has used the *NGSS* in her own classroom and improved and refined teaching to the standards with her students. She is consulting with the Wisconsin Center for Educational Research to develop teacher tools that promote sense making and language learning for English language learners in science. She authored or coauthored an *NGSS* culturally responsive engineering grant, a school garden curriculum grant, and a culturally and linguistically responsive teacher training grant for her school district. Currently, she is pursuing a PhD at the University of Wisconsin–Madison.

Rita Januszyk is a retired fourth-grade teacher from Gower District 62 in Willowbrook, Illinois. Her responsibilities have included teaching in grades K–5 and serving as the district's science coordinator and enrichment coordinator. She received a bachelor's degree in biological science from the University of Illinois at Chicago, served as a scientific assistant at Argonne National Laboratory, and received a master's degree in elementary education from Northern Illinois University. More recently, she was a member of the *Next Generation Science Standards* (*NGSS*) writing team and member of the *NGSS* Diversity and Equity Team through Achieve Inc. She is also a writer on the middle school team for the Illinois State Board of Education Model Science Resource Project.

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PREFACE

OKHEE LEE

The *Next Generation Science Standards* (NGSS Lead States 2013) are being implemented when critical changes in education are occurring throughout the nation. On one hand, student demographics across the country are changing rapidly and teachers have seen the steady increase of student diversity in the classroom, while achievement gaps in science and other key academic indicators among demographic subgroups have persisted. On the other hand, the *NGSS* and the *Common Core State Standards* (CCSS), in English language arts and mathematics are spreading. As these new standards are cognitively demanding, teachers must make instructional shifts to prepare all students to be college and career ready. Furthermore, as the standards are internationally benchmarked, the nation's students will be prepared for the global community.

The *NGSS* offer both opportunities and challenges for educators in enabling all students to meet the more rigorous and comprehensive standards set forth by the *NGSS*. The *NGSS* indicate performance expectations of students by blending science and engineering practices, crosscutting concepts, and disciplinary core ideas. Most science teachers are unaccustomed to teaching for three-dimensional learning and will be compelled to make adjustments in their instruction.

The *NGSS* have addressed issues of diversity and equity from the inception. The *NGSS* Diversity and Equity team takes the stance that the standards must be made accessible to all students, especially those who have traditionally been underserved in science classrooms, hence the title "All Standards, All Students." Through the two-year process of the *NGSS* development, the team completed four major charges: (1) bias reviews of the *NGSS*, (2) Appendix D on diversity and equity, (3) inclusion of the topic of diversity and equity across appendixes, and (4) seven case studies of diverse student groups.

Within the broader scope of the team's charges, this book focuses on the seven case studies written by the team members who are classroom teachers. The case studies are an attempt to pilot the vision presented in *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (hereafter referred to as the *Framework*; NRC 2012) and the *NGSS* with respect to diverse student groups across grade levels and science disciplines. These case studies illustrate how teachers blend the three dimensions of the *NGSS* with effective classroom strategies to ensure that the *NGSS* are accessible to all students. Furthermore, they provide practical and tangible routes toward effective science instruction with diverse student groups.

Each case study consists of four parts. First, it starts with a vignette of science instruction to illustrate learning opportunities through effective classroom strategies and connections to the *NGSS* and *CCSS ELA* and *CCSS Mathematics*. The vignette emphasizes what teachers *can do* to successfully engage students in meeting the *NGSS*. Second, it provides a brief summary of the research literature on effective classroom strategies for the student group highlighted in the case study. Third, it describes the context for the student group—demographics, science achievement, and educational policy. Finally, it ends with an *NGSS*-style foundation box for a user-friendly review of the *NGSS* and the *CCSS* that were taught in the vignette.

The vignettes in the seven case studies were modeled after those of *Ready, Set, Science! Putting Research to Work in K–8 Science Classrooms* (Michaels, Shouse, and Schweingruber 2008)—which is a companion to *Taking Science to School: Learning and Teaching Science in Grades K–8* (NRC 2007)—as a precursor to the *Framework*. Both sets of vignettes authenticate ideas about science education through classroom trials. However, the vignettes in this book differ in several ways: (1) they represent seven diverse demographic groups of students within the same volume; (2) they illustrate the blending of science and engineering practices, crosscutting concepts, and disciplinary core ideas; (3) they include research-based classroom strategies to improve access of diverse student groups to the NGSS; (4) they are extensive, ranging from two weeks of science instruction to an entire school year; and (5) they span K–12 grade levels and include all science disciplines.

While the book focuses on the seven case studies, we expand its scope by including seven additional chapters. The book begins with contributions by Stephen Pruitt (Chapter 1), Helen Quinn (Chapter 2), and Andrés Henríquez (Chapter 3). Then, we describe the team's charges (Chapter 4) and our conceptual framework to guide the readers in how to interpret and apply the case studies across classroom contexts (Chapter 5). The main body of the book includes the seven case studies (Chapters 6 through 12), to be followed by professional development considerations and a reflection guide for each case study. Next, we offer suggestions about how teachers can draw from case studies to inform their unit design by incorporating important shifts to support student learning (Chapter 13). Finally, Joe Krajcik, in collaboration with Emily Miller, introduces a teaching rubric that assists reflection on three-dimensional learning and focuses on equity (Chapter 14). By keeping a balance between the case studies and chapters, we maintain the integrity of the *NGSS* work on the case studies while further enhancing the team's work to make it more relevant and applicable to the broader education system.

The book makes significant contributions in several ways. First, the case studies in the book are an integral part of the development of the *NGSS*. Content standards across subject areas are written for all students, but the specific opportunities and demands that are extended to diverse student groups through rigorous standards have never been similarly addressed. Second, educational research tends to address diverse groups separately but not collectively as this book does. Third, the book benefits from the combination of teacher, expert, and "teacher-as-expert" voices. Teacher-practitioners offer invaluable insights into implementation of the *NGSS* with diverse student groups, adding authenticity to the claim of utility for science educators. Finally, the book provides the context for each student group in terms of demographics, science achievement, and educational policy.

This book is intended for K–12 science educators, science supervisors, leaders of teacher professional development, education researchers, and policy makers. The primary audience of the book is classroom teachers. We encourage them to make instructional shifts in implementing the *NGSS* with diverse student groups who have historically not met district and state goals in science. In addition, this book is intended for science supervisors and professional development providers to offer support systems for classroom teachers. Furthermore, this book serves as a guide for teachers, supervisors, or professional development providers to design action plans for the *NGSS* implementation with diverse student groups. Through this publication, the case studies may reach a broad audience and initiate dialog about how to enable all students to achieve the academic rigor of the *NGSS*.

We would like to acknowledge many individuals who contributed to this book. First of all, we appreciate those individuals who contributed to the case studies:

1. *Economically Disadvantaged Students:* Rita Januszyk wrote the case study. The vignette is based on the video of the teaching of Bethany Sjoberg, Highline Public Schools, Seattle, WA. The video came from Windschitl, M., J. Thompson, and M. Braaten (2008–2013). *Tools for ambitious science teaching.* National Science Foundation, Discovery Research K–12, *http://tools4teachingscience.org*. Joseph Krajcik and Cary Sneider, both *NGSS* writing team members, collaborated on the vignette.
2. *Students From Racial and Ethnic Groups:* Emily Miller wrote the case study. She worked with Susan Cohen, a middle school science teacher at Madison Metropolitan School District and planned the curriculum with Leith Nye, Great Lakes Bioenergy Resource Center, Wisconsin.
3. *Students With Disabilities:* Betsy O'Day, *NGSS* Diversity and Equity Team member, wrote the case study.
4. *English Language Learners:* Emily Miller wrote the case study. She planned the unit with Nick Balster, University of Wisconsin–Madison, and taught the unit with her team members Stacey Hodkiewicz and Kathy Huncosky, Madison Metropolitan School District, Wisconsin.

5. *Girls:* Emily Miller wrote the case study. The vignette is based on the teaching of Georgia Ibaña-Gomez, School District of Cambridge, Wisconsin, and curriculum planning with Cheryl Bauer Armstrong from the Earth Partnership for Schools at the University of Wisconsin–Madison. Cary Sneider, *NGSS* writing team member, collaborated on the vignette.
6. *Students in Alternative Education:* Bernadine Okoro, a member of the *NGSS* Diversity and Equity Team, wrote the case study in collaboration with Emily Miller.
7. *Gifted and Talented Students:* Rita Januszyk wrote the case study.

In addition to Betsy O'Day and Bernadine Okoro, we also would like to acknowledge Jennifer Gutierrez and Netosh Jones, two additional members of the *NGSS* Diversity and Equity Team.

We would like to acknowledge the support of the editorial team members of NSTA Press. Claire Reinburg has guided us from the inception of the book proposal along with Wendy Rubin, Managing Editor, and Andrew Cooke, Senior Editor, who have provided valuable editorial support. We would also acknowledge Ted Willard, NGSS@NSTA Program Director, for his encouragement and vision. Finally, we would like to acknowledge Bilal Dardai, who provided excellent editorial assistance of the draft manuscript.

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CHAPTER 8

STUDENTS WITH DISABILITIES AND THE *NEXT GENERATION SCIENCE STANDARDS*

MEMBERS OF THE *NGSS* DIVERSITY AND EQUITY TEAM

ABSTRACT

The percentage of students identified with disabilities in schools across the nation is currently around 13%. As a result of the Elementary and Secondary Education Act (ESEA), school districts are held accountable for the performance of students with disabilities on state assessments. Although students with disabilities are provided accommodations and modifications when assessed, as specified in their Individualized Education Plans (IEP), achievement gaps persist between their science proficiency and the science proficiency of students without disabilities. The vignette below highlights effective strategies for students with disabilities: (1) multiple means of representation, (2) multiple means of action and expression, and (3) multiple means of engagement. These strategies support all students' understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts as described by the *Next Generation Science Standards* (*NGSS*).

VIGNETTE: USING MODELS OF SPACE SYSTEMS TO DESCRIBE PATTERNS

While the vignette presents real classroom experiences of *NGSS* implementation with diverse student groups, some considerations should be kept in mind. First, for the purpose of illustration only, the vignette is focused on a limited number of performance expectations. It should not be viewed as showing all instruction necessary to prepare students to fully understand these performance expectations. Neither does it indicate that the performance expectations should be taught one at a time. Second, science instruction should take into account that student understanding builds over time and that some topics or ideas require extended revisiting through the course of a year. Performance expectations will be realized by using coherent connections among disciplinary core ideas, science and engineering practices, and crosscutting concepts within the *NGSS*. Finally, the vignette is intended to illustrate specific contexts. It is not meant to imply that students fit solely into one demographic subgroup, but rather it is intended to illustrate practical strategies to engage all students in the *NGSS*.

INTRODUCTION

There are five sixth-grade classes at Maple Grove, the only middle school in a small rural school district. Approximately 10% of the K–12 school population receives special education services. The school has about 480 students in grades 6–8. The district population consists of 1,320 students: 92.3% white, 3.6% African American, 2% Hispanic, 0.5% Asian, and 0.3% Native American; 34% are classified as low socioeconomic status.

The incidence rates of identified special education students in the district are highest in the categories of specific learning disabilities (2.4%) and other health impairments including ADD/ADHD (2.7%). In addition, 1.1% of students are in the category of "speech impaired," 1.4% "language impaired," 0.8% "intellectual disabilities," and 0.8% "autism."

There are special education students in each of the sixth-grade classes with Individualized Education Plans (IEPs) that specify the accommodations and modifications when participating in the regular education classroom. Mr. O. thinks about potential barriers that any of his students, including those with special needs, may have to the planned instruction. Then he adjusts instruction to overcome those barriers. Often, changing an approach to accommodate barriers makes instruction more effective for all students. The students with disabilities, along with their regular education peers, receive science instruction from the science teacher five days a week for 50 minutes each day. Most of the identified students receive instruction in reading/language arts and mathematics in a coteaching model. Some students receive additional pullout services in those content areas or in social skills.

In the lesson sequence in this vignette, Mr. O. uses multiple means of representations for Moon phases—Stellarium (planetarium software), Styrofoam balls, a lamp, golf balls, and foldables (three-dimensional interactive graphic representations developed by Zike). Mr. O. provides additional practice for students who may need it, such as placing cards with Moon phases in chronological order and then identifying each phase. He modifies assignments for students with intellectual disabilities as mandated by their IEPs. In addition, strategic grouping of students provides support for struggling students, including special education students. Throughout the vignette, classroom strategies that are effective for all students, particularly for students with disabilities according to the research literature, are highlighted in parentheses.

SPECIAL EDUCATION CONNECTIONS

Jeanette and Nicole have intellectual disabilities; they have a paraprofessional who accompanies them to selected regular education classrooms, providing instructional support. Nicole is identified with socio-emotional disability and receives special education services for both language arts and mathematics. Kevin is diagnosed with autism, exhibits difficulties in social skills, and is cognitively high functioning. Hillary and Brady have specific learning disabilities and receive special education services for both language arts and mathematics. Jeff is also identified with specific learning disabilities and receives services for language arts. His math skills are advanced for his grade level. All of these students are part of the diverse community of learners working toward three-dimensional scientific understanding of the Earth-Sun-Moon relationship, as described in this vignette.

Exploring the Earth-Sun-Moon Relationship

Mr. O. initiated the unit by asking students to open their notebooks, write the numbers 1–8 down the next blank page, and title the page "Relative Diameters?" On the interactive whiteboard, he projected a slide from a multimedia presentation *Two Astronomy Games* that showed nine images, each identified by a letter and a label (Morrow 2004). The images were the Sun, Earth, a space shuttle, the Moon, the solar system, Mars, a galaxy, and Jupiter. Students were asked to number the objects in order from smallest (number 1) to largest (number 8) and from nearest to the surface of the Earth to farthest from the surface of the Earth. He planned to have students come back to this page later. Kevin seemed pleased and announced, "I love to study space!"

With a standard-size playground ball in hand, Mr. O. asked the class to imagine the ball was Earth and he wrote down the class' consensus of the ball's dimensions that they had figured out in math class. Then he presented the class with a box of seven balls in a variety of sizes and listed their dimensions on the interactive whiteboard. He asked: "If Earth was the size of this playground ball, which of these balls would be the size of the Moon?" One student (from each table) came up and chose the ball they thought would be correct. Their choices varied from a softball to a small marble. Before going further, the class reviewed the term *diameter* and Mr. O. asked, "If you know that Earth's diameter is 12,756 kilometers and the Moon's diameter is 3,476 kilometers, with your table groups, come up with a method to see if the ball you chose is the right size for this size Earth [holding up the playground ball]" (practice: Using Mathematics and Computational Thinking) (CC: Scale, Proportion, and Quantity).

After some discussion time, students reported their calculations. One group noticed that there was a proportional relationship in the diameters of approximately 1:4, Earth to Moon. A student asked how they made that determination. Jeff responded, "If you estimate using 12,000 and 3,000, three goes into twelve four times." He showed on the interactive whiteboard how four circles of the Moon fit across the diameter of the Earth. Mr. O. said, "Now think of your ball as a representation of the Moon and decide if you think it is the correct size. What can you do to be sure? Decide on a process." He let them use the playground ball as needed (DCI: MS-ESS1.A Earth's Place in the Universe).

Each group reported their findings and methods for determining whether or not their choice would be correct. One group made lines on paper where the endpoint of their ball was and did the same for the playground ball. Using those measurements and the 1:4 ratio, they decided if their Moon was the correct size. Another group used string to measure the diameter of the balls and then determined whether or not it was correct. Still another group held their ball up against the playground ball and moved their ball four times while marking the playground ball with a finger to see if their ball was the correct size for the model of Earth.

The groups reported their findings. Kevin was agitated as he explained, "I told my group they were not right. The racquetball is the only one that is possible as the Moon, but they wouldn't believe me." Mr. O. asked Kevin to restate the rule for when his group disagrees. Kevin thought and said, "When my group disagrees, I listen and then tell them what I think."

Only those groups with the racquetball had the correct size for the playground ball. Two of the students from one of those tables came up and showed how far they thought the Moon would be from Earth using the playground ball and racquetball model. Several students disagreed with the distance shown by the students. Four students came to the front, one by one, and showed their ideas about the distance between Earth and the Moon. Then Mr. O. showed them the actual distance from Earth to the Moon and the circumference of Earth in kilometers. He asked them again to use the new evidence to determine how to figure out the distance in the model and to show it using string. Students were shocked at the distance the Moon was from Earth in this model. Their estimates had been much lower.

As the class finished presenting their arguments for the correct size balls for the Sun and Earth, students considered the relative size of the Sun and the distance of the Sun from Earth in the model. They used the evidence of the diameter of the Sun and its distance from Earth in the same way they determined the size and distance of the Moon from Earth. Some students were surprised at the size of the Sun and its distance from Earth in this model. Jeff decided that they could not fit the Sun in the room. He explained that it would take over 100 playground balls to approximate the Sun's diameter. Jeff was eager to share his mathematical skill at finding the answer: "I know the answer! It would take almost 12,000 playground balls lined up to show how far away the Sun would be in this model." Two students nonchalantly said, "That's a lot," and "The Sun is very far away from Earth" (CC: Scale, Proportion, and Quantity).

The students returned to their initial ideas on the "Relative Diameters" page in their notebooks, renumbered the objects, and recorded any ideas that had changed after making the model. After giving students time to write their responses, Mr. O. showed images of the items on the interactive whiteboard and led a discussion of the great distances between objects in the solar system in preparation for modeling the Moon's phases (DCI: MS-ESS1.B Earth's Place in the Universe).

For this lesson sequence, Mr. O. considered the makeup of the table groupings of students. He wanted the special education and other struggling students to have support while determining methods to check their choice of the Moon model, so he grouped students with that concern in mind. He used physical representations of Earth and the Moon and had students represent the distance physically, thereby assisting them in visualization and comprehension. *(The strategy of providing multiple means of representation was important to support understanding for his special education students, but it also benefited all of his students.)*

Exploring Moon Phases

Mr. O. showed how the Moon's and Earth's orbital planes are offset by 5 degrees in an effort to help students understand how light can illuminate the Moon when it is on the other side of Earth without being blocked by Earth's shadow. Throughout this instruction the special education students were strategically placed at tables in groups that would support their engagement in the content and activity.

Mr. O. downloaded an open-source planetarium program onto his whiteboard-connected computer as well as onto the 14 student computers he had in his classroom. On the first day of Moon phase instruction, each student received a one-page Moon calendar similar to one they took home. The students who had completed the calendar kept it out to compare their observations to the data collected using the software. Mr. O. launched the program on the interactive whiteboard, introduced the students to the software, and showed them how to change the date and set up the scale Moon so they could see the phases.

Recording began on the first Sunday on the calendar and ended on the last Saturday, resulting in five weeks worth of data to analyze (practice: Analyzing and Interpreting Data). Mr. O. modeled how to record the data on the whiteboard next to the interactive whiteboard. Students recorded the time and location of moonrise and moonset as well as the apparent shape of the Moon in the sky for each date. To make sure that students understood the process and were recording accurately, he walked through the room and checked student work throughout the lesson. Also during this modeling process, the students paid attention to the Sun-Moon relationship so they could see the light from the Sun traveling in a straight line to the Moon. The Moon was in the sky as the Sun was rising, and they focused on the Moon so that they could use the model for predictions. Mr. O. asked, "Does anyone know where the Sun is right now?" Brady responded, "It's more to the east and still rising." Using the time and date function in the program, he advanced the time to show the sunrise and said, "Look at the Sun and Moon. What pattern do you notice about the light on the Moon in relation to the Sun?" (CC: Patterns). Hillary answered, "It is going from the Sun to the Moon." Mr. O. responded, "Hmm. The light travels in a straight path from the Sun to the Moon. You have already learned that light travels in a straight line. Can we use that information to predict the position of the Sun even if we can't see it? Let's try as we continue."

After a few days' worth of data were collected, Mr. O. asked students to predict the time and direction for moonrise and moonset and brought their attention to the patterns in the data. He asked, "What time do you think the Moon will set on this day? The last time was 12:09." Mark said, "I think 12:59." Mr. O. advanced the time until the Moon set—at 13:08. Jeff called out, "So it is setting about an hour later each time." A student said, "So let's see if that pattern continues the whole month." Once the students had a foundation for data collection (about 8–10 days), they went to the computers in partners so they could work more independently to complete the data collection on the calendar.

Mr. O. wanted some control over the assignment of partners to provide support for students who needed it and to challenge more advanced students, so he predetermined the partners and assigned them before sending them to the computers. Jeanette and Nicole worked with their paraprofessional. As a modification to recording the data, they were given a calendar with a set of Moon phase images. As they worked with the paraprofessional, Jeanette said, "When do we write the answer?" Nicole answered, "You have to wait and look at Stellarium and glue the picture." The paraprofessional redirected Nicole and made sure that the directions were understood: Match the image to the one on Stellarium and glue it on the calendar for each day. They did not record the moonrise and moonset times. Hillary, Jeff, and Brady were each paired with a partner whose academic abilities were a little higher than their own, allowing them to receive some support from the partner. Kevin was paired with someone at the same ability level who would be patient with his unique social skills. Kevin enthusiastically stated, "I love science and I love to learn about space."

While students worked at the computers to complete the calendar, Mr. O. took aside small groups of students to do an activity in which they modeled Moon phases using Styrofoam balls, their heads, and a lamp with a bare bulb. Students stood in a circle around the lamp representing the Sun, holding a Styrofoam ball on a stick representing the Moon. They held the ball at arm's length and rotated their bodies using their heads as a representation of Earth so they could see the Earth view of the Moon in all its phases in the lit portion of the ball. The students went through the phases, naming each one and making sure that all students could see the lit portion on the Styrofoam balls for each phase.

Jeanette kept turning the wrong way as she looked at the student across from her. "Is this the way?" she asked, as Mr. O. gently helped direct her turn. Nicole was focused on the computer groups, so Mr. O. directed Nicole to look at the Styrofoam ball and the changing shadow. "What? I don't see the shadow," she said. Mr. O. pointed out the curve of light on the Moon. "I see it!" Nicole said.

Small groups allowed Mr. O to make sure that all students were able to accurately illustrate the phases in the model, giving him the opportunity to physically move them into position as necessary. In addition, he kept students from the first group who he felt might need more time with the model in the second group for more practice if needed.

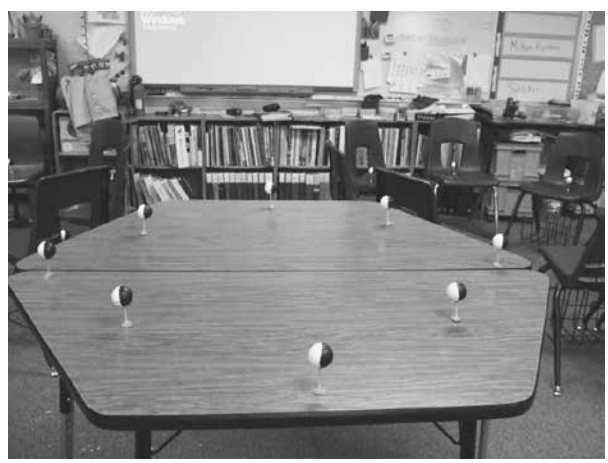
The students collaborated to explain how the model of the Moon phases illustrated changes in the apparent shape of the Moon. They discussed limitations of the models—the things that a model is unable to show accurately. The students identified the relative sizes of the Sun, Earth, and Moon as well as the relative distances between each as being inaccurate in this model (practice: Developing and Using Models).

To finish the class period, all students were at the computers working with Stellarium and their calendars. Mr. O. walked around the room assisting students with their data collection. Jeanette called Mr. O. over and quietly said, "I lost the Moon and can't find it." He showed her how to search for it using the "find" function. Many of the students had changed the dates, so he stopped the class to note, "Many of you have found that this program shows future dates." To reinforce the language Mr. O. had used on many occasions throughout the unit, he asked, "What does that tell us about the planets and the Moon? They all move …" and students responded, "… in predictable patterns."

Over the next two days while students continued working on their calendar with Stellarium, Mr. O. again pulled small groups of students to use another model showing Moon phases (practice: Developing and Using Models). This one used golf balls that were painted black on half of the sphere, leaving the other half showing the side of the Moon lit by the Sun (Young and Guy 2008). The golf balls were drilled and mounted on tees so they would stand up on a surface. Mr. O. had two sets—one set up on a table that showed the Moon in orbit around the Earth in eight phase positions as the "space view" model (Figure 8.1), and the other with the model Moons set on eight chairs circled in the eight phase positions to show the "Earth view" model

FIGURE 8.1.

SPACE VIEW MODEL



First, students were shown the space view model and asked what they noticed about the Moons. Mr. O. wanted them to notice that the white sides of all the balls (showing light) faced the same direction. He asked them to identify the direction of the Sun. Nicole was looking toward the window, and Mr. O. asked her, "Nicole, where is the Sun in our model here in the classroom?" Nicole looked around and responded, "Over here, I think, because that's where the lit up sides are facing."

Then Mr. O. drew the students' attention to the model on the chairs, the Earth view model. All the balls in this model faced the same direction as those in the space view model. Students again identified the direction of the Sun and noted that the position of the Moons in both models was the same (DCI. MS-ESS1.A Earth's Place in the Universe). One at a time, students physically got into the center of the circle of chairs and viewed the phases at eye level (Figure 8.2, p. 90), which simulated the Earth view of each phase. (*Providing multiple means of action and expression is one of three principles of Universal Design for Learning.*)

FIGURE 8.2.

THE EARTH VIEW MODEL

Each of the students with Individualized Education Plans (IEPs) was put in a different small group, with the exception of Jeanette and Nicole, who were in the same small group. Their turn inside the circle was last, giving them the opportunity to observe, listen, and practice while verbalizing the phases and location of the Sun within the system. This activity made the diagram, often found in books and worksheets showing both views on the same diagram, less confusing to the students.

Although most students were not finished with the calendar, Mr. O. brought all students together the next day to create a foldable showing the Earth view of the Moon phases similar to diagrams found in books. Students created their Moon phases using eight black circles and four white circles, cutting the white circles to make two crescent Moons, two gibbous Moons, and two quarter Moons. The white circle pieces were placed on the black circles to create the phases, and later glued on the foldable. Jeanette was unsure of the placement of the pieces. "Where does this one go?" Jeanette asked referring to the gibbous Moons, which were incorrectly placed. "Look at mine. I'm right," said Nicole who also had confused the two phases. As he walked around the room checking student work, Mr. O. gently pointed out the lit side of the Moon and asked which phase that represented. Inside the foldable, students drew a large circle to represent the Moon. (*Providing multiple means of representation is one of the three principles of Universal Design for Learning.*)

They partnered to read *The Moon* by Seymour Simon (2003). Students used the information in the book to label the Moon phases on their foldable, write about the Moon's surface, and record any new questions that arose from their reading. Kevin asked, "When is the next solar and lunar eclipse?" Jeanette questioned, "What samples were brought back from the Moon?" And Nicole wanted to know, "Where did Americans land on the Moon?"

To support their reading of the text, Hillary, Brady, and Jeff were given the option of being paired with students who had more advanced reading skills or using Mr. O.'s recordings made on handheld computers. Jeanette and Nicole had the support of their paraprofessional in reading and obtaining information from the text. Mr. O. asked Kevin, "What would you prefer?" He answered, "Oh, I think this time I want to read by myself because I love space and want to find out more about the Moon." As students finished their reading and writing, they went back to finish their calendars using the software.

Students finished the calendar at different rates. When finished, they checked their work against the calendar that Mr. O. had completed. Since several pairs finished at the same time, he grouped the pairs to discuss the patterns they noticed in their calendars. He gave them a list of questions to guide their discussion and asked them to conference with him when they were finished. (*Providing multiple means of engagement is one of the three principles of Universal Design for Learning.*) He expected all students to observe that the lit segment of the Moon's face increased, decreased, and increased again relative to the part in shadow. He also expected students to notice that the lit side of the Moon was on the left after the full Moon phase and on the right after the new Moon phase, as viewed from Earth. Students who finished with all tasks were allowed to use text materials and internet resources to research answers to the questions they developed when reading *The Moon*, while the rest of the students completed their calendars.

Assessing Student Learning

Throughout the lesson sequence, Mr. O. continually assessed students' progression through observations and conferences. If he noticed students needed more experience with Moon phases, he provided them with additional activities such as videos and Moon phase cards. In one formal assessment of understanding, Mr. O. paired students together so that one was assigned to be the Earth and the other the Moon. He designated one wall of the classroom as the Sun and then asked the Moons to show different phases. The students switched roles so that Mr. O. could assess everyone. He also used this model to demonstrate the Moon's coincident rotation and revolution. In another formal assessment, he asked students to draw a model on whiteboards showing the relationship of the Earth, Moon, and Sun in full Moon phase.

NGSS CONNECTIONS

NGSS require that students engage in science and engineering practices to develop deeper understanding of the disciplinary core ideas and crosscutting concepts. This presents both challenges and opportunities to special education students, since a broad range of disabilities impacts their science learning. This vignette highlights examples of strategies that support all students while engaging in science practices and in rigorous content. The lessons give students varied exposure to the core ideas in space science, helping to prepare all students to demonstrate mastery of the three components described in the *NGSS* performance expectation. See Figure 8.3 (p. 95) for the comprehensive list of *NGSS* and *CCSS* from the vignette.

Performance Expectations

MS-ESS1-1 Earth's Place in the Universe
Develop and use a model of the Earth-Sun-Moon system to predict and describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.
MS-ESS1-3 Earth's Place in the Universe
Analyze and interpret data to determine scale properties of objects in the solar system.

Disciplinary Core Ideas

ESS1.A The Universe and Its Stars
Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models.
ESS1.B Earth and the Solar System
The solar system consists of the Sun and a collection of objects, including planets, their Moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them.

Science and Engineering Practices

Developing and Using Models
Develop and use a model to describe phenomena.
Analyzing and Interpreting Data
Analyze and interpret data to determine similarities and differences in findings.

Students were engaged in a number of science practices with a focus on Developing and Using Models and Analyzing and Interpreting Data. Space science lends itself well to the use of models to describe patterns in phenomena and to construct explanations based on evidence. With guidance from their teacher, students used the ratios of the diameters of Earth and its Moon to construct a class model of the relative sizes of the two objects. Using distance and Earth's diameter or circumference ratios, they also constructed a distance model of those objects. In addition, the relative size of the Sun and the relative distance from Earth in this model was calculated and described, although not constructed (due to the constraints of the room and location). Throughout the vignette, a variety of models were used to help students identify patterns in the relative positions of the Earth, Moon, and Sun, and to explain Moon phases.

Crosscutting Concepts

Patterns
Patterns can be used to identify cause-and-effect relationships.
Scale, Proportion, and Quantity
Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Students made predictions about the data collected and recorded them on the calendar, using the lens of the crosscutting concept of Patterns. When analyzing and interpreting the data, they identified the patterns in the Earth-Sun-Moon relationship. The pattern made by the lit portion of the Moon was observed and recorded. In addition, students considered the crosscutting concept of Scale, Proportion, and Quantity as they constructed models of relative sizes and distance of the Sun and planets.

CCSS CONNECTIONS TO ENGLISH LANGUAGE ARTS AND MATHEMATICS

Students used the text in *The Moon* (Simon 2003) to label each phase of the Moon and summarize information about the surface of the Moon in their graphic organizer foldable. This reading and writing connects to the *CCSS ELA*:

- **RST.6-8.1** *Cite specific textual evidence to support analysis of science and technical texts.*
- **WHST.6-8.2** *Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.*

When comparing sizes and distances, students were challenged to find ways of comparing numbers, applying the *CCSS Mathematics* MP.1. In addition, students used rounding and estimation to calculate the quotients in the ratios, both skills developed in earlier grades and used again in fifth grade, standard 4.OA. Throughout the unit, students reasoned quantitatively as they compared the sizes of the Earth and Moon, standard MP.2. As students made conclusions about which ball was the Moon, they argued for their selection and agreed or disagreed with each other using their calculation, standard MP.3:

- **6.RP.A.1** *Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.*
- **MP.1** *Make sense of problems and persevere in solving them.*
- **MP.2** *Reason abstractly and quantitatively.*
- **MP.3** *Construct viable arguments and critique the reasoning of others.*

EFFECTIVE STRATEGIES FROM RESEARCH LITERATURE

Students with disabilities have IEPs, specific to the individuals, that mandate the accommodations and modifications that teachers must provide to support their learning in the regular education classroom. By definition, accommodations allow students to overcome or work around their disabilities with the same performance expectations of their peers, whereas modifications generally change the curriculum or performance expectations for a specific student (National Dissemination Center for Children with Disabilities 2010). Special education teachers can be consulted to provide guidance for making accommodations and modifications to help students with IEPs succeed with the *NGSS*.

Two approaches of providing accommodations and modifications are widely used by general education teachers in their classrooms. *Differentiated instruction* is a model in which teachers plan flexible approaches to instruction in the following areas: content, process, product, affect, and learning environment (Institutes on Academic Diversity 2009–2012). This vignette highlights Universal Design for Learning as a framework with a set of principles for curriculum development that provides equal access to all learners in the classroom (CAST 2012). The framework supplies a set of guidelines for teachers to use in curriculum planning that is organized around three principles: (1) to provide multiple means of representation, (2) to present multiple means of action and expression, and (3) to encourage multiple means of engagement. Teachers identify barriers that their students may have to learning and then use the framework to provide flexible approaches of instruction. While both differentiated instruction and Universal Design for Learning benefit students with disabilities, they also benefit all students.

FIGURE 8.3.

NGSS AND *CCSS* FROM VIGNETTE

MS-ESS1 Earth's Place in the Universe		
Students who demonstrate understanding can: **MS-ESS1-1.** Develop and use a model of the Earth-Sun-Moon system to predict and describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. **MS-ESS1-3.** Analyze and interpret data to determine scale properties of objects in the solar system.		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
SCIENCE AND ENGINEERING PRACTICES	**DISCIPLINARY CORE IDEAS**	**CROSSCUTTING CONCEPTS**
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to support explanations, describe, test, and predict more abstract phenomena and design systems. • Develop use a model to describe phenomena. **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.A: The Universe and Its Stars** • Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B: Earth and the Solar System** • The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them.	**Patterns** • Patterns can be used to identify cause-and-effect relationships. **Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

***CCSS* Connections for English Language Arts and Mathematics**

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

CONTEXT

DEMOGRAPHICS

The number of children and youth age 3–21 receiving special education services under the Individuals with Disabilities Education Act (IDEA) rose from 4.1 million in 1980 (10% of student enrollment) to 6.7 million in 2005 (14% of student enrollment) (National Center for Education Statistics 2011). By 2009, that number had decreased to 6.5 million (13% of student enrollment). Special education services under IDEA are provided for eligible children and youth who are identified by a team of professionals as having a disability that adversely affects academic performance.

Students with disabilities are also protected under Section 504 of the Rehabilitation Act of 1973, which covers all persons with a disability from discrimination in educational settings based solely on their disability. Section 504 requires a documented plan in which a school provides reasonable accommodations, modifications, supports, and auxiliary aides to enable students to participate in the general curriculum, although it does not require students to have an IEP. Since the implementation of Public Law 94-142 enacted in 1975, there has been concern about disproportionate representation of racial and ethnic minorities, economically disadvantaged students, and English language learners in special education programs (Donovan 2002; U.S. Commission on Civil Rights 2009). While there continues to be a disproportionate number (both overrepresentation and underrepresentation) of different populations of students identified in special education within general and specific disability categories, determining the factors that affect this inequality is difficult and complex.

SCIENCE ACHIEVEMENT

On the National Assessment of Educational Progress (NAEP) in science, the gap in grade 12 scores between students with disabilities and students with no disabilities has persisted at 38 points in 1996, 39 points in 2000, and 37 points in 2005. The grade 8 gap has continually decreased from 38 points in 1996, to 34 points in 2000, and to 32 points in 2005. The grade 4 gap increased from 24 points in 1996 to 29 points in 2000 before it finally decreased to 20 points in 2005. The results indicate two important points. First, while achievement gaps persisted across the three grade levels, patterns of increase or decrease were inconsistent at each grade level. Second, achievement gaps were wider as students advanced to higher grade levels.

In 2009, the NAEP science achievement gaps between students with disabilities (including those with 504 plans) and students with no disabilities were 32 points at grade 12, 30 points at grade 8, and 24 points at grade 4. This confirms that achievement gaps were wider as students advanced to higher grade levels, consistent with results in 1996, 2000, and 2005 described above.

The NAEP did not allow accommodations for students with disabilities prior to 1996. In 1996, some schools were allowed to use accommodations for students with disabilities while others were not allowed to assess the impact on NAEP results. In a continuing effort to be more inclusive, guidelines were developed that specified that students with disabilities should be included in the NAEP assessment. Despite attempts to standardize the inclusion process, exclusion rates vary across states (Stancavage, Makris, and Rice 2007).

Thus, all students with disabilities are not included in the NAEP science assessment, making it difficult to identify accurate achievement gaps between students with disabilities and their peers. In addition, the data are not disaggregated according to disability category, further complicating the process to identify spe cific achievement gaps. The National Assessment Governing Board recommended that NAEP should report separately on students with IEPs and those with 504 plans and should count only students with IEPs as students with disabilities. Prior to 2009, NAEP's "students with disabilities" category included both students with IEPs and students with 504 plans. In 2009, although students with 504 plans received accommodations according to their plans, their scores were reported in the category of students without disabilities.

EDUCATION POLICY

Enacted in 1975, Public Law 94-142, Education for All Handicapped Children Act, mandated the provision of a free and appropriate public school education in the least restrictive environment for children and youth ages 3–21 with disabilities. Public schools were required to develop an IEP with parental input that would be as close as possible to a nonhandicapped student's educational experience. The IEP specifies the types and frequencies of services to be provided to the student, including speech-language; psychological, physical and occupational therapy; and counseling services. It specifies the accommodations and modifications that are to be provided for the student in curriculum, instruction, and assessment. The IEP also described the student's present levels of academic performance and the impact of disabilities on performance.

Students with disabilities are also protected under Section 504 of the Rehabilitation Act of 1973. While special education services under IDEA [IDEA is described in more detail in the following paragraph] are provided for eligible children and youth who are identified by a team of professionals as having a disability that adversely affects academic performance, Section 504 covers all persons with a disability from discrimination in educational settings based solely on their disability. Section 504 does not require an IEP, but does require a documented plan in which the school provides reasonable accommodations, modifications, supports, and auxiliary aides to enable the student to participate within the general curriculum.

In 1990, Public Law 94-142 was revised and renamed Individuals with Disabilities Education Act (IDEA). The most recent revision and reauthorization was completed in 2004 with implementation in 2006. One notable change is the requirement that state-adopted criteria to identify students who have Specific Learning Disabilities (SLD) must not require a severe discrepancy between intellectual ability and achievement; must permit the use of a process based on the child's response to scientific, research-based intervention; and may permit the use of other alternative research-based procedures.

SLD, as a category, has the largest number of identified students and is defined by IDEA in the following way:

> *The term "specific learning disability" means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which disorder may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations … Such term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia … Such term does not include a learning problem that is primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.* (TITLE I/A/602/30)

Under Elementary and Secondary Education Act regulations (ESEA 1965), students with disabilities are monitored for Adequate Yearly Progress (AYP) in the content areas of language arts and mathematics, with increased accountability expected as special education services continue (ESEA Title 1, Part A, Subpart 1. Sect 1111.b.2.C.V.II.cc.). Data on students' science progress are also collected and reported once at the elementary school level, middle school level, and high school level. In 2007, final regulations under ESEA and IDEA were released to allow more flexibility to states in measuring the achievement of students with disabilities (34 C.F.R. Part 200; U.S. Department of Education 2007).

The U.S. Office of Special Education created the IDEA Partnership to promote collaboration among the many national and state agencies and stakeholders dedicated to improving outcomes for students with disabilities. In response to the growing concern about increasing numbers of students identified with learning disabilities, there has been a call for identifying students at risk and implementing scientific, research-based intervention. The response to intervention (RTI) model is an effort to improve early intervention for students while improving learning outcomes and reducing the number of students identified as learning disabled.

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NGSS FOR ALL STUDENTS

It's challenging to teach science well to *all* students while aligning your lessons with the *Next Generation Science Standards (NGSS)*. This unique book portrays real teaching scenarios written by the teachers on the *NGSS* Diversity and Equity Team. The seven authentic case studies vividly illustrate research- and standards-based classroom strategies you can use to engage seven diverse demographic groups:

- Economically disadvantaged students
- Students from major racial and ethnic groups
- Students with disabilities
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- Girls
- Students in alternative education
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Supplementing the case studies are additional chapters to deepen your understanding of the strategies and help you apply what you learn. These chapters address how to design units with the *NGSS* and diversity in mind, apply a rubric to improve your teaching with *NGSS* to diverse student groups, and use the case studies in teacher study groups. Furthermore, leaders behind the *NGSS*—including Helen Quinn, Stephen Pruitt, Andrés Henríquez, and Joe Krajcik—offer their insights and commitments to supporting diversity and equity.

NGSS *for All Students* will help you make the instructional shifts necessary to prepare all of your students for college and careers.

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PB400X
ISBN: 978-1-938946-29-5
9 781938 946295