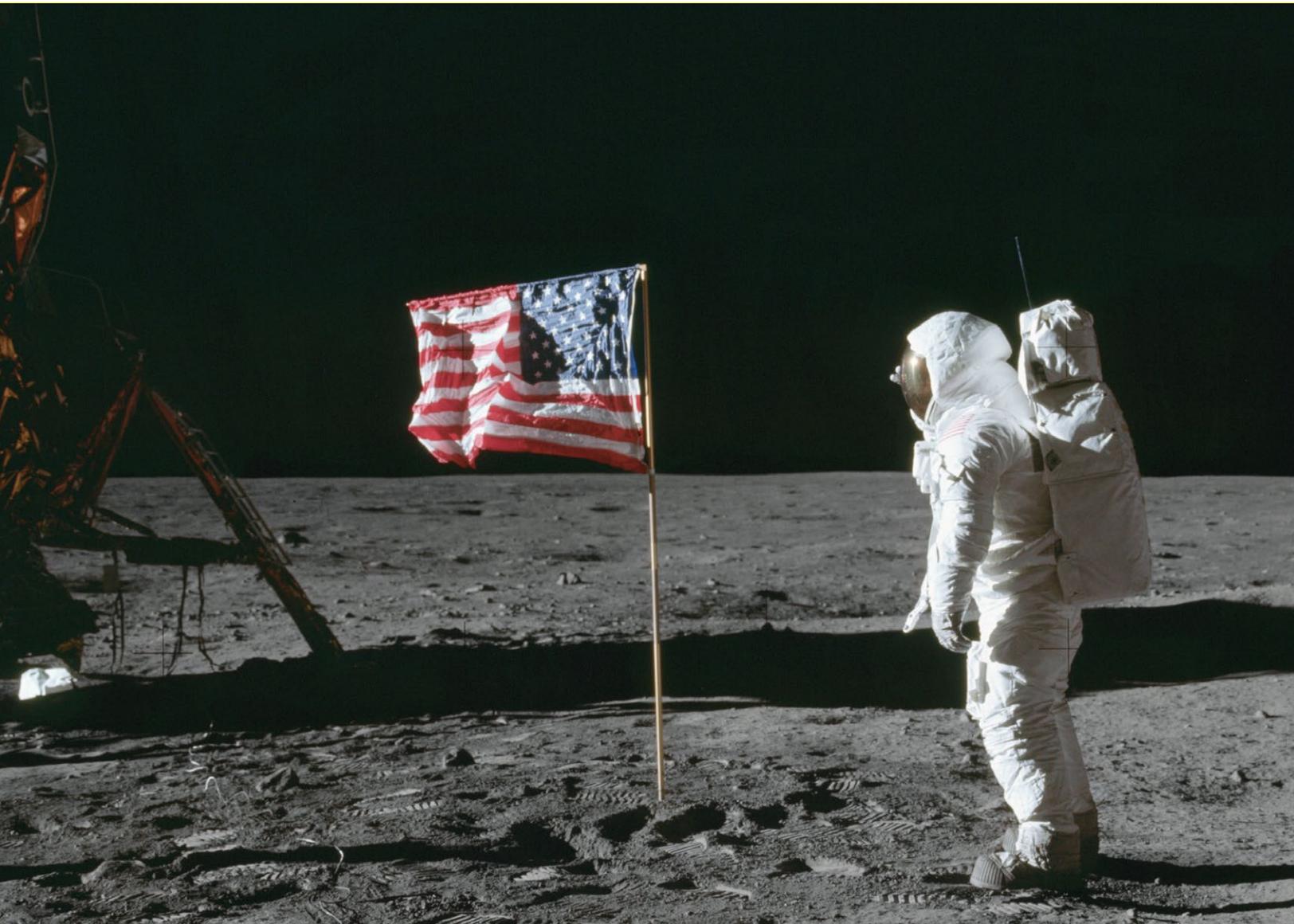


THE EARTH SCIENTIST



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Astronaut Edwin Aldrin poses beside the United States flag on the Moon. Photo Credit: NASA, Johnson Space Center
Photo Date: July 21, 1969 Photographer: Astronaut Neil Armstrong

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From the President

Seasons of Change and Honoring Earth Science Educators

NESTA'S MISSION

To facilitate and advance excellence in Earth and Space Science education.

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Greetings NESTA colleagues!

Fall brings to mind the changing colors of the leaves, the bright lights of a football stadium on Friday nights, the cooling temperatures (well, maybe not in Texas just yet), and the busy schedules a new school year brings to both the educator and the educated. The days get shorter, the nights longer, and holidays provide opportunities to celebrate with loved ones. Fall in my home means new roles, both for my daughter, as a new college freshman, and for my husband and me as almost empty-nesters, exited from the K-12 journey, relinquishing some parental duties while acquiring new ones. In my school, it has also meant my new role as a case manager, in addition to teaching applied sciences to students served by special education. New seasons bring new faculty, new students, new parents, new administrators, and new perspectives, along with new opportunities to share the wonders of our field. In our organization, fall brings new conferences, a new election season, new opportunities to learn, lead, and grow.

Winter brings to mind holidays and the opportunity to reflect. Our roles as Earth science educators are vital and rewarding, though not always immediately recognized. One way in which we honor what you do is at our Friends of Earth Science Reception at the National NSTA Conference, this year in Boston (April 4, 6:30 to 8:30 PM, Harbor Ballroom I & II Room, Westin Boston Waterfront Hotel). At the reception, we recognize excellence in Earth Science teaching through awards from NESTA and our partners. Come see old friends and meet new ones.

Know, dear colleagues, that YOU make a difference, and you are planting seeds for the forest of our planet's future. Each lesson, lab, field trip, and demonstration works to bring that much more awareness to the science that is all around us. I encourage you and others to celebrate our One Earth. Our Future.

Cheers,

Belinda Jacobs

NESTA President 2018-2020

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From the Executive Director

The USGS has as its theme this school year, “Be an Explorer!” They are highlighting [three explorations 100 years apart](#), the 1869 river voyage through the Grand Canyon, the 1969 moon landing, and a hopeful 2069 journey to Mars! This issue of *The Earth Scientist* promotes the theme of exploration and discovery. By exploring the moon, mars, a museum, or the air inside a classroom, students engage in authentic science practices. As you teach and inspire students, think about incorporating “exploration” as a motivating theme and a context for your NGSS “storylines” in your classroom activities.



Earthrise, NASA

Exploring new places can lead to new perspectives and paradigm shifts. On December 24, 1968, Apollo 8 astronauts Frank Borman, Jim Lovell, and Bill Anders became the first humans to orbit the Moon, and the first to witness the magnificent sight called “Earthrise.”

During a live broadcast astronaut Jim Lovell said,

“The vast loneliness is awe-inspiring and it makes you realize just what you have back there on Earth.”

Afterwards astronaut Bill Anders recalling the Apollo 8 Mission said,

“We came all this way to explore the Moon, and the most important thing is that we discovered the Earth.”

One Earth. Our Future. Both of these quotes remind us that exploration can lead to stewardship.

When students explore outdoor spaces, such as national parks, or indoor spaces, such as museums, or when they virtually explore the Moon and Mars, they often come to appreciate the wonder and beauty of our planet and develop a connection to it. NESTA seeks to inspire *all* students to be stewards of our one Earth and to encourage personal choices and public policies informed by scientific data. *Our future depends on this.*

Sincerely,

Dr. Carla McAuliffe

Executive Director, NESTA

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NESTA Awards Presented in St. Louis (3/13/2019)

By Richard Jones

They say that an army runs on its stomach. Well, NESTA runs on its volunteers. The only thing that NESTA can do, to in some way repay its volunteers, is to recognize them publicly with an award—a plaque or a piece of paper, which in essence says “Great Job! Way to Go! Keep up the Great Work! We Couldn’t Do This Without You!” Such a pat on the back is essential to Keeping NESTA running. We depend upon the efforts of our volunteers, and the support of our sponsors to make possible the services we provide. Each year, at the NSTA National Conference on Science Education, NESTA makes a special effort to recognize those who give of themselves for the betterment of NESTA.

While not all awardees or organizations were able to be present this year in St. Louis, the following people and organizations were recognized.

Our most prestigious award, The Jan Woerner & Herold B. Stonehouse Lifetime Achievement Award, is presented every other year, in honor of two of the founders of NESTA, and represents an individual or Organization’s efforts in promoting Earth and Space Science education in keeping with the goals of NESTA. This year, NESTA is proud to recognize two outstanding recipients: Dr. Margret M. Holzer, PhD and Ardis A. Herrold for their lifetime of dedication and service to the Earth and Space Science and the NESTA.

This year we are also honored to present Tina Harte with the Thomas B. Ervin Distinguished Service Award for her steadfast service in the promotion of Earth Science Education and her long service to NESTA. In addition to Tina, NESTA also honored Belinda Jacobs and John-Henry Cottrell with the Thomas B. Ervin Distinguished Service Award.

This year the NESTA presented Certificate of Appreciation to individuals for their continued commitment to Earth Science Education, and to various organizations for Appreciation of their Continuing Support of NESTA Programs that contribute to the wellbeing of NESTA. This year we are proud to Honor Ed Robeck and Eric Pyle for their continued commitment to Earth Science Education. In addition to Ed and Eric, NESTA also honored Manly Midget and Amy Pallant with Certificates of Appreciation.



Recipients of Certificates of Appreciation



NESTA also presented Certificates of Appreciation to:

- Wendy Abshire for the American Meteorological Society (AMS) – In Appreciation of Continuing Support of NESTA Programs
- John Taber for Incorporated Research Institutions for Seismology (IRIS) – In Appreciation of Continuing Support of NESTA Programs
- Don Haas for the National Association of Geoscience Teachers (NAGT) – In Appreciation of Continuing Support of NESTA Programs
- Bruce Moravchik for the National Oceanic and Atmospheric Association’s National Ocean Service – In Appreciation of Continuing Support of NESTA Programs
- Carla McAuliffe for TERC – In Appreciation of Continuing Support of NESTA Programs
- Activate Learning – In Appreciation of Continuing Support of NESTA Programs
- UNAVCO, Inc. – In Appreciation of Continuing Support of NESTA Programs

NESTA Certificates of Service were presented to the following NESTA members who, during the past year, contributed to the well-being of NESTA:

- Cheryl Manning – NESTA Past President 2018-2020
- Belinda Jacobs – NESTA President 2018-2020
- Richard Jones* – NESTA President-elect 2018-2020 and Leadership at NESTA Events at NSTA National and Reno and National Harbor Area Conferences
- Howard Dimmick – NESTA Treasurer, and Merchandise Coordinator 2018-2020
- Missy Holzer* – NESTA Secretary 2018-2020 and for Leadership at NESTA Events at the NSTA.
- Parker O. Pennington, IV* – for service as a Director at Large 2017-2019 and Board Member Representative to the Executive Committee 2018-2019, as well as Rock Raffle Coordinator for all NSTA Conferences.
- Thomas Ervin* – for service as an Appointed Director, Historian, Awards Co-chair, Board Member Representative to the Executive Committee 2017-2019, and unwavering leadership at NESTA Events.

The Earth Scientist

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To become a member of NESTA visit nestanet.org.

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Patty Schuster, Page Designs

Recipients of Certificates of Service



Richard Jones, Missy Holzer, Parker O. Pennington, IV, Tina Harte and Thomas Ervin

- Andrew Boyd – for service as the RegionII Director on the Board of Directors, 2017-2019
- Chris Campbell – for service as the Region IV Director on the Board of Directors, 2017-2019
- Dana Smith – for service as the Region VI Director on the Board of Directors, 2017-2019
- John-Henry Cottrell – for service as the Region VIII Director on the Board of Directors, 2017-2019
- Pradip Misra – for service as a Director at Large 2017-2019 and Board Member Representative to the Executive Committee 2018-2019
- Joe Monaco – for service as an Appointed Director, Volunteer Coordinator 2017-2019 and for Leadership at NESTA Events at the NSTA Area Conference, Reno, Nevada
- Deborah Ezell – for service as an Appointed Director, STEM + Arts = STEAM 2017-2019
- Ardis Herrold – for service as an Appointed Director and Professional Development Chair, 2017-2019
- Michael Passow – for Leadership at NESTA Events at NSTA Area Conferences,
- Tina Harte* – for service as Editor of the E-News and Leadership to the NESTA

A Certificate, and a 2 Year, Honorary NESTA Membership were presented to three Earth Science Teachers who, during the past year, were recipients of the National Association of Geoscience Teachers Outstanding Earth Science Teacher (OEST) Award at the Section and/or State level. We were honored to have Dieuwertje “DJ” Kast, Ben Graves and Ann Robichaux in attendance at the Friends of Earth Science Reception. All OEST Award recipients receive an honorary, two-year membership in NESTA.





Ed Robeck and Sergio deAlba



Wendy Abshire (far right) with DataStreme Program Mentors

In addition to our NESTA Awards, we were also honored to have Sergio deAlba from Los Banos, California present to receive the AGI Edward C. Roy Jr. Award presented by Ed Robeck during the Friends of the Earth Reception.

Wendy Abshire of the American Meteorological Society (AMS) presented Mentoring Awards to the DataStreme Program Mentors present at the reception and Bruce Moravchik, pictured below, of National Oceanic and Atmospheric Association's National Ocean Service program recognized the Planet Steward Alumni present.

The NESTA would like to thank our awardees for their outstanding service and dedication to Earth Science Education. We also encourage you to consider nominating NESTA member(s) for Certificates of Appreciation, Certificates of Service, the Thomas B. Ervin Distinguished Service Award and The Jan Woerner & Herold B. Stonehouse Lifetime Achievement Award. The call for nominations will be announced in Mid-December 2019 and must be submitted by February 15, 2020!



About the Author

Richard Jones is an Associate Professor at the University of Hawai'i at West O'ahu in Kapolei, HI where he currently teaches Geology, Meteorology, and Science Education courses. He has more than twenty years of experience teaching public schools in Wyoming, Hawaii and Montana as a champion for Earth Science. He holds B.S. degrees in Geology and Secondary Science Education and a M.S. in Natural Science from the University of Wyoming and an Ed.D. in Curriculum and Instruction – Science Education from Montana State University. Richard can be reached at rmjones7@hawaii.edu.



1869-1969-2069 Paper Explorer Series from the USGS

This year the theme of the United States Geological Survey (USGS) outreach is “Be an Explorer!”

What do your students think it takes to be an explorer? Where do they want to go? Down an unmapped canyon? To the South Pole? To the moon or to Mars? Encourage them to have fun exploring! Modeled after the idea of Flat Stanley, the USGS has created a series of Paper Explorers.

- Have them download, print out, and color a Paper Explorer and take him or her on an adventure in their neighborhood, in front of a fun photo or map, or on vacation!
- Ask your students to photograph the places he or she goes.
- If desired they can tag USGS on Instagram @USGS_YES and use #paperexplorer, or email a JPEG to us at USGS_YES@usgs.gov. By doing so, students are granting the USGS permission to use the photo in educational materials, in accordance with its social media policy.
- After the Paper Explorer has been on adventures with the student, they can send him or her on adventures with a friend or relative.
- Last, they can send their Paper Explorer to: U.S. Geological Survey, Youth & Education in Science (YES) Program Mail Stop 911, 12201 Sunrise Valley Drive, Reston, VA 20192 and their Paper Explorer may get to be part of the USGS educational materials and web site! Submissions will not be returned.

1869 – Educator, Civil War Major, Geologist, and Explorer **John Wesley Powell** first mapped the Green & Colorado rivers. He later went on to become the second director of the USGS.

usgs.gov/media/files/paper-powell

1969 – **Neil Armstrong** was the first human to walk on the moon and **Dorothy Vaughan** was one of the “human super computers” who was responsible for the calculations for the Apollo missions to be able to safely land (and return from) the moon. USGS scientists at Astrogeology Science Center in Flagstaff trained every person who walked on the moon.

usgs.gov/media/files/paper-neil-armstrong

usgs.gov/media/files/paper-dorothy-vaughan

2069 Paper Explorers – Anyone and everyone! Who will be the first person to walk on Mars? Could it be your student? Stay tuned for the USGS 2069 #paperexplorer and imagine your students as the first to walk on Martian soil!

Be an Explorer!

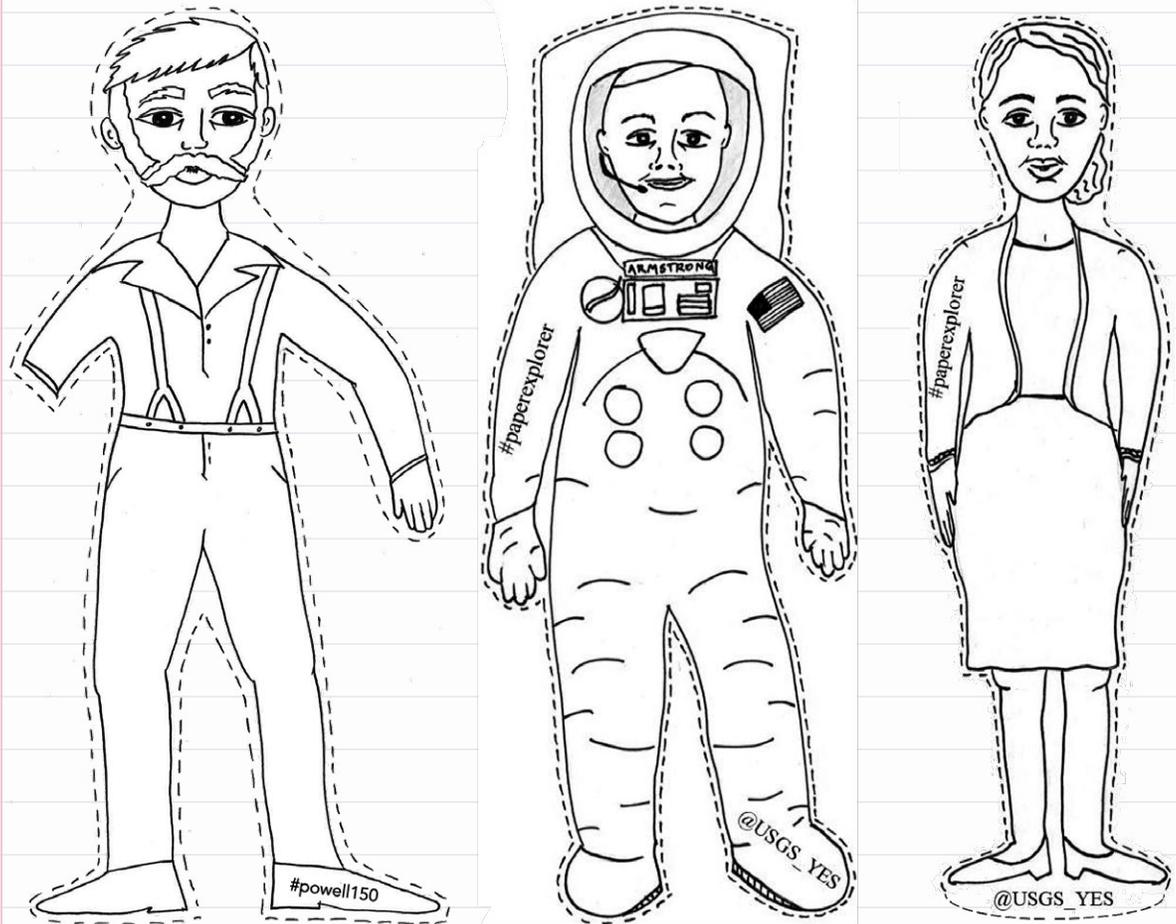


Figure 1. Paper Explorers John Wesley Powell, Neil Armstrong, and Dorothy Vaughan.

U.S. Department of the Interior
U.S. Geological Survey

BE AN EXPLORER

1869-1969-2069



Original art by Tyler Nordgren, used with permission. <https://www.tylenordgren.com/>

USGS Youth and Education in Science
Be an Explorer Campaign
www.usgs.gov/education
www.usgs.gov/BeAnExplorer

@usgs_yes on Instagram

1869: John Wesley Powell, with a crew of nine men, descended the Green and Colorado Rivers, including the unmapped Grand Canyon. He would later become Director of the USGS.

1969: U.S. astronauts were the first explorers to land and walk on the surface of the moon. USGS scientists trained NASA astronauts of Apollo 11 to safely walk on the lunar surface.

2069: As scientists continue to collaborate on the exploration of space, will you help the USGS and NASA discover the mysteries hidden in Valles Marineris, the Grand Canyon of Mars?



TODAY'S TECHNOLOGY

Explore the Moon with NASA's Moon Trek

Moon Trek in an online Web portal allows anyone with access to a computer to search through and view a vast number of lunar images and other digital products. The portal integrates a suite of interactive tools that incorporate observations from past and current lunar missions and enables 3D visualization and fly-overs. Moon Trek can be used by anyone interested in accessing or utilizing lunar data.

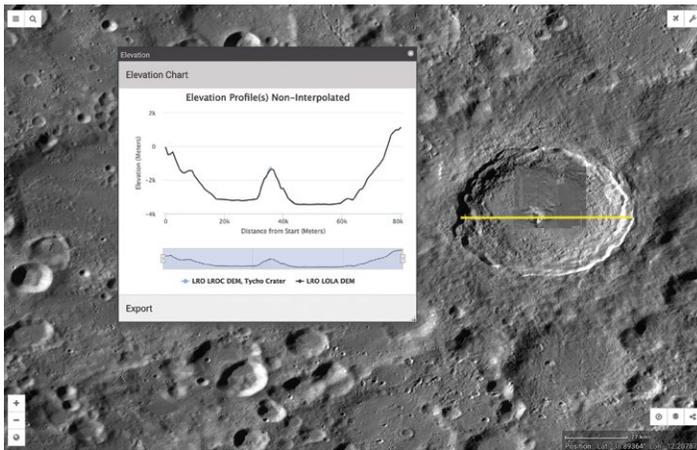


Figure 1. Elevation profile of the Tycho Crater on the Moon

Moon Trek provides easy-to-use tools for browsing, data layering and feature search, including detailed information on the source of each assembled data product. Using Moon Trek, many hundreds of lunar data products can be both visualized, stacked, blended, and downloaded. Its analysis tools allow users to perform a wide range of analyses such as measuring distances, creating elevation plots, and conducting lighting and slope analysis. Users can also draw bounding boxes around any areas of interest to

generate output files for 3D printing of desired surface features.

Take your students on a trip to the Moon with **Moon Trek!** trek.nasa.gov/moon

If you have questions or comments about Moon Trek, please contact trek@jpl.nasa.gov

Table 1. Middle School performance expectation, science and engineering practice, disciplinary core idea, and cross-cutting concepts congruent with Moon Trek explorations and analyses.

Performance Expectation

MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.

Science and Engineering Practices

- Analyze and interpret data to determine similarities and differences in findings.

Disciplinary Core Idea

- ESS1B. 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.

Cross-Cutting Concepts

- 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.



Abstract

Most visitors like to look at dioramas at the American Museum of Natural History in New York City to enjoy the “stuffed animals.” But dioramas provide opportunities to understand and teach about Earth Science processes and locations. The impact of dioramas has been evident since Frank Chapman, Curator of Birds, invited Teddy Roosevelt in 1903 to view the new display about wading birds, which directly led to the establishment of the first National Bird Refuge. Beginning in the 1920s, famed taxidermist Carl Akeley led expeditions to collect African mammals. He encouraged artists to capture true color records of the environment at a time before color photography or movies. The artists utilized techniques dating to the Renaissance to recreate the scenes on curved surfaces of the displays. These can be used to create lesson plans that teach geography, geology, meteorology, and related topics. Students can compare features and processes in the displayed locations with their home communities. They can consider the climate shown when the exhibits were created, what exists now, and what changes may be expected. Online resources allow students to explore displays even if not at the museum, and also learn about their origins and other interesting background concepts.

Introduction

Each day, thousands of visitors to the American Museum of Natural History (AMNH) in New York City learn science as they stand in front of dioramas depicting ecosystems around the world. Every display, large or small, was meticulously created through collaboration amongst scientists, taxidermists, museum specialists, and artists. Family visits, school trips or just online viewing through the Museum’s website provide rich opportunities to teach Earth Science concepts if you “look beyond the stuffed animals.”

The first museum dioramas were created by Carl Akeley at the Milwaukee Museum in the 1880s (1). Frank Chapman, AMNH Curator of Birds, crafted exhibits in the Hall of North American Birds

in the early 1900s. To spotlight dangers threatening wading birds hunted for their feathers for ladies' hats, Chapman invited President Theodore Roosevelt to view the Wading Birds Diorama (Figure 1). Roosevelt's father was one of the Museum's early Trustees, and as a boy, Teddy learned much about Nature and taxidermy from Museum staff. One immediate result of his visit was the establishment of the first National Bird Refuge on Pelican Island, FL.

The twenty dioramas in the Hall of North American Birds depict forests, prairies, marshes, deserts, and other ecosystems ranging from the Florida Everglades to Alaskan riverbed. Visitors use information provided in explanatory signs and their imagination to learn what happens in each ecosystem and how they differ. The Museum's website includes selected images that can be used for curriculum development even if you cannot physically go to New York. For example, the Peregrine Falcon diorama (Figure 2) provides an opportunity to discuss the Palisades along the west shore of the Hudson River. More extensive suggestions for lesson plans are provided below.

In the 1920s, Akeley joined the AMNH and fulfilled a decades-long dream to organize a collecting trip to populate a "Hall of African Mammals" (2). Akeley also used this opportunity to fight strongly for creation of the first national parks in Africa to protect endangered species. Akeley included artists on his collecting teams to be able to re-create authentic background images in the days before color photography or computers.

Artists such as James Perry Wilson made "plein air" paintings to capture true colors of the scenery, vegetation, soil, and other features at the chosen locations (3). Back at the Museum, the artists rediscovered techniques dating back to the Renaissance to paint on curved background surfaces so as to blend seamlessly with the foreground. Wilson created an ingenious grid system for translating flat photos and sketches into undistorted landscapes on the curved diorama walls. Students can combine visits or web-browsing with reading articles that explore production of the dioramas and its importance for Museum visitors (4).

A prime example that illustrates these efforts is the African water hole diorama (5, Figure 3). Combined with online resources now available, you can use this display to teach about ecosystems, world geography, season rainfall patterns, Mount Kenya, conflicts over regional water supplies, and much more (6).



Figure 1. Wading Birds Diorama that influenced Pres. Teddy Roosevelt to establish the first Federal Bird Refuge.



Figure 2. Peregrine falcons nesting on the Palisades above the Hudson River.



Figure 3. Watering Hole, Hall of African Mammals. James Perry Wilson first developed techniques for creating the seamless backdrop diorama with this display.

Mammals (11). Informative panels next to each diorama describe both the animals that are on display and the environmental setting.

Connections to Art and Field Experiences

In recent decades, Museum scientists and artists have developed revolutionary techniques to upgrade many of the exhibits (12, 13). Perhaps this could provide inspiration for artistically talented students who do not think of themselves as being “strong in science” to discover career opportunities they may never otherwise know about. Reading stories about artists such as Sean Murtha (14) or photographers like Hiroshi Sugimoto (15) may be influential and perhaps even career-steering.

Dioramas capture forever one particular moment in time. But the environment has changed since then, and the Museum has mounted recent expeditions to re-visit some of these. One expedition revisited Akeley’s gorillas to get new perspectives on the species depicted, status of the national parks and other teachable moments concerning global ecological threats (16). Museum scientists also examined the impact of Chapman and Roosevelt’s partnership to preserve Pelican Island ecology after 110 years (17). Students can learn more about these efforts and other authentic field experiences through website’s Science Bulletins and other video collections (18).



Figure 4. Brown Bears in Canoe Bay, Alaska Peninsula

Diorama artists produced a sense of ‘being there’ as revolutionary for its time as 3-D virtual imagery is today. When this Hall opened in the 1930s, few people had opportunities to travel to distant locations and color photographs or movies were rare. Students can learn more about the impact on Museum visitors through recent blogs and other posts available on the AMNH website (7).

Akeley died unexpectedly in 1926 (8). But his inspiration carried on with completion not only of this Hall, but also creation of similar displays in the Hall of Asian Mammals (9), Hall of North American Mammals (10), and nearby Hall of Small

Teaching with Dioramas

How might teachers use the dioramas to create effective lessons? Depending on your curriculum goal and skill-building plans, you could have students study differences among landscapes across the globe—from Arctic mountains to the Great Plains to savannahs, deserts, and tropical rain forests—or concentrate on features at specific locations. Student teams could use online sources to learn what geological processes formed the landscape and pertinent cultural connections, then create presentations for classmates.

Consider as one example, the famous diorama showing Alaska Brown bears (19, Figure 4). Whether during a museum visit or using the online image, students could use web resources to find answers to such questions as:

- Where is this location compared with your home location?
- What geological features do you observe? What processes create them?
- Make a diagram to represent the local food web.
- What can you learn about the weather at that moment from the clouds and other conditions depicted in the diorama?
- What is the climate of this region? How might it change over the next few decades?
- How might such climate change impact the food webs?
- What skill sets were needed to complete the original creation and recent restoration of this diorama?
- Imagine you have a grant to conduct field research to Canoe Bay, Alaska Peninsula—What factors should you and your “team” consider to carry out a successful expedition?
- Write a story about the events that led up to the moment depicted in the diorama.

Other dioramas were selected to include famous geological features, such as Devil’s Tower, Wyoming in the background of the Mule Deer exhibit (Figure 5). The accompanying information next to the display (20) can be combined with other resources, such as the National Park Service website (21) for this National Monument to help students understand historical contexts, including its importance to Northern Plains tribes and first application of the Antiquities Act that allows Presidents to protect culturally and scientifically valuable federal lands for future generations.



Figure 5. Mule deer at Devil’s Tower, Wyoming

Although the focus of this article are the dioramas in the AMNH, Akeley’s influence on museum exhibits and the Public’s expectations has spread to many other institutions. You can probably find equivalents at museums, nature centers, and other places in your local area and around the world that can provide the seeds for exciting lessons. You may also want to partner with your school’s art teacher to help students create their own “dioramas” and set up displays in your school with greater understanding of how this combined Science/Art form developed.

Dioramas are, of course, only one form of art used to enhance Earth Science learning. Art lessons based on Earth Science are readily available such as “Layering Changes Earth Science and Art” (22). Mogk (23) provided a variety of suggestion in a SERC “Earth and Mind” Blog. Another example of articles that students might read to become inspired about integrating Science and Art discusses the connections of M.C. Escher and geology (24). Other examples of using artwork—from Ice Age cave paintings through Renaissance and other “Schools” to drawings done by students during field expeditions—provide examples of “Art in the Service of Earth Science” (25).

Conclusion

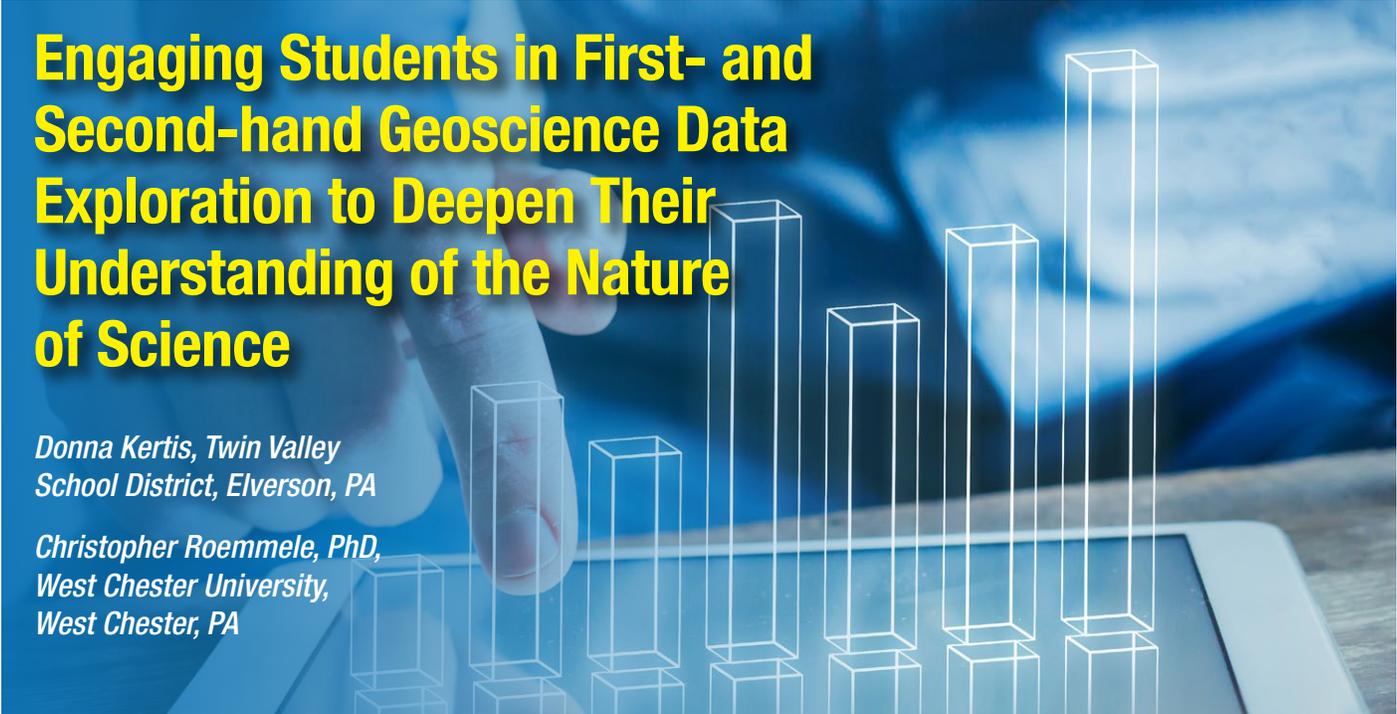
As educators begin to implement the Next Generation Science Standards, particularly through a STEAM (Science-Technology-Engineering-Art-Math) approach, they would do well to remember that “mastering STEM practices equips students with the critical thinking skills to be better creators and more attuned consumers of art” (26). You can find many other blogs and articles to encourage STEAM approaches, such as one equating the Arts with “engineered communication” (27). So, the next time you or your students visit the AMNH or a similar institution, “Look Past the Stuffed Animals” at the realistic artwork and learn much more about our planet.

References

- 1 <https://www.amnh.org/explore/news-blogs/news-posts/the-man-who-made-habitat-dioramas>
- 2 <https://www.amnh.org/exhibitions/permanent-exhibitions/akeley-hall-of-african-mammals>
- 3 <http://peabody.yale.edu/james-perry-wilson/chapter-4-en-plein-air-paintings>
- 4 <https://www.newyorker.com/culture/photo-booth/the-making-of-the-american-museum-of-natural-history-wildlife-dioramas>
- 5 <https://www.amnh.org/exhibitions/permanent-exhibitions/akeley-hall-of-african-mammals/water-hole>
- 6 https://en.wikipedia.org/wiki/Ewaso_Ng%27iro
- 7 <https://www.amnh.org/explore/news-blogs/on-exhibit-posts/habitat-dioramas-early-tools-for-wildlife-conservation>
- 8 https://en.wikipedia.org/wiki/Carl_Akeley
- 9 <https://www.amnh.org/exhibitions/permanent-exhibitions/hall-of-asian-mammals>
- 10 <https://www.amnh.org/exhibitions/permanent-exhibitions/bernard-family-hall-of-north-american-mammals>
- 11 <https://www.amnh.org/exhibitions/permanent-exhibitions/hall-of-small-mammals>
- 12 <https://www.amnh.org/explore/news-blogs/on-exhibit-posts/video-series-offers-behind-the-scenes-look-at-the-restoration-of-the-bernard-family-hall-of-north-american-mammals>
- 13 <https://www.youtube.com/watch?v=mpFUloMYO7E>
- 14 <https://www.amnh.org/exhibitions/permanent-exhibitions/irma-and-paul-milstein-family-hall-of-ocean-life/resources-for-educators/dioramas/let-s-talk-with-sean-murtha-about-dioramas>
- 15 <https://www.amnh.org/explore/videos/at-the-museum/hiroshi-sugimoto-four-decades-of-photographing-dioramas>
- 16 <https://www.amnh.org/explore/news-blogs/news-posts/revisiting-akeley-s-gorillas2>
- 17 <https://www.amnh.org/explore/news-blogs/q-as/pelican-island-at-110-years>
- 18 <https://www.amnh.org/explore/science-bulletins>
- 19 <https://www.amnh.org/exhibitions/permanent-exhibitions/bernard-family-hall-of-north-american-mammals/alaska-brown-bear>
- 20 <https://www.amnh.org/exhibitions/permanent-exhibitions/bernard-family-hall-of-north-american-mammals/mule-deer>
- 21 <https://www.nps.gov/deto/index.htm>
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- 26 <https://www.knowatom.com/blog/when-art-and-ngss-meet-common-core-math-ela>
- 27 <https://www.knowatom.com/blog/steam-the-arts-as-engineered-communication>

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Engaging Students in First- and Second-hand Geoscience Data Exploration to Deepen Their Understanding of the Nature of Science

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Abstract

Engaging students in the analysis of increasingly complex geoscience datasets may influence students' understandings about the nature of science (NOS). After initial student-driven questions about weather and classroom temperature, students collected and analyzed the weather conditions both outdoors and within the classroom. Whole-class discussions about the data were exploratory in nature. After lessons on topics including weather vs. climate and differential heating of surfaces, students analyzed and compared and contrasted 30-year climate data for two cities. Students were then given access to longer-term atmospheric data, and through a process of guided, exploratory, data analysis, were encouraged to make inferences, discuss alternative interpretations, and consider limitations on inferences imposed by different graphical representations of the data. Evidence is presented to qualitatively demonstrate student learning about the nature of science through the activities that took place. Quantifiable comparisons between pre-activity and post-activity are given. Results indicate students increased their understanding and appreciation of the nature of science and were very engaged in the process of data collection and interpretation.

Introduction

Many middle grade and secondary students of science may have misconceptions about geoscience content and naive ideas about the work that scientists do and nature of science (NOS). Studies of science literacy in the U.S. suggest that misconceptions are persistently held, even following science classes in which they are taught the content correctly (Augustine, 1998; Halloun & Hestenes, 1985; DeLaughter, Stein, Stein & Bain, 1998). Teaching students the "scientific method" as a universally applied, multi-step memorization task may also lead to the false notion of how scientists work, and how scientific theories emerge and develop. Uncovering and correcting misconceptions can not only lead to greater understanding and content mastery but may improve student affect as well. It is of primary importance, therefore, for instructors of the geosciences to directly address student misconceptions, and for instructors of pre-service teachers in science methods course to emphasize and allow instructional time to teach how to ascertain and then change these misconceptions (Gosseling & Hurst, 2005).

Data Analysis and the Nature of Science (NOS)

Data collection and analysis has been shown to influence students' perception of the changing nature of ideas in science and its tentative but durable nature over time (Vanderlinden, 2007). We feel that using carefully curated and authentic geoscience data sets and guided exploratory data analysis can provide students with a rich understanding of geoscience processes, as well as an understanding and appreciation of the nature of science. Exploratory data analysis involves the search for identifiable trends or patterns in a given dataset. Students want to find a trend but detecting that no pattern exists is also desirable and may help students gain a more realistic view of the nature of science. We also include first-hand data collection, in addition to second-hand data analysis and comparison, to provide even greater depth of content knowledge and understanding, and rigorous critical thinking skills (Hug & McNeill, 2008). For this unit, "first-hand data" refers to data the students themselves collect. "Second-hand data" is data collected from outside sources. Our goal is to guide students through data collection and exploration and allow students to see the benefits of using both types of data in order make their arguments. Concern about misconceptions and misunderstanding can arise from having a student participate in an activity for which they do not have the prerequisite knowledge (Schwartz & Bransford, 1998, Raia, 2005), which is why using both first-hand and second-hand data analyses are essential with guided instruction, in order to assist students in generating new understanding of the nature of science, especially as it relates to a complex topics such as climate change.

Identifying Patterns and Drawing Evidence-based Conclusions

The NSTA Position Statement on Science Education of Middle-level Students states young adolescents need opportunities to develop critical-thinking skills and apply learned content in the formulation of evidence-based explanations for natural phenomena (NSTA, 2016). This unit included lessons to align with the nature of science practices listed in the Next Generation Science Standards (National Research Council, 2012), with emphasis on the recognition of patterns and drawing conclusions based on scientific data. Lessons in the unit focused on using data and graphs to increase students' nature of science knowledge. Therefore, it was vital to ensure students understood the science content of this unit (weather and climate), in addition to various types of graphs and representations, as we began the unit activities. To avoid students' tendency to formulate conclusions based on personal beliefs (Hogan & Maglienti, 2001; Hug & McNeill, 2008), guiding questions were asked throughout the activities and emphasized that students cite evidence for their claims, and justify inferences or conclusions using specific evidence from the data.

Name _____

Is it Science or isn't it Science?

Survey

This is a survey to check your understanding about the nature of modern science. Please **agree** or **disagree** with each item on your answer sheet as **you think a scientist would answer it**.

PLEASE DO NOT WRITE ON THIS SHEET.

USE YOUR SPECIAL ANSWER SHEET.

Marking Code: A = agree, (or you kind of lean towards agreeing)
B = disagree, (or you kind of lean towards disagreeing)

1. Science is based on proof.
2. Science has solved most of the major mysteries of nature.
3. Science involves what is measureable.
4. Scientists can study and explain events that happened millions of years ago.
5. Science is able to solve any problem or question.
6. Science is repeatable.
7. Science is decided by debate.
8. Science is unchanging.
9. Science can be influenced by the thoughts, gender, or nationality of the scientist.
10. Science is certain.
11. A scientific theory is a guess.
12. Science is primarily a collection of facts.
13. Science requires precision and accuracy, but not creative activity.
14. Scientific ideas are made stronger by evidence.
15. Science is open to change.
16. Anything done scientifically is always accurate and reliable.

Figure 1. Pre-Activity Survey modified from (ENSI/SENSI) Lesson at Indiana University

A Question Leads to First-hand Data Collection

Prior to beginning the unit, a short survey was given to students regarding the nature of science (NOS) to determine baseline student understanding of common misconceptions about NOS (Figure 1). Upon entering the science classroom, the unit began with an authentic student question, “Why is it so hot (or cold) in here?”, and the question seemed like a great starting point at the beginning of a unit on weather: an investigation into looking for temperature patterns over time. We used this opportunity to collect primary-source (first-hand) data to monitor the room for temperature changes throughout the day using a large, dual-scale alcohol thermometer. Students assumed the responsibility for measuring and recording air temperature in the room at the same location at approximately the same times during the course of the school day for a period of three to four weeks. Shortly after commencing indoor classroom readings, students questioned whether or not the indoor temperature was being influenced by the outdoor temperature (this unit took place in February and March). To compare and contrast data, the students used an electronic indoor-outdoor weather display unit to collect inside temperature, outside temperature, and minimum and maximum daily temperatures for both inside and outside the classroom.

At the end of data collection (about 3 to 4 weeks), we projected images in succession for the students to analyze: the original handwritten data table with the classroom thermometer data, the same data entered into an Excel spreadsheet (Figure 2), a line graph with a trend line created from the spreadsheet data (Figure 3), a bar graph showing minimum and maximum outside temperatures in March (Figure 4).

We also provided the class with the following verbal cues as they reflected on each data representation, taking brief notes in their science journals, to help them to focus on analysis points:

- What trends or patterns do you observe from each chart or graph (if any)?
- What inferences can you make from the data?
- What else do you want to know after looking at this data?

This journaling allowed more students an opportunity to formulate thoughts before a whole-class discussion. The entire process allowed students to not only collect their own data set but also to analyze and explore the data they collected. Students’ journal responses reflected their developing ability to use data representations to recognize patterns

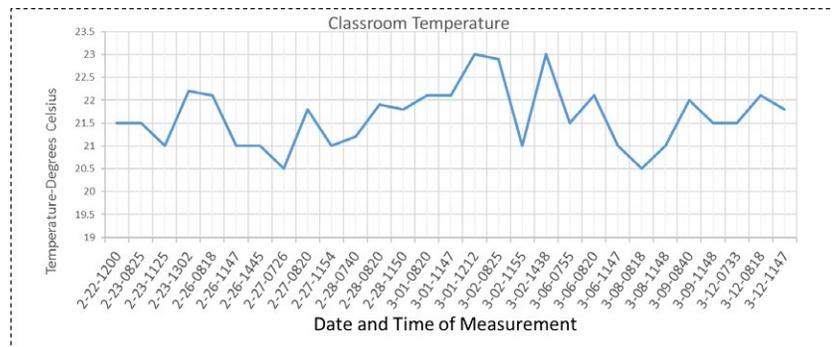


Figure 2. Indoor classroom temperature data in an Excel Spreadsheet.

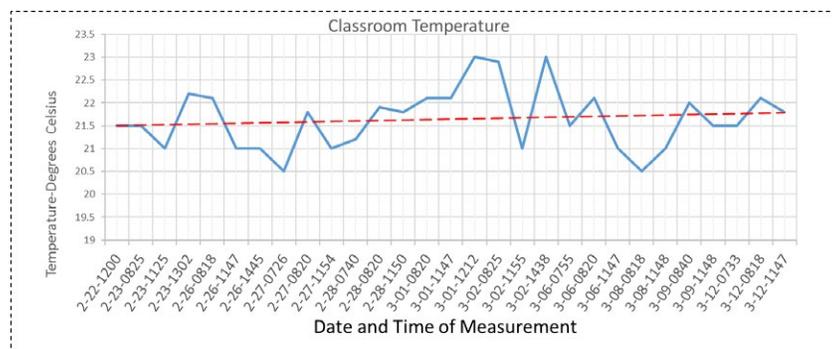


Figure 3. Indoor classroom temperature data in an Excel Spreadsheet with a trend line.

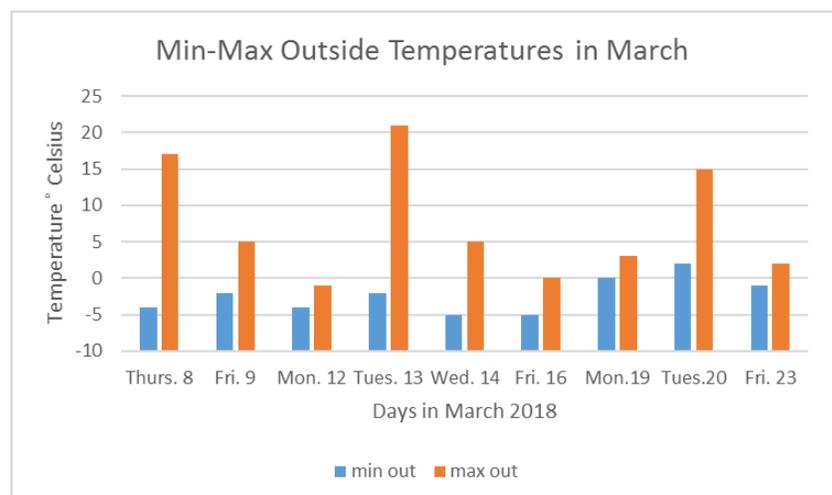


Figure 4. Minimum and maximum outside temperatures in March.

or trends, and significantly, to understand that discernable patterns in data do not always present themselves. Gathering and making sense of data frequently leads to additional questions instead of answers: a “mature” concept about the (sometimes messily, complex) nature of science.

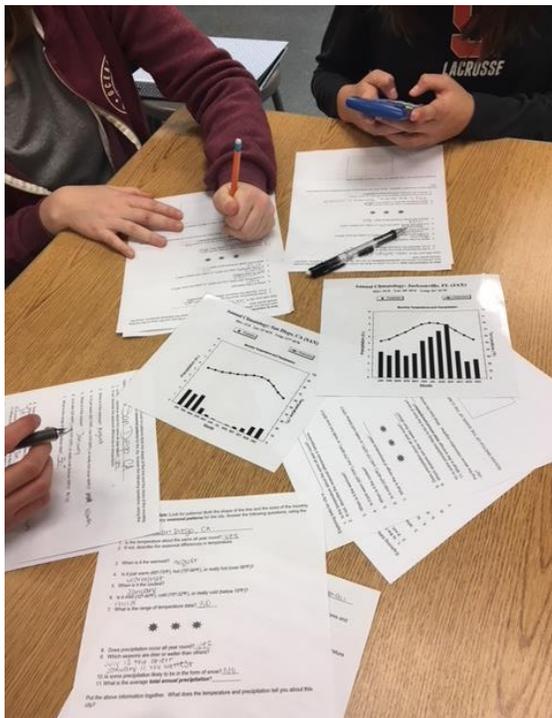


Figure 5. Students analyzing climate graphs.

Second-hand Data Exploration

We wanted students to understand that the fundamental process of scientific data collection, namely precise observation and accurate recording of measurements, are the same regardless of the expertise of scientists or the sophistication of their instruments. Therefore, we began to work with one of the second-hand data sets in the class periods immediately following the analysis of student temperature data. After a lesson on interpreting a climate graph, and informal assessment for understanding, we distributed climate graphs to students, grouped by their own choice of U.S. cities. We used 30-year average monthly climate graphs obtained from the National Drought Mitigation website. Analysis of the graphs included opportunities for students to make personal connections to cities’ climates by describing the seasonal activities they would enjoy there (Figure 5).

The final secondary-source data set we presented was an interactive Excel spreadsheet containing longer-term maximum and minimum temperature data, selectable by a drop-down menu, for U.S. climate divisions. We conducted whole-class exploration of this data set first by modeling the thinking processes involved in selecting and exploring data in the worksheet, and then involving student volunteers in the selection and exploration process. Then the students got into their city “climate data groups” to analyze

the graphs by discussing answers to a set of focus questions. We made the decision to distribute laminated hard copies of the graphs because of classroom technology limitations, but this method also helped student groups to keep their focus on a limited number of cities for which to compare and contrast the data. Classroom teachers with access to a greater number of computers may choose to allow students to generate their own graphs directly from the spreadsheet data. Copies of the activity sheets and related supplemental material can be found at <https://bit.ly/2Wc4CZb>.

Student Explanations and the Nature of Science (NOS)

Throughout the data activities, we used questions designed to guide students toward a greater understanding of the powerful implications of careful analysis of large data sets. At the same time, we wanted students to develop an awareness of the limitations of a scientist’s inferences and the tentative nature of science. One of the analysis questions for the long-term minimum-maximum temperature data was, “How would the inferences made by a scientist studying climate today be different from the inferences of a scientist in 1915?” Most students appeared to recognize the contextual limitation of having a much smaller set of data to analyze.

The final part of the long-term second-hand data analysis had student groups placing arrow stickers on a U.S. map to indicate both the maximum and minimum temperature trends from 1895-2017 at their previously-chosen location. It gradually became evident to students that long-term climate trends were similar throughout the US, with all locations showing average temperature increases (see Figure 6). This produced a flurry of questions from the students, for example, whether the maximum or minimum increase was more significant; what are the causes and implications of these increases; and are similar trends happening around the world?

We asked students to write a post-activity reflection to assess their growth in understanding and appreciation of NOS. The question we asked was, “What did you learn about how science is done from doing the data activities?” Out of 94 students, 77 of them (82%) did not write any NOS misconceptions, and wrote at least one statement evidencing an informed view of NOS. (The remaining 17 students either wrote statements revealing a NOS misconception, did not write at least one statement containing an informed view of NOS, or wrote responses that did not pertain to the question asked.) (Table 1). Before the data study unit, 72% of the students thought that science had already solved most of the mysteries of nature, while 62% agreed with the statement “Science is primarily a collection of facts.” These results indicate that a significant majority of students held serious misconceptions about the Nature of Science, but in their post-activity reflections, the students did not apply these or other misconceptions to their experiences with the exploratory data



Figure 6. Map indicating long-term temperature changes.

Table 1. Post-data study reflections indicating the Nature of Science (NOS) knowledge growth.

NOS Category	Reflections evidencing informed NOS views “What did you learn about how science is done from doing the data activities?”	Number of student responses
Tentative nature of science	Science runs off of a learn from past mistakes policy.	2
	Our perception of science is always changing as new evidence is acquired.	4
	Things change often, and everything won't always stay the same. New evidence comes to light.	10
	Science is sometimes predictable, and can change over time.	3
	Science is changeable, but always based on evidence.	3
Science practices	Science is not about proven facts.	
	Science generally requires multiple tests before something can be confirmed.	3
	Inferences can be made from observations.	2
General statements reflecting informed views of NOS	Accurate, consistent measurements are important.	4
	Your inferences could impact the way the scientific process is handled.	2
	Science doesn't always show what you'd expect.	2
	Science can't solve all problems.	4
	A theory isn't just a guess. To have a theory you need a lot of evidence to support it.	6
	Not every scientist can be correct. That's why we still keep doing experiments today.	2
	Science is different for everyone. People may understand data in different ways.	2
	It shows how your opinion can be different from the actual results.	2
Science works by collecting data over a long period of time, then comparing to see if you can find a pattern.	2	
Reflections that refer specifically to what was learned about data	Data looks different on different graphs.	2
	Science may take a very long period of data; scientists may need to wait before coming to any conclusions.	4
	Data collecting is extremely important.	6
	Analyze data to look for relationships.	2
	You have to get along with others to make the science process work.	2
	There are a lot more kinds of graphs than just a bar graph or a scatter plot, like the America graph where the [temperatures] were rising. Some graphs have two lines [y axes].	2
	Science is different for everyone. I learned how people understand data in different ways, there are many ways to collect the same type of data.	7
Percent of students whose reflection did not contain any NOS misconceptions, AND ALSO wrote at least one statement evidencing informed views of NOS		82%

Table 2. Science and engineering practices (SEPs) related to NOS targets and classroom activities

K-12 SEP's (National Research Council)	How it was addressed	Example evidence from student conversations	Example evidence from data sheet responses
Asking questions	Students were guided to ask questions after the long-term maximum and minimum temperature data analysis.	<p>Do the ocean temperatures have anything to do with it? (A1)</p> <p>What kind of data will be available over the next century? (C1)</p> <p>What predictions can be made with just this information? (H1)</p> <p>Is earlier than 1895 data available? (Y1)</p>	<p>Have the humidity levels increased along with the temperatures?</p> <p>What does wind have to do with climate?</p> <p>Are increases in temperature happening all around the world? Are some countries temperatures decreasing?</p> <p>How much pollution was produced in each year, because pollution has a big effect on the Earth?</p>
Developing and using models, analyzing and interpreting data, using computational thinking	<p>Guiding questions</p> <p>(examples): Is any of the precipitation likely to be in the form of snow?</p> <p>What is the range of the temperature data?</p> <p>What is the total annual precipitation?</p>	<p>The data in columns on the spreadsheet is hard to understand until it is graphed. (J1)</p> <p>Graphing can help you to spot highs and lows. (Ce2)</p> <p>The trend line is to show the total average amount of change overall. (Y2)</p> <p>If the minimum goes up, that really shows the temperature is rising more than if the maximum temperature does. Also, I think if December averages go up, because December is all over the place. (C2)</p>	<p>Similarities: Austin and Nashville both have wet climates, and mild-to-hot temperatures. Differences: Austin has less average precipitation than Nashville, and Nashville has a wider temperature range.</p>
Constructing explanations, engaging in argument from evidence	<p>Primary-and secondary-source data analysis activities</p> <p>Secondary-source data analysis activities</p>	<p>Every arrow on the map is going up, so my inference is that there is global warming. But I would want to see a humidity graph, and a graph of pollution each state gets, with the carbon dioxide and everything. (R1)</p> <p>This shows national warming. (Ay1)</p>	<p>Honolulu temperatures may stay the same because it is on an island all surrounded by water.</p> <p>Differences in precipitation could be caused by the distance to the ocean.</p> <p>New York is farther away than Philadelphia from the equator, which would explain the slightly cooler temperature. It is also closer to the ocean, which would account for the smaller range in temperature.</p> <p>Chicago would be more interesting to live in than Green Bay, because there is a greater seasonal difference.</p> <p>It could be colder and wetter in Minneapolis than Anchorage because the elevation is 700 feet higher in Minneapolis.</p>
Obtaining, evaluating, and communicating information	Students participated in first-hand data collection activities	<p>Maybe our indoor data is going up because it's been so cold lately, and the heating system is working, and is responding to that. (R3)</p> <p>We could find out exactly what the cloud cover was for each of the days. (M3)</p>	

analysis activities. Table 2 is a summary of activities in the unit and how each one corresponds to specific K-12 science and engineering practices from the National Research Council.

Conclusions

Students were generally enthusiastic about participating because there was an atmosphere of authentic collaboration: they were immersed in doing science, which is an ideal setting in which to learn about the nature of science. The students measuring the primary-source data portion of the study were highly motivated: they consistently gathered data with precision and accuracy. It was clear from the individual student responses that there were great benefits to seeing many different types of graphs, comparing and contrasting data, and constructing evidence-based explanations. Exploratory data analysis reveals the complexity of Earth systems, and many students gained an understanding of this complexity. By taking measurements themselves, it became easier for students to relate to the authenticity and complexity of the large geoscience data sets they analyzed and also witness how complex even their own classroom temperature data was for them to analyze. The execution of this unit indicates that exploration of readily available authentic geoscience data may provide an opportunity for K-12 students to develop more realistic views about the nature of science, as well as critical thinking skills, both of which are vital to the education of tomorrow's citizens and policy makers.

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Literacy is from Mars: Using *The Martian* to Enrich Scientific Literacy Skills

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Abstract

Having a solid foundation in literacy is critical to understanding the everyday advances in science and technology that are taking place around us. The National Assessment of Adult Literacy (National Center for Education Statistics, 2003) describes three types of literacy: quantitative, document and prose. This article describes one way to provide an engaging and meaningful approach to advancing scientific literacy in the Earth Science classroom using Andy Weir's highly successful and entertaining scientific novel, *The Martian*. The activities we used in our classrooms enriched students' literacy as they used their skills to analyze meaningful problems in the context of this novel.

Bring Him Home.

He's stuck on Mars. You need to figure out how to get him back to Earth. Do you have the skills you need to communicate this information? More than just words, you need numbers, graphs, charts and calculations to accomplish this task. Can you do it?

Introduction

The scenario above, based on the novel *The Martian* by Andy Weir, represents our vehicle for delivering motivating scientific literacy instruction for our students. Furthermore, NASA is developing the capabilities needed to send humans to Mars in the 2030s. Travel to and from Mars is both motivating and timely. Teachers know that when students are learning science, they are reading and writing more than just words. They are also using diagrams and data analysis. Scientific literacy skills are pivotal to communicating in all the content areas, including Earth Science.

The National Assessment of Adult Literacy (National Center for Education Statistics, 2003) identifies three types of English literacy. *Quantitative literacy* is used in the interpretation of numbers and calculations that are embedded in written materials. *Document literacy* allows students to derive understanding from figures, charts and graphs. *Prose literacy* enables students to critically interpret written text. These three literacies correspond to the Next Generation Science Standards (NGSS Lead States, 2013) scientific practices of 1) using mathematics and computational thinking, 2) analyzing and interpreting data and 3) obtaining, evaluating, and communicating information (Table 1). Based on a survey of students given in 2015 (Graves-DeMario, Kieliszek & McMillen, 2016), secondary science students showed weaknesses in all three types of literacy. As teachers, we

sought an engaging way to promote these literacies in our classrooms.

We turned to a movie that had captured the imagination of a nation and the novel that had inspired it (Figure 1). We were certain that a classroom study of *The Martian* would allow students to practice implementing critical literacy skills while deriving a deeper understanding of Earth Science concepts. In our classrooms, we found it practical to either read the book as a whole, incorporating questions in the process, or to use excerpts of the book, asking targeted questions. We also found showing the movie trailer piqued student interest in the book. Examples of excerpts and targeted questions that were used in our classrooms are included in the sections that follow.

Quantitative Literacy

“Quantitative literacy is the ability to understand and use numbers and data analyses in everyday life” (Madison, 2001). Understanding the meaning of numerical data in context allows readers of technical information to judge its validity. In Earth Science, readers are constantly asked to critically analyze quantitative information. An understanding of geology, meteorology, oceanography and astronomy can only be achieved through successful integration of quantitative literacy. As learners, adolescents need to be taught how to apply their mathematical understandings to derive meaning from Earth Science content. Quantitative literacy applications are found throughout *The Martian*. By drawing student attention to them, we were able to deliberately focus on enriching these skills. In one example, our 8th grade Earth Science students were asked to analyze a sentence from *The Martian* and apply quantitative literacy skills to calculate the rate of travel.

EXCERPT:

p. 2:

“Suffice it to say we got to Mars 124 days later without strangling each other.”

QUESTION:

The minimum distance from Earth to Mars is 54.6 million kilometers (54,600,000 km). What was the average speed in kilometers per hour of Watney and the Ares 3 crew on their journey to Mars if they travelled this distance? Remember that there are 24 hours in a day. Show your work below including a formula. Round your answer to the nearest whole number and provide a proper label.

Sample Response

Speed = Distance/Time

Speed = 54,600,000 km/124 days = 440,322 km per day

Speed = 440,322 km per day/24 hours per day = 18,347 km per hour

Table 1: Correspondence of Types English Literacy to NGSS Scientific Practices

Type of English Literacy	NGSS Scientific Practice
<i>Quantitative literacy</i> — interpreting numbers and calculations that are embedded in written materials	Using mathematics and computational thinking
<i>Document literacy</i> — deriving understanding from figures, charts and graphs.	Analyzing and interpreting data
<i>Prose literacy</i> — critically interpreting written text	Obtaining, evaluating, and communicating information



Figure 1. In a scene from *The Martian*, astronaut Mark Watney employs some ingenious methods to plant crops on Mars. Shown here, real-life NASA astronaut Kjell Lindgren harvests lettuce grown from the Veggie experiment while on board the International Space Station.

Image Credits: Peter Mountain/NASA

Using this calculation, students can judge whether the amount of travel time stated by the author was reasonable. This is just one of many applications of quantitative literacy contained in *The Martian*. Exercises such as these allow students to use their knowledge of mathematics to evaluate the numeric data presented.

Document Literacy

Document Literacy is “identifying and using information located in documents such as forms, tables, charts, and indexes” (Kirsch et. al, 1986). The ability to analyze information from figures, charts and graphs is essential to deriving understanding in Earth Science. Throughout *The Martian*, readers are asked to integrate document literacy to make sense of the text presented. At the beginning of the book, Weir includes a detailed, scaled map of the surface features of Mars. Our Earth Science students were asked to use document literacy skills to answer questions using the map, scale and following excerpt:

EXCERPT:

p. 88:

“He drove straight away from the Hab [Ares 3] for almost two hours, did a short EVA [extra-vehicular activity], then drove for another two. We think the EVA was to change batteries. ... He’s seventy-six kilometers from the Hab,” Mindy said. “...He went south-southwest.”

“Okay, maybe there’s hope,” Venkat said. “What’s he doing right now?”

“Recharging. He’s got all the solar cells [Sols] set up,” Mindy said.

“... We’ll see what he does tomorrow.”

p. 92, the next day:

“Still going in a straight line,” Mindy said, pointing to her monitor.

“I see,” Venkat said. “He’s sure as hell not going to Ares 4.”

“...He did the usual two-hour drive, EVA, two-hour drive. He’s one hundred and fifty-six kilometers from the Hab now.”

(Note: The Hab is short for Habitat- the structure where Watney is living)

QUESTION:

Using the map and the passage above, do the following:

1. Starting at the Hab, draw a line in the direction that Watney travelled.
2. Use the map’s scale, plot two Xs to indicate Mark’s position on that line after day 1 and day 2 of driving. Label them 1 and 2.
3. Venkat and Mindy discover that Watney is heading for Pathfinder. Determine the amount of distance Mark still had to go to reach Pathfinder after the second day. Assuming it takes him 8 more Sols to get there from his day 2 position, what is his rate of travel in kilometers per Sol?



Figure 2. Sample of student answer for document literacy question.

In the example shown, students were asked to use not only document literacy, but also quantitative literacy to extract a thorough understanding of Watney’s position on the map. It is only through the application of scientific literacy that a clear picture of the scenario described can be understood. Mapping can often be a disconnected and difficult topic for students, but this application provided an authentic purpose for its use. A student’s response to the question posed is shown in Figure 2.

Prose Literacy

Prose literacy involves “the knowledge and skills needed to... search, comprehend, and use continuous texts” (National Center for Education Statistics, 2003). This form of literacy is the primary focus of ELA classrooms. However, it is also essential in Earth Science. The opportunities for using prose literacy in *The Martian* are numerous, making it a comfortable vehicle for use in ELA as well as Earth Science classrooms. Our students were given the following excerpt and question:

EXCERPT:

“One thing at a time,” Teddy said. “Venk, what makes you sure he’s alive?”...

“So I spent the last few hours checking everything I could. Commander Lewis had 2 outings in Rover 2. The second was on Sol 5. According to the logs, after returning, she plugged it into the Hab for recharging. It wasn’t used again, and 13 hours later, they evac’d.”

He slid a picture across the desk to Teddy.

“That’s one of the images from last night. As you can see, Rover 2 is facing away from the Hab. The charging port is in the nose, and the cable isn’t long enough to reach.”

“...She must have parked it facing the Hab or she wouldn’t have been able to plug it in,” [Teddy] said. “It’s been moved since Sol 5.”

“Yeah,” Venkat said, sliding another picture to Teddy. “But here’s the real evidence. In the lower part of the image, you can see the MDV [Mars descent vehicle]. It’s been taken apart. I’m pretty sure they wouldn’t have done that without telling us.

“And the clincher is on the right of the image.” Venkat pointed. “The landing struts of the MAV [Mars ascent vehicle]. Looks like the fuel plant has been completely removed, with considerable damage to the struts in the process. There’s just no way that could have happened before lift-off. It would have endangered the MAV way too much for Lewis to allow it.”

QUESTION:

Venkat Kapoor used three pieces of evidence in his discussion with the team to support that Mark Watney was not dead. Describe the three pieces of evidence and explain how they help the others to come to the conclusion that Mark is currently alive on Mars.

Sample Response

The first piece of evidence is that Rover 2 has been repositioned since their second sortie on Sol 5. It is neither plugged into the Hab for recharging nor was it facing the Hab when photographed the night before, the way it was left by Commander Lewis. Second, there is extensive deconstruction evidence on the MDV, signaling that a human was searching for vehicle parts. Third, the fuel plant was removed from the MAV, which could not have happened before lift-off.

Conclusion

Research has shown that students are more engaged and gain more conceptual understanding when using interesting texts to interact with scientific phenomena (Swan, 2003). *The Martian: Classroom Edition* includes a teacher’s guide which provides questions that focus primarily on prose literacy. As teachers who wished to also pursue quantitative and document literacy, we needed to use diagrams and calculations from the text to generate our own classroom materials. We found the payoff to be extraordinary as students worked collaboratively and diligently to solve problems and be part of the team to Bring. Him. Home. Other books rich in scientific literacy opportunities include *The Immortal Life of Henrietta Lacks*, *Napoleon’s Buttons*, *Journey to the Center of the Earth* and *The Hitchhiker’s Guide to the Galaxy*. By incorporating literacy exercises from books such as *The Martian* in Earth Science, students can experience a greater level of engagement in the content and hone their literacy skills in all areas.

About the Authors

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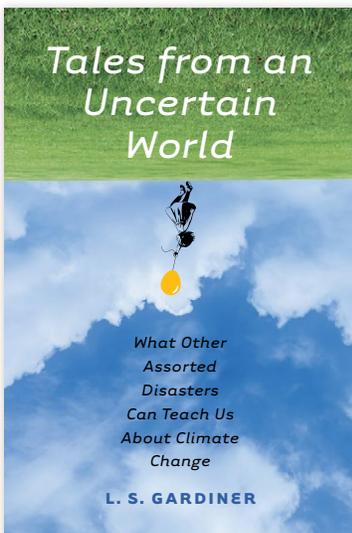
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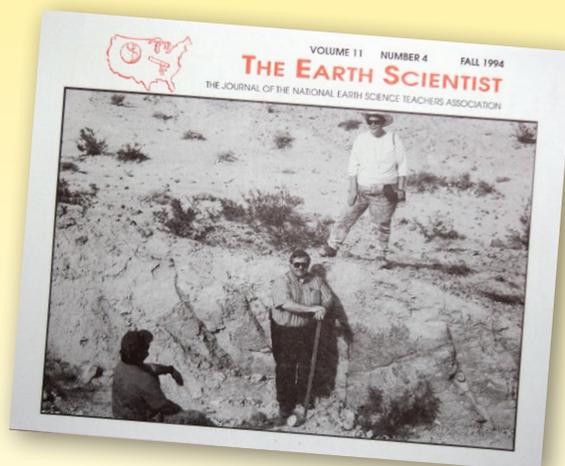
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25 Years Ago in TES

Twenty Five years ago, in 1994, TES was in its eleventh year of publication. This cover photo features an image of Earth Science Teachers investigating the vertical effect due to an earthquake. The photo was taken during a California Earth Science Academy field trip to the Landers Earthquake site in February 1994. Old timers among us may recognize: (top) Jan Woerner, (middle) Dan Morse, and (bottom) David Nichley. This issue began with an article titled, "What Research says about a Learning Cycle". Next up was an article about "Changing the Metaphore". Next was an article about teaching Earth Science in Grades K-6. This was followed by an article describing a *BINGO* game that could be used as a Review Strategy for Physical Properties of Minerals. There was an informational blurb about the *Toyota/NSTA Tapestry Grants*. Next, there was an article about Identification of hand specimens of Rocks and Minerals. This was followed by an article titled, "Science and Society: Escape to a Real World". The next article was a summary of Earth Science Education in Alabama. And the final article was titled, "What the Research Says to the Earth & Space Science Teacher about Target Students." The article defines *Target Students* as the relatively small number [3 to 7] of students with whom a teacher tends to interact during a whole class interaction. These pupils are called upon because of their assertiveness and/or their proximity to the teacher.



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