A Framework for Diversity and Equity in K-12 Science Educational Media

Report prepared for GBH Education's *Bringing the Universe to America's Classroom*

December 2020

The material contained in this report is based upon work supported by NASA under cooperative agreement award No. NNX16AD71A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

Lead Author
Blakely Tsurusaki, University of Washington Bothell

GBH Project Leadership
April Bo Wang, Diversity & Equity Project Lead
Pegeen Wright, Bringing the Universe to America's Classrooms Principal Investigator
Shawn Stevens, Bringing the Universe to America's Classrooms Co-Investigator

GBH Diversity and Equity Framework Advisory Group
Mariana Athayde, Lowell Public Schools
Megan Bang, Northwestern University/Spencer Foundation
Felicia Moore Mensah, Teachers College, Columbia University
Edna Tan, University of North Carolina Greensboro
Carrie Tzou, University of Washington Bothell
Ann Rosebery, Chèche Konnen Center
Kent Wallace, Fisk University
Christopher Wright, Drexel University

Table of Contents

Introduction

Over the past five years, GBH Education (GBH) in collaboration with NASA produced a collection of digital media resources, *Bringing the Universe to America's Classrooms* (BUAC), to support K–12 instruction in earth, space and physical science. These free resources, available via PBS LearningMedia, relate to disciplinary core ideas (DCIs) defined by the Next Generation Science Standards (NGSS) and emphasize engaging students with phenomena and science and engineering practices aligned to NGSS. Supplementary in nature, these resources are meant to enhance teachers' curricula, not replace it. For each grade band, there are sets, or collections, of resources. Each set relates to a single topic and links to level-appropriate DCIs.

In developing BUAC, GBH committed to supporting the diversity—academic, linguistic, cultural, and socioeconomic—of learners in our K-12 educational system. While we will discuss the importance of defining diversity beyond the grouping of people into categories in Part I, the statistics below still offer a telling snapshot of the heterogeneity of K-12 students in the United States:

- In the 2018–19 school year, 7.1 million, or 14% of public school students ages 3–21 in the U.S. received special education services under the Individuals with Disabilities Education Act (IDEA). 33 percent of these had specific learning disabilities, a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations (National Center for Education Statistics, 2020).
- About 5 million students, or 10% of students enrolled in U.S. schools, are English Language Learners (ELs), students whose primary language is not English and whose English language skills are insufficient to keep up with classes conducted only in English. By 2025, an estimated 25 percent of public school students will be ELLs (National Center for Education Statistics, 2020).
- 32 million children, more than 50% of our K-12 learners, live in poverty and participate in free and reduced-cost lunch programs each day (National Center on Education and the Economy, 2019).
- In 2014, U.S. schools became majority minority, with minority students making up 50.3% of the student population. In fall 2017, of the 50.7 million students enrolled in public elementary and secondary schools, 24.1 million were White, 7.7 million were Black, 13.6 million were Hispanic, 2.8 million were Asian/Pacific Islander (2.6 million were Asian and 185,000 were Pacific Islander), half a million were American Indian/Alaska Native, and 2 million were of two or more races (National Center for Education Statistics, 2020).

In our initial proposal, GBH targeted two sub-groups, students with disabilities using assistive technologies and English Learners. This work included ensuring our interactive student-directed lessons were available with audio language support in both English and Spanish. We also worked with our English Language Learner Teacher Advisory Council and produced and tested printable support materials for English Learners. In year 4, we submitted a new proposal and were granted the opportunity to explore the issues of diversity and equity as they pertain to cultural and linguistic inclusion, as well as accessibility. To that end, the GBH BUAC project has created A Framework for Diversity and Equity in K-12 Science Educational Media. Its key purpose is to guide GBH in future digital and instructional resource development. More broadly, the Framework can contribute to the field of media-enabled K-12 science education, both informal and formal. To that end, GBH will share the Framework with other resource developers, educators, and researchers, and members of the NASA Science Activation community.

A Diversity and Equity in K-12 Science Education Advisory Group was formed to guide this work (see page 1 for list of members), and convened in February, 2020, to launch this effort.[1] During the launch, the advisors discussed key ideas related to diversity and equity and generated a list of research and resources that could serve as the foundation for the development of the Framework. Four themes emerged from the discussion: anti-deficit perspective, and relatedly: representation, science representation, and access and engagement. Ultimately, these four themes guided the development of A Framework for Diversity and Equity in K-12 Science Educational Media.[2]

The Framework consists of five parts:

Part I, *A Summary of Diversity and Equity Research*, summarizes key research in diversity and equity related to four themes identified by the advisory group.

Part II, *Practices that Support Diversity and Equity in K-12 Education*, identifies practices that support diversity and equity in science education that are grounded in the research literature. This section includes practices and examples of how the practices can be enacted.

Part III, *A Review of Media Resources that Support Diversity and Equity in Science Education*, contains a review of media resources that exemplify aspects of diversity and equity. This review guided the development of the *Design Principles for Diversity and Equity in K-12 Science Educational Media,* outlined in Part IV.

Part IV, *Design Principles for Diversity and Equity in K-12 Science Educational Media,* is meant to guide the development of science educational media to support equity and diversity.

Part V, *A Summary of BUAC Sample Resource Review*, summarizes the Collection's strength and opportunities for improvement, based on an analysis of a selection of BUAC resources.

[1] The first meeting took place on February 18th and the second meeting took place on February 26th. Two separate meetings were held to accommodate schedules and only April Bo Wang, Pegeen Wright, and Blakely Tsurusaki attended both meetings.
[2]A combined summary of the two meetings was sent to the advisory group in March and advisors were encouraged to provide feedback and add additional research and resources.

Part I. Summary of Diversity and Equity Research

In this chapter, we summarize key research in diversity and equity, with a focus on the four themes identified by the advisory group: anti-deficit perspective, representation, science representation, and access and engagement.

First, we summarize the meaning of diversity in educational settings. Originally this work was conceived as A Framework for Diversity, Equity, *and Inclusion* in K-12 Science Educational Media. While GBH thinks about inclusion in terms of making sure communities and voices are included and represented in the development process, the advisory group pointed out that inclusion in K-12 school settings typically refers to special education. As such, we decided to move forward with a Diversity and Equity Framework. This is not to say that the Framework will not attend to any criteria that may support special education learners. However, we did not explicitly address special education. This also means that the literature for special education is not included in this summary.

Next, we emphasize the importance of approaching science education from an anti-deficit perspective. This summary is followed by an exploration of Representation, divided into: 1) Who Does Science? – addressing the underrepresentation of communities in science and factors that impact representation and 2) What is science? – discussing what counts as science and how this has been shaped historically and culturally. Finally, Part I ends with a section on Access and Engagement: How do students learn science? This section summarizes research related to barriers to learning science and ways to decrease barriers through asset-based pedagogies.

Representation (who does science?), science representation (what is science?), and access and engagement, are necessarily intertwined. For example, redefining what counts as science changes the discourse around who does science and who is able to do science. Broadening ideas of who does science and what science is impacts access and engagement. Some research may be included in one section even though it could have been included in more than one section. The themes and summary of the research should be taken as a whole.

This is not intended to be a comprehensive review of all aspects related to diversity and equity in science education. It is meant to summarize key issues and ideas that can inform the development, selection, and modification of K-12 science educational media. Also, while this Framework was developed for a formal, K-12 audience, many of the research, ideas, and practices also apply to informal settings.

Expanding how we think about diversity

Diversity is often characterized first by grouping people into categories such as race, ethnicity, socio-economic status, gender, etc. and discussing the diversity of a population according to these categories. Educational policies, such as the No Child Left Behind Act (NCLB) and the reauthorized Elementary and Secondary Education Act (ESEA) address diversity in terms of accountability groups, in which there should be measurable objectives and improvement, that include economically disadvantaged students, students from major racial and ethnic groups, students with disabilities, and students with limited English proficiency (https://www2.ed.gov/policy/elsec/leg/esea02/pg2.html).[3] The *Next Generation Science Standards, Appendix D, "All Standards, All Students": Making the Next Generation Science Standards Accessible to All Students*, includes seven case studies that address diversity and equity by tailoring science instruction for seven particular student groups.[4] In addition to the four groups included in NCLB and ESEA, these case studies address girls, students in alternative education programs, and gifted and talented students (NGSS Lead States, 2013; Lee, Miller, & Januszyk, 2015).[5]

While inequities in education in the United States were historically formed around race, class, gender, and dis/ability (Ladson-Billings, 2006) and addressing diversity in terms of groups or communities can be useful, it is also important to recognize the dangers of this approach for the reasons outlined below. With increasing globalization, communities are now being characterized by 'super-diversity' (Vertovec, 2007) or 'hyper-diversity' (Malsbary, 2016) to signify a complexity of diversity that moves beyond simple categories such as class, race and ethnicity. While curriculum, research, and policy has sometimes focused on single groups, such as African Americans or Asian Americans, there are varied experiences within these groups that impact how individual members learn or engage in their school contexts. For example, Black is a broad category that encompasses a large range of communities with various cultures and experiences. One person who identifies as Black does not have the same experiences as all other Blacks.

When considering diversity, Gutierrez and Rogoff (2003) caution against attributing characteristics to individuals or communities simply because of a community categorization such as race, gender, or socioeconomic status. Instead, we should recognize that our knowledge and how we learn is shaped by individual and communities' practices and experiences. The category of English Learners (ELs), for example, includes a wide range of linguistic diversity. English proficiency, which can be measured along dimensions of listening, reading, speaking and writing, is also heterogeneous (National Academies of Sciences, Engineering, and Medicine, 2018).[6] Two ELs in the same classroom who identify as speaking the same language at home may have different skills across listening, speaking, reading, and writing because of their schooling and cultural experiences in their native language and/or English. One cannot assume

[3] There are many ways to describe students whose native language is a language other than English. NCLB and ESEA use limited English proficiency, while others use English Language Learners, English Learners, or emergent bilinguals. A 2018 report from the National Academies of Sciences, Engineering, and Medicine, *English Learners in STEM Subjects* uses English Learners (ELs). This report will follow the lead of this report and use the term English Learners.
[4] The *Next Generation Science Standards*, or *NGSS* are K-12 science education standards that were released in 2013. The *NGSS* are not a curriculum, they are a set of standards used to guide curriculum development, teaching, and learning in K-12 science education.
[5] The *Next Generation Science Standards*, Appendix D, "All Standards, All Students": Making the Next Generation Science Standards Accessible to All Students (NGSS Lead States, 2013) refers to students in alternative education programs as structured after-school opportunities, family outreach, life skills training, safe learning environment, and individualized academic support.
[6] While English proficiency is heterogeneous, it is typically defined in relation to white, middle-class English.

that someone who is Latinx is an EL or someone who is Asian American can speak an Asian language.

Furthermore, approaching diversity by simply grouping communities into categories does not take into account the intersectionality (Crenshaw, 1991) of individuals, or the multiple communities and experiences and identities people hold and participate in, within these groups. Individuals identify with and participate in many communities. In addition, an individual may be classified by school district, state, or federal policies or self-identify as being both of low-socioeconomic-status and bilingual. In considering how to support diverse learners in K-12 science education, it is important to recognize such intersectionality.

Diversity is a complex issue that is influenced by many connecting factors. Categorizing communities can be useful as descriptors and a way to consider diversity issues in science, such as how particular communities are underrepresented in science. There are also many ways that categorizations can be harmful – such as when it leads to stereotypes about groups of people or contributes to further marginalization of groups and individuals. Finally, it is important to consider heterogeneity within individual and group experiences and practices when thinking about issues related to teaching and learning.

Anti-deficit perspective

The Diversity and Equity Framework in K-12 Science Educational Media takes an explicit anti-deficit perspective. It is important to recognize that K-12 formal schooling in the United States has historically been developed from a dominant, white, middle-class perspective. This will be further discussed in the following sections. This same perspective has also affected science learning in schools, including what is learned and how it is learned. This means that students who are not from white, middle-class backgrounds are often expected to learn and meet expectations of science learning established by curricula and pedagogy geared towards the dominant population.

The achievement gap,[7] the term coined to describe when students do not meet these learning expectations, signifies the gap in achievement between minoritized populations[8] and their white counterparts (Ladson-Billings, 2006). The achievement gap is often framed in a way that suggests that there is a deficit - that minoritized students are lacking in their abilities and must catch up to their peers - rather than as an achievement debt. Ladson-Billings argues "...that the historical, economic, sociopolitical, and moral decisions and policies that characterize our

[7] The achievement gap is often measured through national and state standardized tests. It can also be used to describe differences between middle-class, white students and non-white, middle class students in graduation rates, types of courses taken such as Advanced Placement courses or advanced math and science courses, college enrollment data, etc. There are inherent issues with standardized tests, including bias and how they are used to sort and classify students. Standardized tests have historically been used to structure racial inequities (Au, 2016).

[8] In this report, the term 'minoritized' refers to people who do not come from white, middle-class backgrounds. Minoritized is used to recognize that people and communities are minoritized through action, such as educational policy that denies equitable access and opportunities for learning. Minoritized includes people that are marginalized due to race, ethnicity, gender, socio-economic status, dis/ability, etc.

society have created an education debt" (2006, p. 5). The achievement debt accumulated due to not only structural inequities such as who was/is allowed what kind of access to education, and the resource disparities between schools and districts, but also the policies around teaching and learning that were developed based on a white, middle-class perspective. As part of this, historical stereotypes about who does or can do science still persist today. This will be discussed in the sections Representation: Who does science? and Access and engagement: How do students learn science?

Instead of thinking about differences in science educational achievement as an achievement gap, which takes a deficit perspective, this Framework recognizes the underlying historical and systemic inequities in education and society. A Framework for Diversity and Equity in K-12 Science Educational Media will privilege students' cultures, experiences, and skills and recognize that much learning occurs both inside and outside of the classroom (Banks et al., 2007). It takes an asset-based approach, building on work such as that of Moll, Gonzalez and their colleagues, who studied the funds of knowledge – historically accumulated and culturally developed bodies of knowledge and skills – of minoritized communities. They argue that funds of knowledge are important, relevant to school learning, and should be valued and leveraged in formal school settings to support student learning (Moll, et al., 1992; Gonzalez, Moll, & Amanti, 2005). The Framework also builds on other asset-based pedagogies such as culturally relevant pedagogy (Ladson-Billings, 1995a, 1995b) and culturally sustaining pedagogies (Paris & Alim, 2017). These asset-based pedagogies view students' everyday experiences not as something to overcome, but as essential to learning and enriching to learning experiences for all students.

Finally, it is important to note that the goal of this work is to develop a Diversity and Equity Framework, not a Diversity and Equality Framework. Equality denotes the idea that all students should be given the same experiences for learning. It assumes that if all students are given the same experiences, they will all have equal opportunity to learn. However, this perspective neglects to take into account historical, structural inequities that have influenced access, opportunities, and learning. A focus on equity recognizes these factors, while also recognizing that students have different experiences, skills, and expertise that influence how they learn. It acknowledges that students may need different types of science learning opportunities. This acknowledgment applies to all students, not only minoritized students (Warren et al., 2020).

1. Representation: Who does science?

Individuals and populations are heterogenous; however, it is helpful to think about community categories by descriptors such as gender or race and ethnicity in order to recognize inequities in science education and science professions. Women, persons with disabilities, and other minoritized groups which include African Americans, Hispanic or Latinx,[9] and Indigenous groups,

[9]More recently, Latinx has been used as a gender neutral term to describe people who are of or relate to Latin American origin or descent instead of Latino or Latina, which are gendered terms. For more information about the use of Latinx, Latino, Latina, and Hispanic. See https://www.pewresearch.org/hispanic/2020/08/11/about-one-in-four-u-s-hispanics-have-heard-of-latinx-but-just-3-use-it/

are underrepresented in science, science education, and science occupations (National Science Foundation, 2019). In 2016, ~56% of bachelor's degrees in science were awarded to white students, while only 9.0% were awarded to Asian students, 9.0% to Black or African American students, 13.5% to Hispanic or Latinx students, 0.5% to American Indian or Alaska Native, and 0.2% to Native Hawaiian or Other Pacific Islander students (National Science Foundation, 2019, Table 5-3).

There are many reasons for the underrepresentation of minoritized groups in the sciences. As noted above, K-12 formal schooling in the United States was historically developed based on white, middle-class, monolingual and monocultural norms and ideas (Alim and Paris, 2017; Ladson-Billings, 2006; Warren et al., 2020; Bang et al., 2012). Because of this, Steele (1997) argues that minoritized groups, such as African Americans and females face 'stereotype threat'; they are negatively stereotyped in a particular domain, such as science, which can impact academic achievement.[10] In other words, societal stereotypes posit that minoritized groups such as African Americans and females are not as smart or as good at physical sciences as others. In addition, Brown (2019) discusses how Black people pay the black tax, an additional price or tax, "in the form of unfair evaluations, racially biased social norms, and low expectations" (p. 13).

Tan and her colleagues (2013) found that even when minoritized girls performed science in school-sanctioned ways, such as asking scientific questions and testing variables while experimenting, they did not receive recognition for their learning. In one case, a teacher was surprised that a minoritized girl earned an A in her class; the teacher only saw the student as Black student and from a low socio-economic status background, and failed to recognize her achievements as a scientist. Some may argue that other factors, such as gender or socio-economic status impact the type of access and opportunities to learn students have. While these play a role, research has shown that race matters. There continues to be racial inequities related to school resources and academic opportunities, as well as differential teacher quality and treatment of Black, Indigenous, and students of color (Annie E. Casey Foundation, 2006; Tatum, 2007).

While some students may face stereotypes about their abilities that impact their achievement in science and/or do not gain recognition of their achievements, others who do not self-identify with science.[11] Science identity has been identified by the National Research Council (2009) as fundamental for engaging in lifelong science endeavors - at a personal and professional level. It is important to recognize that there are a variety of reasons people identify or do not identify with science and/or scientists. For example, a student may identify with a scientist because they are of the same race or ethnicity as them, come from a similar socio-economic background, or have similar interests as them.

---

[10] Educational achievement is often measured through national and state standardized tests. Similar to the achievement gap, educational achievement can also be measured by graduation rates, types of courses taken such as Advanced Placement courses or advanced math and science courses, college enrollment data, etc. There are inherent issues with standardized tests, including bias and how they are used to sort and classify students. Standardized tests have historically been used to structure racial inequities (Au, 2016).

[11] Stereotypes can influence how people perceive themselves and how they identify with science.

The ASPIRES project, a longitudinal study of youth's science and career aspirations age 10-14 (Archer et al., 2013), found that students viewed 'scientists as brainy,' and therefore, even when they expressed interest in science, saw it as 'not for me.' Years of research on U.S. students' perceptions of scientists show that stereotypical perceptions of scientists, including who does science and the work that scientists do, persist (Finson, 2002). Finson examined decades of research and found that the stereotype of scientists as white males has endured since 1957. Cheryan, Drury, and Vichayapai (2012) found that when undergraduate women interacted with computer science role models who fit stereotypical images of computer scientists, they had lasting negative impacts on their interest in computer science. This is particularly telling because these interactions only lasted for approximately two minutes. Brown (2019) discusses how stereotypes about scientists pervade society, even in popular television shows that depict scientists as white, awkward men, which can create barriers for some to identify with science.

Evans and her colleagues (1995) found that integrating female role models into science, math and technical curricula improved the attitudes of ninth grade students. Interventions aimed at changing attitudes towards scientists and women in science through visits from female scientist role models have been effective (e.g., Bohrmann & Akerson, 2001; Mason, Kahle, & Gardner, 1991). Students' lack of role models, particularly those who look like them and come from similar communities, can lead to a disassociation with science (Johnson, Brown, Carlone, & Cuevas, 2011). This, along with stereotypical images of scientists, can lead to students from minoritized populations as seeing science as 'not for me.'

Students should also have opportunities to learn about the cultural and historical contributions of minoritized populations, which is intertwined with the next section: what is science? For example, they should learn about Mae Jemison, the first African American astronaut, or the contributions of Persians to astronomy, and Indigenous communities to navigation. Representation matters. A Framework for Diversity and Equity in K-12 Science Educational Media emphasizes the importance of representing minoritized groups in their resources. Students need opportunities to expand their ideas about who does science.

2. Science representation: What is science?

Science is often represented as facts and numbers, and as a discipline, it is viewed as neutral, objective, and universal (Warren et al., 2020; Bang, et al., 2012; Bang, Marin, & Medin, 2018; Harding, 1986; Harding, 1997). In addition, both science and science education have historically focused on particular ways of knowing and doing science that is referred to as "Western science". This has led to a narrow view of what counts as science.

There are standards for observations and the reliability and validity of data. However, there is not one way to conduct science (National Research Council, 2012), science is not conducted in a vacuum, and there are multiple knowledges and ways of knowing (Warren et al., 2020). As

Harding (1998) asserts, there are many ways of organizing and producing knowledge.[12] "There exists no justifiable scientific or philosophic reason to restrict them to the small numbers that have been favored at particular times and places. The scientific method can be enhanced by our appreciation of the wealth of intellectual resources to be gained by valuing and promoting cognitive diversity" (p. 1600). [13]

Engaging with Multiple Perspectives in Science

Science is conducted according to norms and conventions that are determined by many contextual factors and build on existing methods and knowledge. Thus, decisions about what questions to investigate, how to study the questions (including what type of data to collect and how to collect the data), and interpretations of data are influenced by the knowledge, values, and experiences of the people conducting the science. How one person or group of people investigate a research question may vary from another group. Kuhn (1996) states, "What a man sees depends both upon what he looks at and also upon what his previous visual-conceptual experience has taught him to see" (p. 113).

First, personal, cultural, and historical context influences what questions to investigate. People may experience phenomena differently, depending on the climate, land formations, wildlife, etc. of where they live. For example, someone living in a coastal community facing rising sea levels may study and understand climate change differently than someone living in a landlocked state. Cultural practices may also influence how people understand science. For example, people who interact with land regularly for food (e.g., farming, fishing, hunting) may understand climate change differently than those who interact with land for recreational purposes. Another timely example lies in the differences in how women and men, people from different racial and ethnic backgrounds, and people of different ages experience Covid-19 differently. These differences are compounded by issues of place (e.g., population density, socioeconomic issues).

Second, context influences how scientists investigate questions. There are many instances of how scientific understandings have been developed based on data and studies of homogenous populations. This particularly true in the medical field. For example, the majority of asthma biomedical research has been performed on populations of European descent. However, a study found that only 5% of genetic traits linked to asthma in European Americans applied to African Americans (White, et al., 2016). There is also a history of mistreating minoritized populations in the name of science. In the Tuskegee study, Black men participated in a study of syphilis where they were studied without informed consent and were not given treatment for their disease (Center for Disease Control and Prevention, n.d.).

In addition, observations, which are a foundational aspect of science, are theory-laden; they are influenced by culture and social practice (Harding, 1995; Bang, Marin, & Medin, 2018). Bang,

[12] Harding argues for the importance of cognitive diversity, referring to how "The human intellectual repertoire consists of many styles and many ways of organizing the production of knowledge." (1998, p. 1600)

[13]1It is important to note that Harding put 'The' scientific method in quotes. While she does not explain why she places 'The' in quotes, presumably this is to signify that unlike how science is often taught in schools as there being a single scientific method comprised of a series of steps to follow to conduct science, there are actually multiple ways that scientists conduct science.

Marin, and Medin (2018) argue that cultural orientations can facilitate different interpretations of observations. They studied this by asking United States college students and Indigenous Panamanian Ngöbe adults to look at illustrations from a children's book on coyote and badger hunting. This study of college students and Indigenous Panamanian Ngöbe adults was designed based on the research of wildlife biologists. The wildlife biologists originally hypothesized that coyotes and badgers hunting in the same area competed for prey. After further observation, the biologists found that the badgers and coyotes often hunted cooperatively, which made them more successful in obtaining prey. Bang, Marin, and Medin found that the United States' college students interpreted the relationship as competitive, while the Ngöbe adults viewed it as cooperative. The two groups held different hypotheses about the relationship between coyotes and badgers, with the Ngöbe adults' hypothesis being in line with current understanding of the hunting behaviors of coyotes and badgers.

Finally, cultural and historical perspectives can influence how scientists interpret and represent data. For example, Darwin's view of the unity of life — the relationship among organisms — is represented by a branching tree, an image adapted from Victorian practices of tracing family lines and property inheritance (Bang, et al., 2013). In contrast, Helmreich's work in microbiology in oceans found that microbes engage in lateral gene transfer within generations across species and vertical inheritance over generations, leading to representations of the connections between species as a net. Both scientists''s representations of the relationship among organisms were influenced by their cultural and historical contexts.

It is important to note that recognizing the historical, cultural, and contextual nature of science is not an argument for relativism. As Bang and her colleagues state, "Lest we be misunderstood, we are not arguing for cultural relativism but for serious intentional engagement with understandings of nature-culture relations emerging within modern scientific fields." (2013, p. 315). As discussed earlier in this report, there are standards for scientific evidence and what constitutes valid and reliable data. However, decisions are made by curriculum designers, teachers, policy makers, and people in positions of power about what science students learn in schools and how that science is represented. The science students learn and how they learn often presents a very narrow view of science. In their research, Bang, Marin, and Medin (2018) show the importance of expanding ideas of science beyond Western science to include other sciences, such as Indigenous sciences.

Science is Dynamic

While science is often presented as static, it is in actuality constantly changing and evolving over time as we gain new evidence and ways of thinking about the world. Warren et al. (2020) point out that "this dynamic nature of disciplinary activity is routinely invisibilized in schools, where disciplines are flattened and engaged as if they are static, known, and finalized domains, not always evolving" (p. 7). The Next Generation Science Standards places an emphasis on science practices as a way to encourage providing students with opportunities to do science and to "minimize the tendency to reduce scientific practice to a single set of procedures…" (National

Research Council, 2012, p. 43). Asking students to learn science by having them use science practices is one piece of supporting students' understanding of the dynamic nature of science.

Furthermore, the science disciplines are heterogeneous; they involve asking different questions and using different methodologies to investigate questions (Bang, Marin, & Medin, 2018; Harding, 1997). In turn, these questions and methodologies are continually evolving (Kuhn, 1996). The Institute for Systems Biology, located in Seattle, Washington, is an example of an organization that crosses multiple disciplines and topics. Rather than limiting investigations through the lens of genetics, geneticists work with computer scientists, engineers, and mathematicians to map and visualize genomes in order to answer scientific questions. Through interdisciplinary approaches, scientists apply new perspectives, including methodologies, to investigate questions. Scientists increasingly work in interdisciplinary teams to solve today's problems, such as climate change, an issue that crosses traditional disciplinary boundaries.

It is important to provide students with images and understandings of science as heterogeneous and dynamic. Science should not be presented as facts to be memorized. Scientific data and theories can be analyzed and critiqued. Students should have opportunities to engage in science practices and study how theories change (Kuhn, 1996). For example, Barbara McClintock's discovery of transposable elements, or jumping genes, revolutionized previous understanding genomes as stationary (Pray & Zhaurova, 2008).

Access and Engagement: How do students learn science?

There are many barriers that prevent students from learning science. There are well documented inequities in physical resources, whether it is curricula or lack of equipment and tools such as microscopes, sinks, and computers, and in school spending per student (Kozol, 1991; Ladson-Billings, 2006; Banks et al., 2007).[14] Some students may face stereotype threat, the idea that certain students are academically and behaviorally challenged (Steele, 1997). Some may face language barriers, as schools offer varying levels and models of support for English Learners (National Academies of Science, Engineering, and Medicine, 2018).[15] Others may face cultural barriers, as the norms of science classrooms in the United States may differ from students' ways of learning in their everyday lives (e.g., Barnhardt & Kawagley, 2005; Lee, 1999).

GBH and other educational media producers can reduce barriers to access and engagement through designing diverse learning resources. Learning science does not involve just learning content. A major shift in the NGSS is the emphasis on teaching students science by having them participate in the practices of science, including:

---

[14] It is important to acknowledge that there are also inequities in other areas, such as teacher quality and class size. While media resources can help support teachers, they cannot address many issues related to class size or teacher quality without additional supports such as professional learning resources and professional learning opportunities.
[15] The National Academies of Science, Engineering, and Medicine (2018) *English Learners in STEM Subjects* report argues that STEM learning experiences can support English language development in English Learners. However, in practice, by the time they reach high school, English Learners are frequently sectioned into low-rigor, "EL-only" content courses or excluded from the core curriculum altogether (Tolbert et al., 2014; National Academies of Sciences, Engineering and Medicine, 2018).

1. Asking questions (for science) and defining problems (for engineering),
2. Developing and using models,
3. Planning and carrying out investigations,
4. Analyzing and interpreting data,
5. Using mathematics and computation thinking,
6. Constructing explanations (for science) and designing solutions (for engineering),
7. Engaging in argument from evidence, and
8. Obtaining, evaluating, and communicating information.

The NGSS was built on the premise that learning science involves integration of content knowledge and practices (NRC, 2012). It involves "… learning to think, talk, and act as a member of the science community. It also involves developing the values and beliefs shared in the science community" (Lee, 1999, p. 189).

Learning science can be perceived as similar to border crossing. Students crossing borders between their everyday lives outside of the classroom — their life-world — to the subculture of "school science" — the practices, values, and beliefs for what counts as science learning in the United States. As described in the previous two sections, school science is often guided by historically Western science ideals and white, middle class, formal schooling norms. Thus, learning science is a process of assimilation; where the culture of science is at odds with a student's life-world, the student is forced to abandon or marginalize her/his/their life-world. Science learning can also be described as a process of enculturation; where a student's life-world culture aligns with the culture of science, the border crossing is smooth (Aikenhead, 1996; Aikenhead & Jegede, 1999).

A deficit perspective frames the differences between students' life-worlds and science culture as barriers to overcome. In contrast, an anti-deficit perspective frames students' everyday lives as holding unique, valuable expertise from which to draw upon in learning science. Building on and making connections to students' everyday lives is consistent with the NGSS.

Connect to and privilege students' everyday lives in science learning

Throughout a student's lifetime, more learning takes place outside of schools than inside schools.[16] The wealth of knowledge, skills, and practices acquired outside of school should be valued in formal schooling (Banks et al., 2007). The research of Moll and his colleagues emphasize "funds of knowledge": the rich, historically accumulated and culturally developed bodies of knowledge and skills that individuals and communities hold (Moll, 1992; Moll, Amanti, Neff, & Gonzalez, 1992; Gonzalez, Moll, & Amanti, 2005). They worked with teachers to design curricula that leveraged their students' funds of knowledge from their everyday lives, including family, labor, and community practices. Similarly, Moje and her colleagues (2004) studied the funds of knowledge that students found in their social lives, including family, community, peer,

[16] According to their calculations, Banks and his colleagues (2007) found that the time students spend in school from grades 1-12 amounts to only about 18.5% of their time when calculated according to 16 waking hours a day.

and popular culture funds of knowledge. Mejia and his colleagues (2019) explored the relationship between students' funds of knowledge and engineering cultural practices (Mejia, Ruiz, Popov, Esquinca & Gadbois, 2019).

Others have also argued for the importance of viewing students' knowledge, skills, and practices as assets rather than deficits. Ladson-Billings proposed a culturally relevant teaching pedagogy, the goals of which include include: (1) academic success in school subject; (2) promoting cultural competence; and (3) helping students develop a critical consciousness through which they challenge the status quo (Ladson-Billings, 1995a, 1995b). By promoting cultural competence, this pedagogy privileges rather than attempts to overcome or eliminate students' cultures. By supporting students in developing a critical consciousness, this pedagogy also supports students in critiquing the cultural norms, values, and institutions that produce and maintain social inequities. Students should be able to critically apply their learning to real-world problems.

Gruenwald (2003) argues for the importance of place in education. State and national standards and assessments often work towards uniform, standardized curriculum that often neglect place, thus cutting off connections between school and students' everyday lives. Gruenwald states that when we pay attention to place:

> ...pedagogy becomes more relevant to the lived experience of students and teachers, and accountability is reconceptualized so that places matter to educators, students, and citizens in tangible ways. Place-conscious education, therefore, aims to work against the isolation of schooling's discourses and practices from the living world outside the increasingly placeless institution of schooling. Furthermore, it aims to enlist teachers and students in the firsthand experience of local life and in the political process of understanding and shaping what happens there. (p. 620)

Place is not limited to physical geography, but also cultural and ecological context. Thus, place-based education can prevent the marginalization of students' life-worlds. Place-based education has also been shown to increase academic achievement (Sobel, 2004). For example, after a school district in Louisiana implemented a place-based approach to science learning, students' performance on state science assessments significantly improved.

Research has long shown that students learn science when they are able to connect to and build on their interests, knowledge, and experiences from their everyday lives. Rosebery, Warren, and Conant (1992) showed that when English Learners were able to work towards goals that were meaningful to them, they not only learned to think and talk in scientific ways, but also to understand the kinds of knowledge, reasoning, values, and assumptions embodied by science. Calabrese Barton and Tan (2009) found that incorporating students' everyday knowledge and practices into a middle school food and nutrition unit increased active engagement in lessons and ultimately deepened learning. Tsurusaki, Calabrese Barton & Tan (2013) found that when a teacher used transformative boundary objects to bridge science and students' everyday experiences, students were able to use their understanding of science to make informed decisions about real-world problems.[17] Wright (2019) found that when youth were able to use drawing and signifying as part of a collaborative critique process, they both learned the target science concept and engaged in scientific practices.[18]

In building curriculum resources, developers should similarly consider opportunities for including students' personal, cultural, and community contexts.

Extending beyond connecting to students' everyday lives

More recent work on culturally sustaining pedagogies builds on Ladson-Billings work, and calls for teaching to not just promote students' cultures, but to sustain their communities' cultural ways of being (Alim & Paris, 2017; Ladson-Billings, 2014). Alim and Paris (2017) argue that this is critical because of the new K-12 educational context in the United States; 2014 was the first year students of color were the numerical majority in United States public schools. With increasing globalization, the argument for culturally sustaining pedagogies is not only about valuing communities, but also about preparing students to be productive in this new world. Alim and Paris state:

> We cannot continue to act as if the White middle-class linguistic, literate, and cultural skills and ways of being that were seen as the sole gatekeepers to the opportunity structure over a quarter-century ago have remained so or will remain so as our society changes. Simply put, the future is a multilingual and multiethnic one, regardless of attempts to suppress that reality. (2017, p. 6)

Calabrese, Barton, and Tan (2018) provide examples of culturally sustaining pedagogy, which centralize and leverage minoritized youths' ways of learning to challenge existing issues in their communities. They investigate what it means for youth of color, growing up in low-income communities, to engage in sustaining experiences that position them as competent, value their experiences, ideas, and identities, and support their STEM learning experiences. They argue for consequential learning experiences, in which youth investigate issues that are important to them and their communities.

Bang and her colleagues (2013) argue that science education should challenge canonical, Western representations of science that can alienate students from minoritized communities. They investigate the nature-culture divide in Western science, which presents nature as separate from culture. For example, Western science classifies objects and organisms into living and nonliving; according to this classification, water and sun are non-living. In contrast, Indigenous perspectives view things like water and sun as living. By questioning the Western

---

[17] *Transformative boundary objects* are science and everyday tools, such as graphs, nutrition labels, and pedometers that connect science and students' everyday lives, leverage students' experiences in ways that acknowledge their importance, deepen their understanding of and contextualize their science learning, and helps students understand the relevance of the science to their everyday lives and allows them to critically analyze the science and its relationship with their everyday practices.

[18] *Signifying* is a co-constructed, cultural way of communicating with roots in the Black community. It's a linguistic practice that can be characterized as playful confrontation, such as playing the dozens or joining, in which participants exchange pointed and witty banter and boasts (Wright, 2019).

science classification system and how it presents relationships in ecosystems, students are freed to draw upon their own experiences (e.g., how water is used in their communities) to gain deeper understandings of the relationships and roles of objects and organisms. By engaging with diverse meanings, students can engage more meaningfully in culturally sustaining ways that help them learn science.

Ultimately, science curricular resources need to reflect the heterogeneity, cultural and historical perspectives of science.

Science language, language, and learning

Finally, it is important to examine the role of language in access to learning science. Students, especially ELs, may be confused by polysemous words, or words that hold multiple meanings. (Crossley and Salicky, 2019). Moje and her colleagues (2001) found that the polysemy of the word "quality" led to confusion when students learned about water quality and air quality in a science unit. "Quality" differs in meaning depending on context. For example, the "quality" of water and air, as measured by scientists, may be different from how people think about "quality" in their everyday lives.

Yet, it is problematic when teachers try to teach students "science vocabulary" before providing students with any opportunities to learn science. When students are expected to memorize definitions without any experience with the science phenomena, they cannot contextualize their understanding of the vocabulary. Warren and her colleagues (2001) showed how using everyday talk while doing science is an important part of learning science and should not be discounted. Brown (2019) studied the challenges students face when trying to learn the vocabulary and language of science at the same time as learning the content and practices of science. He argues that the language of science should be disaggregated from the learning of science and that the language of science needs to be explicitly taught after students explore the science content.

Another challenge is that disciplinary vocabulary is often defined by other disciplinary vocabulary, which teachers do not always explain, or even by non-disciplinary words that students do not recognize (Snow, 2010; Harmon et al., 2005). This prevents students from accessing concepts. By ensuring that students first experience science phenomena (visually, etc.), teachers can then refer to the phenomena as a piece of non-linguistic context with which to explain the disciplinary language of science.1

Students' language is often framed as a deficit, whether it is cultural ways of talking or when English is not their native language. Schools normalize ways of using language (Orellana & García, 2014), including which language(s) are used and what language is considered correct. For example, students may not be allowed to speak another language in schools besides English, or to use other ways of communicating such as signifying. Even if other ways of communicating are allowed, they may not be acknowledged as useful for learning. However, research has shown that language in all its forms – colloquial, bilingual, multilingual – can be an asset to learning (e.g., Warren et al., 2001; Wright, 2019; Lee, 1995). Indeed, restricting the ways that students are allowed to talk can limit students' opportunities to learn (Hudicourt-Barnes & Ballenger, 2008). Learning science and the academic language of science is made more difficult when students are not able to draw on all of their rich language practices.[19] Hudicourt-Barnes and Ballenger state:

> Different households and communities value different knowledge and sense-making practices. However, regardless of their household or community values, all children come to school knowing how to effectively interact with the adults and other children in their lives, how to learn new ideas and practices, and how to use what they know toward purposeful ends. (pp. 21-22)

Students' language practices should be viewed as an asset. Students should be able to draw on all of their language resources to learn. Translanguaging argues that education should acknowledge and work with all of the language practices students bring to learning (Orellana & García, 2014). García, Johnson, and Seltzer (2017) argue for a translanguaging stance that includes three core beliefs.[20]

1. Students' language practices and cultural understanding include those from their home and communities and those they acquire in school and these work together and enrich each other.
2. Students' families and communities are valuable sources of knowledge and should be included in learning in school.
3. The classroom should be a space where teachers and students work together to create knowledge, challenge traditional hierarchies, and work toward a more just society.

Thus, translanguaging allows all students to participate in learning, rather than alienating students who may have different language practices than those traditionally accepted. In addition, translanguaging privileges students' language and cultural practices, and challenges the notion that "...a monolingual version of society and breaking the socially constructed *fronteras* that stand between languages and create hierarchies of power" (p. 14).[21] In this way, translanguaging supports bilingual students' identities, socioemotional development, and promotes language sustainability (García, Johnson, & Seltzer, 2017; Orellana & García, 2014).

Summary

Students bring a wealth of knowledge, practices, and experience that they can use to not only make connections to science, but also to help them make sense of science, which includes all of their rich language practices. Thus, in order to broaden access and participation and deepen

---

[19] *Language practices* are the ways of communicating through language. Language practices may include ways of communicating outside of school that are accepted that may not often be acknowledged in school, such as languages other than English or non-standard forms of English, such as signifying, slang, or pidgin (also called more formally Hawaiian Creole English), an everyday way of communicating used in Hawai'i.

[20] *Translanguaging* is a theory that bilingual youth are not going from one language to another, but instead they are drawing from a linguistic repertoire, or language system, that allows them to use all of the language features in their repertoire to learn and communicate.

[21] *Fronteras* means borders.

engagement in science learning, students should be provided with experiences that allow them to make connections to their everyday lives and provide students with a "rightful presence" (Calabrese Barton & Tan, 2020). In developing science educational media, developers must recognize that there is more than one way of knowing and doing science, and consider opportunities for situating learning in contexts that matter to students and their communities.

Part II. Practices that Support Diversity and Equity in K-12 Science Educational Media

Part II focuses on practices that support diversity and equity in K-12 science education. While many practices are related to teaching and pedagogy, this report translates these practices into implications for the design of educational media resources. In this report, media refers to any curricular resources that might be hosted on a digital platform, such as: videos, interactives, lesson plans, Teaching Tips, Background Reading, and other support materials.

All the practices outlined in Part II are identified to support an overarching anti-deficit approach, and are organized by the following themes:

1. Representation: Who does science?
2. Representation: What is science?
3. Access and Engagement: How do students learn science?

For each theme, we present supporting practices and provide explanations. For Themes 2 and 3, we also provide examples. While organized by theme, the practices are intertwined and should be considered as a whole in developing the best possible media resources.

It is important to recognize the role that teachers play in selecting resources, facilitating how those resources are used, and supporting student learning. While developers can design media to support equitable learning, teachers also need training in how to implement equitable teaching practices.

Representation: Who does science?

Key Practice: Students should see themselves reflected in media resources.

This may be through representation of scientists with similar backgrounds (e.g., race, ethnicity, socio-economic status, English Learner, etc.) or who have similar interests, values, and cultural practices. This can include not only diverse images of professional scientists, but also images of youth and communities doing science, including intergenerational groups doing science together. Media resources can be used to expand students' exposure to and ideas of who does science.

Media representation plays an important role in shaping our ideas about society, including how we understand social constructs such as race and gender (Brooks & Hébert, 2006). Research in literacy has found that children who are exposed to literature that feature characters that look like them and whose life stories mirror their own experiences and culture increases motivation and achievement (Hughes-Hassell, Koehler, & Barkley, 2010). Diverse images and stories of scientists are important to counteract stereotype threats and negative associations with science due to stereotypical ideas of scientists. Cheryan and her colleagues (2013) found that women who read fabricated newspaper articles about computer scientists who did not fit stereotypes expressed more interest in computer science than those who read that computer scientists fit stereotypes. Much work needs to be done to broaden students' images of scientists.

While more diverse images of people who do science should be included, it is important that these images are authentic and do not essentialize or reinforce stereotypical ideas related to race, class, gender, etc.

Science Representation: What is science?

Key Practices:

1. Media resources should show the diverse processes and practices of science.
2. Media resources should show the varied ways of doing science, including the cultural and historical nature of science.
3. Media should prompt students with opportunities to engage in science practices.

Science is not about memorizing facts. It is about asking and investigating questions about how the world works. Thus, media resources should avoid presenting science as facts or theories. They should include how phenomena are investigated, how theories are developed, how science knowledge evolves, as well as contextual factors that influence these processes such as location, time, prior knowledge, and culture.

Media resources should also demonstrate the practices of science and provide students with opportunities to engage in the practices of science. Schwarz, Passmore, and Reiser (2017) state:

> An observer should be able to walk into a science class on any day and ask a student, "What are you trying to figure out right now?" The intellectual aim of any work in the science class should be clear to everyone. Rather than stating, "We are learning about photosynthesis or plate tectonics," students should be able to say (and believe!), "We're trying to figure out how the tiny seed becomes this huge oak tree" or "We're trying to better understand why volcanoes and earthquakes happen more often in some parts of the world." These examples illustrate how the students are figuring out the world and illustrate a sense-making goal in the classroom. (p. 7)

Science education should not be about solely the content, but also about how students are learning about a science concept through doing science. It should include using science practices to investigate questions. *A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas* (National Academies of Science, 2012) identifies eight practices, used in the Next Generation Science Standards (NGSS Lead States, 2013):[22]

[22] The *Next Generation Science Standards*, or *NGSS* are K-12 science education standards that were released in 2013. The *NGSS* are not a curriculum, they are a set of standards used to guide curriculum development, teaching, and learning in K-12 science education.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Finally, media resources can show the historical and cultural nature of science and how different perspectives can influence science. It can show multiple perspectives of science concepts and how scientists approach and investigate questions in similar and different ways. This will help students see the heterogeneous nature of science and how theories and scientific understanding is not static; it changes over time as we gain new information and ways of investigating questions.

As previously mentioned, the ways in which teachers acknowledge and respond to students' questions and ideas are critical in shaping what and how students learn science. While digital media may not be able to respond to students' ideas and questions in the ways that teachers can, they can be designed to provide opportunities for students to draw on their own knowledge and experiences.

Example 1

In his work with youth who were learning about the transmission of sound, Wright (2019) designed learning experiences where equal attention was paid to developing students' scientific knowledge and practices. The youth were engaged in developing and using models (Practice 2) and developing and engaging in argument from evidence (Practice 7). Instead of presenting models of how sound travels to the students, Wright asked the students to draw on their experiences with sound to develop, critique, and refine models of the transmission of sound. This allowed the students the opportunity to use their own knowledge, skills, and experiences to create a scientific model, then refine it based on evidence.

Application: Rather than just showing a model, the media resources can show how a model is developed or provide students with the opportunity to develop a model. Or, when showing a model or asking students to use a model, the media can provide students with information about how the model was developed (e.g., where the data came from, what factors were considered in creating the model, etc.). Media might also prompt students to analyze a model and examine multiple models of a phenomena to learn about how models are developed and used, including their affordances and limitations.

Example 2

Bang and her colleagues (2017) worked with Native American middle school-aged students and their teachers to investigate the biological and ecological health at a local forest preserve. During their investigation, students engaged in asking questions

(Practice 1), planning and carrying out investigations (Practice 3), constructing explanations (Practice 6), and engaging in argument from evidence (Practice 7) in order to learn science concepts, including: the interdependent relationships in ecosystems; ecosystems dynamics, functioning, resilience; and biodiversity. The teachers supported students' in drawing upon their own community histories, values, and practices to learn science. The students learned about the process of science and how scientific knowledge is created, rather than learning about science as facts. They also learned that there are different ways of knowing. In this case, Indigenous perspectives of humans as being "part of" the natural world challenged Western ideas of science which position humans as separate from their environment. When only one way of knowing is represented (typically Western science), this often alienates students from minoritized populations who do not see their values and perspectives reflected in that way of knowing.

Application: Media resources should represent multiple cultures and ways of knowing. For example, developers can use video(s) to show multiple representations. When this is not possible, media resources can offer guidance for teachers to contextualize learning within their own communities and/or to show other representations in multiple communities. Media resources should also provide opportunities for students to engage in science practices. They can show how there are multiple ways to investigate questions and how context, history, and cultural practices influence science.

Access and Engagement

Key Practices:

1. Media resources should consider the place and context of learners.
2. Media resources should provide context for why students should learn about the science phenomena that are relevant to their lives.
3. Youth and communities should be involved in the process of developing media resources.

Media can provide a variety of places and contexts for science phenomena to show what the phenomena looks like in different settings. While it may be difficult to create resources for every possible place and context, media can be designed to prompt students to investigate phenomena in their contexts and consider its relevance to their lives. For example, when examining weather, students can compare the temperature of their school, homes, or places they have visited. Or, students learning about seasons can investigate the differences between how seasons look in their community compared to other parts of the world.

A strategy for developing media resources that are relevant to students' lives is to involve students and their communities in the development of media resources. Students and their communities can be involved in a variety of ways, whether by surveying students and communities about their interests and needs, involving them in co-design throughout the process, or providing opportunities for them to provide feedback on resources. Bang and her colleagues (2017) worked with community members, elders, and teachers to ensure that curriculum not only addressed NGSS practices and concepts but also was grounded in cultural practices and local context.

The examples below demonstrate learning experiences in which students were able to connect science to their everyday lives and context.

Example 1

Calabrese Barton and Tan (2018) provide examples of the importance of place and context in their work with youth in makerspaces.[23] In one example, they work with primarily African American youth, aged 11-16, to design a makerspace. While makerspaces have the potential to engage diverse audiences, the maker movement remains largely a white, adult, middle-class pursuit. The youth investigated existing examples of makerspaces, conducted interviews, analyzed their findings, communicated their findings through video, then presented their video and design to the community. In their investigation, they found that most makerspaces were designed from an adult perspective that did not feel welcoming to the youth. For example, tools were too high or locked up and the spaces were not colorful. The youth took these factors into account when designing a more welcoming space. They also included: big, mobile tables that could be moved for collaboration; places to display projects in ways that invited the community into the space; and space for youth to take breaks or think. Importantly, the youth wanted a makerspace where they could make things to "save the world," not just a place to tinker. They had a specific vision and purpose for the space.

Application: Like a makerspace, educational media resources should be designed with the end user(s) in mind. What aspects of a media resource will appeal to teachers? And once used by teachers in the classroom, what aspects will engage students? Media producers might also consider, as Calabrese Barton and Tan did, including students and communities as co-designers in the resource development process Media resources should pay attention to place and context, as they are important motivating factors for students.

Example 2

In a study of middle school students learning about dynamic equilibrium (energy in/energy out) in the human body, a teacher used a curriculum designed to leverage and ground the curriculum concepts in students' experiences (Tsurusaki, et al., 2013). For example, the students collected data on their daily food intake and compared their results to the U.S. Department of Agriculture guidelines such as MyPlate (which replaced MyPyramid and the Food Guide Pyramid.) They also examined factors that influenced their food intake through mapping their neighborhoods, investigating food options (e.g., fast food, convenience stores, fresh food options), biological factors that influence taste, and social influences such as food commercials. They examined food labels in their homes and critically analyzed the role of science in society, community practices around

[23] *Makerspaces* are spaces that may be in schools, libraries, community centers or other spaces that contain tools for making, learning, and exploring. These spaces may be for youth and/or adults and may contain specialized equipment such as 3D printers, laser cutters, sewing machines or general materials such as construction paper, scissors, and glue. They are spaces where participants can "make" or create something.

food. Finally, they made recommendations for their peers and community for eating and activity practices that fit with their lives.

Application: Media should ground curriculum concepts in students' lives and connect learning to societal impacts. For example, media resources supplementing the unit just described could include interactive neighborhood maps, digital journals to record food labels in the home, and short videos covering societal connections such as food deserts, neighborhood design, and food advertising.

Example 3

Schwarz, Passmore, and Reiser (2017) provide two examples of studying Moon phases to demonstrate the difference in student learning when it is grounded in students' experiences and when it is decontextualized. In the first example, the teacher tells the students about the phases of the moon and lists the eight phases. Then, she provides facts about Moon phases, e.g. the relationship between the Sun, the Earth, and the Moon. Finally, she instructs students how to demonstrate a Moon phase using a Styrofoam ball (Moon), blue ball (Earth), and flashlight (Sun). In this example, the teacher provides the guiding question: why does the apparent shape of the Moon change?

In the second example, the students record the shape of the Moon and discuss why the Moon appears at some times of the day and not others. From their observations, they learn that it takes 28 days for the Moon to complete a cycle as it orbits the Earth and brainstorm why the shape of the Moon changes as it orbits the Earth. Rather than telling the students how to model the Moon phases, the students participate in the development of the model. In this example, the students and teachers co-construct the guiding question.

These two examples show how the same concept, the Moon phases, can be taught in two different ways. There are two important distinctions in these examples: 1) where the questions came from and 2) who was involved in figuring out how to investigate the question. In the first example, the teacher decided the question and the students were given directions to investigate something they had already been shown. In the second example, the question was co-constructed, guided by the teacher and the students' observations of the Moon and the students co-constructed the investigation of their question.. The second example shows how the Moon phases can be grounded in the students' observations, which makes the learning more relevant to them than how they were taught the Moon phases in the first example.

Application: Rather than delivering informational "facts" about science concepts, the media should provide students with the opportunities to ask questions, make observations, and construct models. For example, media might include sped-up videos of the moon over a month so that students can more quickly observe the changing shapes of the moon over a month. Accompanying materials, such as lesson plans and student handouts should scaffold students asking questions and the process of planning and carrying out investigations.

Key Practices:

1. Media resources should provide multiple ways for students to engage with materials.
2. Media resources should allow for students to use multiple ways to show their understanding. (e.g., storytelling, visually, etc.)

Media resources should include probing questions and scaffolding questions to address multiple ways of knowing.[24] Rosebery and Warren (2008) use science talk as a way to provide students with ways to:

- think about how an idea or perspective fits into their understanding of the world;
- identify and build connections between what they already know and what they are being asked to learn;
- raise and explore questions;
- and learn from one another (p. 5).

Media should also offer multiple ways for students to engage in discourse. Media resources can build in examples of scientists (professional scientists or students) working individually, in small groups, and in larger groups to do science. Finally, media resources should allow multiple opportunities for students to explore a concept and provide various ways that students can explain their understanding (e.g., drawings, graphs, models, writing, video). While these, as well as other practices in this section, are good strategies to engage all students, it is important from a diversity and equity perspective in science education because oftentimes there are certain, white, middle class, Western ways that are considered the appropriate way to learn science. Broadening what counts as learning science, such as various ways of talking and sharing science (e.g., storytelling, signifying), expand opportunities to learn in ways that validate students' ways of learning and being. This is particularly important for minoritized students, as their experiences may differ from white, middle class, Western ways.

Example 1

In a science talk about plants, a student asked if plants grow every day. The students discussed how the human eye cannot always see growth, and asked questions about what growth feels like to plants and humans (Rosebery, Warren, 2008).

Application: While teachers play a critical role in facilitating science talks, especially in ways that accept and build on students' ideas, media resources can provide probing questions and scaffolding questions to address multiple ways of knowing.

Example 2

The table below[25] demonstrates how different activities can provide students with opportunities to draw on language and multiple competences to make meaning of a

[24] Probing questions and scaffolding questions are questions that help support student learning. They are questions that ask students to think more deeply about an idea, topic, or practice and/or make connections to other experiences or topics. They can be questions that ask for clarification of an idea, topic, or practice. Questions can become more challenging in order to build on, or scaffold, students' experiences as they interact with the media resource.

[25] Source: National Academies of Sciences, Engineering, and Medicine. 2018. English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives. Washington, D.C.: The National Academies Press.

disciplinary concept.[26] In this example, students are learning about division with fraction. They begin by exploring the problem using manipulatives in a small group (Context 1), share their learning with the class (Context 2), individually write about their learning (Context 3), and finally try to use the discipline's technical language and mathematical symbols.

TABLE 3-1 Shifting Registers in Mathematics Activities While Holding Content Constant

Context	Context 1	Context 2	Context 3	Context 4
Modalities	Spoken by a small group of students with accompanying action or gesture	Spoken by a student about the action, after the event	Written by a student	Written using equations in the textbook
	S1: Mark it like this S2: No, try this way S1: Ok, count those . . . 30 S2: the tarts all need 2; 30 divided by 2 S1: 15	S1: We drew the 10 peaches and then cut each 1 into 3 parts. Then we counted all the parts. So it was 30 parts, and each tart had to have 2 parts, so we divided 30 by 2 and got 15.	When you want to find how many thirds there are, you can divide each peach into 3. When you count how many thirds, you get 30. Since each tart needs two thirds, you can divide 30 by 2 and get 15. That means that Sophia can make 15 tarts.	To divide a whole number by a fraction, multiply the whole number by the reciprocal of the fraction. $10 \div (2/3)$ $= 10 * (3/2)$ $= (10*3)/2)$ $= 15$
Relationship	Peer-to-peer, face-to-face interaction	Reporting on behalf of a small group	Individual written production for the teacher	Author writing for a remote audience of learners
Content	Solving a fractions division problem	Solving a fractions division problem	Solving a fractions division problem	Solving a fractions division problem

Application: Media should provide students with multiple ways to investigate concepts independently, in smaller and larger groups, and through use of manipulatives, talk, and writing in ways that scaffold learning. This might take the form of various creation and reflection technological tools, *discussion prompt*s, or digital manipulatives.

Key Practice: Media resources should provide students with experiences with science practices and phenomena before introducing the academic language of science.

The academic language of science needs to be explicitly taught; however, students should first be able to explore science learning using their everyday language. Specifically, Brown (2019) suggests scaffolding science learning:

1. Pre-assessment – identify context in students' lives that will support understanding of concept, and find out what language resources they use to describe science ideas
2. Introduce science ideas in simple, everyday language
3. Introduce new academic language
4. Multiple opportunities to use new language (p. 113)

Only after they have explored phenomena using existing assets, including everyday language and experiences, should academic language then be introduced. We cannot expect students to learn the academic language of science without explicitly providing instruction about the academic language of science. As Gee (2008) states, "Immersion in practice is not, however,

[26] Source: National Academies of Sciences, Engineering, and Medicine. 2018. English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives. Washington, D.C.: The National Academies Press.

enough. The learning environment must be structured to be rich, ordered, and redundant enough so that learners can make good guesses about what these new forms of language mean and can do" (p. 67).

Example 1
Brown and Ryoo (Brown, 2019) found that students who were taught science using everyday language first, and then learned the new science terminology through explicit language instruction, had greater gains in their science learning than students who learned the new science ideas and new science language at the same time. Brown also found that when students were taught about a science concept using complex language, they were slower to recognize patterns and the complex science language produced a negative impact on students' ability to focus compared to the students who were taught using simple science language.

Example 2
Warren, Ballenger, Ogonowski, Rosebery, and Hudicourt-Barnes (2001) showed how students used their native/first language and switched between their native language and English to learn science, arguing that: "Their familiarity with each other and their deep knowledge of their first language allowed them to joke and tease on the one hand, and probe meanings and imagine change in insects and in people on the other. We do not see these everyday ways of talking and theorizing as in opposition to scientific ways, or even as fully distinct from them. They seem clearly to be resources that support deep intellectual engagement" (p. 537). When learning about metamorphosis, the students' everyday ways of talking and thinking supported them in talking and learning about growth and development. In contrast, having to think or talk using academic science, which may have limited their ability to make sense of the phenomena.

Application: Media should begin with everyday language and encourage students to use their languages and experiences to make sense of science questions, concepts, models, etc. In addition, media resources are particularly situated to include different languages, experiences, and modes, such as storytelling (Warren et al., 2001) or arguing (Wright, 2019). Media resources can also encourage students to use all of their available resources to learn science (e.g., translanguaging). Finally, Media resources should also provide youth opportunities to practice using the scientific language in ways that support their understanding of the science.

Summary

The practices in this report support diversity and equity in K-12 science education. The practices can be used to guide development of educational media resources that support the goal of creating culturally sustaining science education opportunities that not only lead to more diversity and equity in science and science education, but also sustain diversity in our society. Additionally, teachers may use these practices to help them select and implement resources to support equity and diversity in their science teaching.

Part III. Review of Media Resources

We conducted a review of "exemplary" media resources that exemplify aspects of diversity and equity to provide insight into the development of Design Principles for Diversity and Equity in K-12 Science Educational Media (Part IV).

In the course of reviewing media, it soon became apparent that no one media resource will meet all aspects of diversity and equity. Rather, media resources can augment specific aspects of diversity and equity in teaching and learning. The following resources were selected as exemplars because they *exemplify at least one key theme* of Diversity & Equity in K-12 Science Education, previously discussed: 1) representation, 2) science representation, and 3) access and engagement. They were also selected to span a diversity of audience grade bands and age groups.

This chapter is divided into two parts by resource type. The first part examines eight videos. The second part examines other types of resources, including activities, lesson plans, student handouts, and virtual reality tours. Each individual resource is analyzed through an anti-deficit perspective. In addition to identifying the resource's strengths in terms of diversity and equity, the analysis will also identify opportunity points, or aspects where the material(s) could be improved to better support diversity and equity.

The review of the media resources in this section helped inform the development and revision of the *Design Principles for Diversity and Equity in K-12 Science Educational Media*, introduced in the next section of this report.

Review of Media Resources: Video

This section includes a review of videos. It does not include a review of any accompanying materials, such as lesson plans or student handouts. Overall, video was found to be a media form that offered ample opportunity to show diverse representation of people doing science, demonstrate science practices, and increase accessibility through multiple means of conveying and representing information (visuals, audio, closed captioning). However, generally videos require additional resources or contextualization to help learners make connections between scientific phenomena and their own lives.

<table>
<tr><th colspan="2">K-2 Grade Band Videos</th></tr>
<tr><td>Sesame Street
PBS KIDS,
Produced by
Sesame Workshop

Cookie Monster's Museum Mystery, Season 49, Episode 35
https://pbskids.org/sesame/videos/watch-full-episodes#</td><td>Strengths
Representation: Who does science?
● Variety of characters in different sizes and shapes
● Variety of races and genders represented

Access and Engagement
● Closed captioning available
● Variety of modes of engagement – skits, singing
● Viewers are encouraged to make their own art
● Shows how various youth and adults are artists and shows them creating art in different ways
● Explains the role of a curator at a natural history museum
● Shares that viewers can build their own dioramas at home

Opportunity Points
Characters could prompt more connections to students' experiences with museums, animals and their habitats.</td></tr>
<tr><td>Ready, Jet, Go
PBS KIDS,
Produced by Wind Dancer Films

A Kids' Guide to Mars, Jet 2 episode
https://mass.pbslearningmedia.org/resource/ready-get-go-exploring-mars/exploring-mars-ready-jet-go/

In this episode, the adults and kids are updating a book on Mars.</td><td>Strengths
Science Representation: What is science?
● Shows how scientific knowledge changes (e.g., updating the Mars book)
● Shows the process of science – the kids and adults are doing science by collecting data (taking photographs)
● Discusses questions scientists on Earth are asking about Mars and how they investigate the questions (e.g., What's under the surface of Mars? Scientists use robots dig and investigate underneath the surface)
● The characters talk about the process of science (e.g., how to investigate a question)
● They include scientific knowledge (e.g., atmosphere of Mars is different from atmosphere of Earth)

Access and Engagement
● Closed captioning available
● Uses a combination of visuals and talk when explaining about Mars (e.g., Face and Face are two television/computer monitors – one talks while the other shows visual images)
● Includes definitions for words such as "atmosphere" in the context of learning about the atmosphere</td></tr>
</table>

	● Adults take up and validate youths' questions as interesting and relevant and respond to them (e.g., "Do you think this was part of a martian house once?" "We don't really know what's under the surface of Mars. That's one thing scientists on Earth are trying to learn about.") ● Adults position youth as possible future scientists ("That's what scientists on Earth are exploring. Maybe you'll be one of them yourself one day.") **Opportunity Points** Could discuss why it is important to learn about Mars and how learning about Mars might impact people living on Earth.
Molly of Denali PBS KIDS, Produced by GBH *Bird in the Hand/Bye-Bye Birdie* https://pbskids.org/molly/videos	**Strengths** *Science Representation: Who does science?* ● Includes Alaska Native youth and representation of people from various race and ethnicities ● Molly, her friend, and the scientist are female ● Includes Native stories about birds *Access and Engagement* ● Closed captioning available ● Engages viewers through starting with investigating a "ghost", which turned out to be a bird – interesting storyline ● Molly and her friend are interested in birds and get to go on a birding research trip ● Models how to figure out what a word means by breaking it down into parts and trying to identify the parts of a word (e.g., cavity is like something that someone has in their teeth, but means something different in this context; cavity is similar to cave or hole) ● Introduces and explains science language (science words such as puffling) **Opportunity Points** The episode could include more about the scientific question(s) characters were answering by collecting the bird data.

3-5 Grade Band Videos	
Rainforest video California Academy of Science https://www.youtube.com/watch?v=LHPuo0rwM1w	**Strengths** *Representation: What is science?* ● Shares process of science – what scientist does, shows data so students watching the video can learn about species diversity ● Discusses why it's important to study species diversity ● Discusses that there are many unanswered questions – science doesn't have all the answers ● Asks students to analyze data (graph) *Access and Engagement* ● Closed captioning available ● Well supported visuals that show students concepts/storyline of video ● Graphics added to video to show concepts – mix of video, graphs, tables

<table>
<tr><td></td><td>

Includes built in pauses for students to discuss or think
Asks students, with their classmates, to investigate biodiversity. They are asked to sample each forest layer, record the number of species found and at what height, and look at their field notes
Prompts students with questions

Opportunity Points

There are lots of species and possibly new words introduced that could be explained (e.g., camouflage, tender leaves, species richness) or did not need to be included. While some words were explained, they could have been defined multiple ways, e.g. visually.
Could ask the viewers to reflect on the similarities and differences between tropical rainforests and their local habitats
Could include more information about the role the rainforests play in peoples' lives, including culturally and historically

</td></tr>
<tr><td>Can Animals Predict Disaster? (Indian Ocean Tsunami)
PBS Nature, Produced by Thirteen/WNET

https://www.youtube.com/watch?v=_lywIBZHEjg

(This review relates to the first 3:07 minutes that can be freely accessed on YouTube and not the entire video)</td><td>
Strengths
Representation: Who does science?

Using observations from people and scientists as valid data to inform scientific research
People from the communities by the tsunami impacted represented
Includes a wildlife tracker and ecotourism guide

Access and Engagement

Closed captioning available
Engages students in a real-world question (can animals predict natural disasters)
Shows video/visuals of tsunami and impact on villages in India

Opportunity Points

The narrator, wildlife tracker, and ecotourism guide are all male. The video could include a more diverse cast.

</td></tr>
</table>

<table>
<tr><td colspan="2">6-8 and 9-12 Grade Band Videos</td></tr>
<tr><td>Bill Nye the Science Guy
Produced by KCTS Seattle

Season 1, Episode 15
https://www.youtube.com/watch?v=a9z-aGB3atg</td><td>
Strengths
Representation: Who does science?

Shows youth who look to be from various races doing science, not evident what their backgrounds are other than what can be inferred from their appearance
Shows a Black scientist working with youth conducting research on fish

Science Representation: What is science?
Includes diverse scientific history related to seasons, e.g. role of Foucault's pendulum in understanding seasons; ancient cultures who created a calendar recognizing the moon's phases

Access and Engagement

Closed captioning available

</td></tr>
</table>

<table>
<tr><td></td><td>

Presents why learning about seasons is important (affects everything on Earth)
Presents information multiple times in multiple ways (e.g., scientific models of seasons, raps, game show style)
Pays attention to context by showing how seasons look different in different parts of the world
Connects science phenomena to students' lives
Students are given ideas about how they can investigate time and seasons at home (e.g., create their own sundial)

Opportunity Points
This episode focused on providing explanations through models. It could be improved by asking student viewers to investigate questions, collect data, and use and/or develop models to investigate their questions
</td></tr>
<tr><td>MythBusters Jr.
Discovery, Produced By Beyond Television Productions

Duct Tape Special

https://www.youtube.com/watch?v=_EV76EPrfSc</td><td>
Strengths
Representation: Who does science?

Youth are central to the episode; they design and conduct the experiments
Youth are introduced, including where they are from, their role (e.g., inventor, programming whiz, welder, builder/designer) and their interests (e.g., wants to be an astronaut, gymnast). They represent a range of geographic locations, interests, and backgrounds.

Science Representation: What is science?

Investigates questions they do not know the answers to
Shows the process of investigating a question, from planning the investigation to collecting and analyzing data.

Access and Engagement

Closed captioning available
Investigates questions that are potentially engaging and interesting to youth
Youth design and investigate myths
Shows multiple purposes and investigations for duct tape

Opportunity Points

Could include history and culture of materials and why they are used
Some of the language used (e.g., efficacy, pneumatic tires) could be explained

</td></tr>
<tr><td>MythBusters - Discovery
Discovery, Produced By Beyond Television Productions

Was the moon landing faked
https://www.youtube.com/watch?v=zPj60sy9Cfw</td><td>
Science Representation: What is science?

Investigates phenomena/myth
Shows the process of developing an experiment to test if the moon landing was faked
Develops a model and talks about how they created the model
Takes photos as data

Access and Engagement

Closed captioning available
Bases investigations on real world ideas about something
Explains science language (e.g., albedo – the reflective quality of a surface) – and uses it more than once

</td></tr>
</table>

	Opportunity Points • Could explain the historical context of the moon landing and why it is important to prove the moon landing occurred. • This clip only shows the two main characters, both white males, aided by a male commentator. Representation could be improved.

Review of Other Resources

This section includes a review of a variety of types of educational resources, such as activity sheets for families, lesson plans, student handouts, and virtual reality tours. Overall, non-video media afforded more opportunities for learners to draw connections between scientific phenomena and their own lives, and to delve into the historical and cultural contexts of science. However, in comparison to video, other resources were less likely to include representation of the people involved in doing science.

K-2 Grade Band Resources	
Learning in Places LE1.C Taking a Socio-Ecological Histories of Places Walk activity http://learninginplaces.org/for-families/le-1-c-taking-a-socio-ecological-histories-of-place-walk/ This is a family activity guide that could also be used by teachers.	**Strengths** *Representation: Who does science?* • Positions families as scientists and asks them to consider how human decisions have contributed to changes in places. • Asks families to recognize First Peoples and their histories and relationships to place *Science Representation: What is science?* • Focuses on socio-ecological histories of places, which interactions between people and natural places • Asks youth and families to think about different time scales (e.g., geologic time, plant and animal time) • Includes how human decision making has contributed to changes in the place • Asks youth and families to think about the histories of the places they observe *Access and Engagement* • Asks youth and families to pick a place in their own neighborhood to observe • Activity plan organized visually to call out different ideas through different color headings, bold font, and colored boxes • Includes guidance for completing the Activity and sheet for recording information • Provides options for recording observations – the Activity sheet provided or a blank piece of paper and they can write or draw observations, questions, and ideas • Provides resources in English, Spanish, and Chinese **Opportunity Points**

	The activity focuses on asking questions and making observations. However, it could ask families to think about what they already know; it could ask them to draw on their funds of knowledge.
Mystery Science How can the Sun help you if you're lost? https://mysteryscience.com/sky/mystery-3/sun-daily-patterns/81?code=NDEwMDY3MDQ&t=student This is a lesson plan that includes a video and an activity.	**Strengths** *Science Representation: What is science?* ● Students build a model to explore how the sun moves throughout the day *Access and Engagement* ● Includes transcripts of the video in Spanish ● Includes vocabulary cards as an extension for students to practice words after they have completed the Activity ● Asks students to draw on their experience: Have you ever been lost? ● Visuals that showed story with arrows that pointed out specific parts of the visuals to direct viewer's attention ● Videos include a mix of pictures and drawings **Opportunity Points** Could include cultural and historical nature of studying the sun's movement and navigation

3-5 Grade Band Resources	
Colors of Nature/Kit 2 Fostering Steam Investigation 1/What is color made of? Chromatography http://fosteringsteam.org/educator-resources/ This is a lesson plan. The specific lesson/investigation reviewed was Investigation 1 of Kit 2.	**Strengths** *Science Representation: What is science?* ● Focuses on asking students to explore art-science concepts, including experimenting, making observations (data collection), data analysis (classifying materials and their properties), and communicating their findings ● Teacher Background Reading includes the history of pigments and how cultural and technological innovations have impacted pigments available for human use ● Lesson plan asks teachers to include historical examples of pigments when starting the lesson ● Asks students to experiment with different ways of doing chromatography ● Students asked to draw on their own knowledge of colors and think about their favorite colors and where they might come from *Access and Engagement* ● Students asked to draw on their own knowledge of colors and think about their favorite colors and where they might come from ● Students investigate color in everyday products, such as spinach and colored markers **Opportunity Points** Includes examples of the history of pigments in art and science in the Background Reading for teachers, but could also include examples of scientists and artists who experiment with and study color in the Background Reading and as part of discussions with students.

Winds and Weather Alaska Native Knowledge Network Activity 1 – Traditional Forecaster http://ankn.uaf.edu/Curriculum/Units/Winds/activity1i.html This is a lesson plan.	**Strengths** *Representation: Who does science?* ● Co-developed with Iñupiaq elder ● Interactions with a traditional forecaster to explore weather from the perspective of an elder/expert, recognizing local weather signs and patterns, and understanding how the local culture and environment have affected the development of scientific weather knowledge is central to the lesson. *Science Representation: What is science?* ● Addresses similarities and differences between how Iñupiaq people and Western scientists view weather and why each perspective can be useful (Unit Reflection questions: http://ankn.uaf.edu/Curriculum/Units/Winds/appendb.html) ● Students study weather over time by observing the weather in their location ● Students consider the cultural knowledge associated with weather (e.g., interaction between weather and ice fishing) ● Students collect and analyze data *Access and Engagement* ● Lesson based on local contexts ● Asks students to reflect and build on their own experiences with weather ● Learning integrates weather and the significance of weather in a cultural context **Opportunity Points** The lesson plan offers opportunities for students to draw on individual and community resources to engage in the practices of science. It was created prior to the *Next Generation Science Standards*, so it could be updated to address the practice of argumentation, and build on what is already included in the lesson to consider types of evidence and what counts as evidence that are used to support arguments.

6-8 Grade Band Resources	
Greenmarket Vendor This is a student handout.	**Strengths** *Access and Engagement* ● Students explore fruits and vegetables at local market ● Boxes for observations allow students to write and/or draw their observations ● Students asked to interview farmers and produce managers to learn more about where their food comes from

9-12 Grade Band Resources	
My Place in Puget Sound curriculum	**Strengths** *Science Representation: What is science?*

Concept 1: How Can water change a boy fish into a girl fish? Lesson 3: Puget Sound & Me This is a lesson plan.	• Students consider the health of a local water system • Includes a teacher note about the history of the water system • Includes consideration of the impact of humans on natural systems and how it changes based on human decisions *Access and Engagement* • Starts by asking students to draw a map of how they think people's actions influence the health of Puget Sound • Asks students to place where they live on the map to consider their relationship to Puget Sound • Asks students to interview 2 people (other students, family, community) about what Puget Sound means to them **Opportunity Points** People who do science are not referenced in this lesson plan. Could include information about people who research the health of Puget Sound, including representation of people from diverse backgrounds.
Virtual Reality Tours through Google Expeditions Google Career Expedition: Microbiome Scientist, Susan Perkins https://blog.google/topics/education/expeditions-career-tours-can-take-kids/	**Strengths** *Science Representation: Who does science?* Woman scientist shares her pathway to becoming a scientist. *Science Representation: What is science?* • Students see the tools she uses to do science and sees visuals of where her work takes place • Susan shares the types of research she conducts *Access and Engagement* • Provides visuals so students can virtually visit her research lab and office • Provides text explaining her career pathway and research • Viewable with app both with and without VR goggles **Opportunity Point** Could offer tour in different languages.
Hour of Code Code.org Lesson 9: AI for Oceans https://curriculum.code.org/hoc/plugged/9/ This lesson plan includes videos and simulations that allow students to practice training an Artificial Intelligence program.	**Strengths** *Science Representation: Who does science?* Woman scientist shares her pathway to becoming a scientist. *Science Representation: What is science?* • Videos explain the process of developing AI • Students go through simulations to experience the process of developing AI program • Videos discuss benefits and problems with AI (bias), including how the strengths and weaknesses depend on how the data is collected, who is collecting the data, and how data is entered *Access and Engagement* • Closed captioning available for videos • Good visuals in the video to show concepts • Explanations of what AI is and what it is used for • Includes 'captions' to emphasize information when the women are talking about a particular concept

	• Provide real world examples of how AI is used in our lives that are relevant to youth **Opportunity Points** • Could offer simulation in different languages. • Could include more representation of various AI professionals. • Could include stories of pathways.

Part IV. Design Principles for Diversity and Equity in K-12 Science Educational Media

Informed by the preceding sections of the report, the Design Principles for Diversity and Equity in K-12 Science Educational Media (Design Principles) were created to guide the development of science educational media to support equity and diversity. They can also be used by educators in selecting and adapting media to support diversity and equity in science education.

Our overarching design principle is that educational media should be developed from and promote an anti-deficit perspective so that resources:

- position students, their families, and their communities as having positive contributions to science and science learning;
- position students and communities as capable of learning and doing science;
- recognize how students and communities have been historically marginalized and not included in science; and
- recognize and make visible existing connections minoritized students and communities have with science.

Within this anti-deficit commitment, we offer the following specific design principles:

Anti-deficit perspective
Representation: Who does science?
Resources include representation of people from diverse backgrounds (e.g., race, ethnicity, socio-economic status, English Learner, etc.)
Resources include representation of people who have a variety of interests, values, and cultural practices
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science
Resources include the contributions that minoritized people and communities have made and are making in science
Representation: What is science?
Resources show the different motivations behind, processes and underlying biases of science
Why and which phenomena are investigated; for what purposes? e.g. Eurocentric worldview might drive precipitation data gathering for purposes of thinking about how it impacts natural resources we consume. An indigenous worldview might drive precipitation data gathering to inform how humans can better maintain harmony with nature
How are phenomena investigated? *Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and in different ways and how one's culture may shape the types of data gathered to support, evolve, or refute a theory*
How are theories developed?

e.g., students learn how theories are developed through observations (data collection), analysis (looking for patterns in data), and using data to support theories, in different communities

How does scientific knowledge evolve?

e.g., students learn how the atomic theory has changed over time as new evidence becomes available through new technologies and new ways of knowing

How do contextual factors (e.g., location time, prior knowledge, and culture) influence scientific processes?

e.g., how climate change affects different locations and communities differently, including what is studied

The cultural and historical nature of science

e.g., how Indigenous knowledge perspective of the cooperative hunting behavior of coyotes and badgers or how kites and falcons intentionally spread fire[27]

Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science

1. Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives
2. Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment
3. Planning and carrying out investigations, including understanding the implications of the design of the study, the source and type of data collected, data representation, etc.
4. Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias
5. Using and understanding the underlying assumptions and parameters of mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)
7. Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence
8. Obtaining, evaluating, and communicating information through individual modes of representation

Resources address the relationship between science and society

Considers how the process of science and science knowledge is used and can impact communities in different ways

e.g., The Tuskegee study, where Black men participated in a study of syphilis where they were studied without informed consent and were not given treatment for their disease*, or satellite images of the coastline of Cape Cod show how hurricanes have impacted the land over multiple decades while we may not have data for how hurricanes impact other areas (or only have more recent data)*

Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in

e.g. prompt students about how they would redesign homes in their community to better respond to climate change; what alternative building materials they might use, etc.

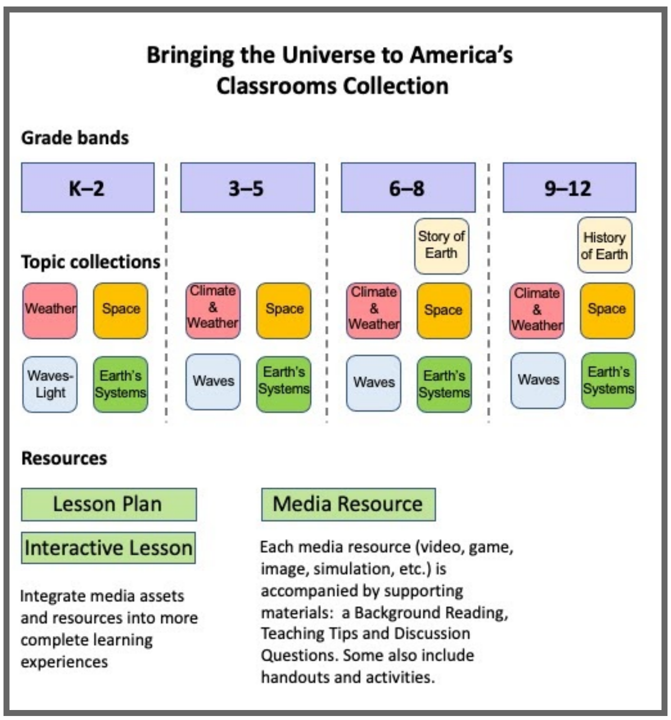
[27] Bonta, M., Gosford, R., Eussen, D., Ferguson, N., Loveless, & Witwer, M. (2017). Intentional Fire-Spreading by "Firehawk" Raptors in Northern Australia.1*Journal of Ethnobiology, 37*(4), 700-718 https://doi.org/10.2993/0278-0771-37.4.7001

Access and Engagement
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allow them to make connections. Answers the "so what" question.
Resources build on students' and their communities' experiences *e.g., ask students to reflect on their experiences with weather where they have lived and visited*
Resources show multiple examples of how phenomena occur in different contexts and why *e.g., what do seasons look like in Boston vs. Seattle vs. Phoenix*
Resources were developed with the help of youth and communities
Resources provide multiple ways for students to engage with the materials *e.g., visually, audibly, different languages, etc.*
Resources allow students to use multiple ways to demonstrate their understanding *e.g., storytelling, visually, drawing figures or diagrams*
Resources onboard students to the academic language of science 1. Students are provided with experiences with the science phenomena and practices 2. Then, students are introduced to the academic language of science once a need is created 3. Finally, students are provided with multiple opportunities to use the academic language of science

Any single standalone media resource probably will not meet all these criteria. However, producers can approach the criteria by thinking about their offerings holistically: how can they design a media and supporting materials that *together* fulfill these design principles? For example, a single activity in a science classroom might include opportunities for students to draw upon community resources but offers no visual representations of diverse scientists. That activity could be paired with an introductory video to offer that representation. Supporting materials can be added into a lesson or unit to meet even more criteria.

In the next section, we will make recommendations at each key level of the BUAC Collection organizational structure:

1. BUAC Collection (top level)
2. Topic Collections (Weather, Space, etc.)
3. Resources: (Lesson Plans, Interactive Lessons, and Media Resources with support materials, such as Teaching Tips or Background Reading)



Part V. A Summary of BUAC Sample Resource Review

This section contains a summary of findings from reviewing eight Bringing the Universe to America's Classroom resources, using the Design Principles for Diversity and Equity in K-12 Science Educational Media as a guideline. See *Appendix A* for analyses of individual resources.

Strengths

The Bringing the Universe to America's Classroom resources provide teachers and students with unique opportunities to engage in Earth and Space Science concepts and practices. Data used as part of the resources, such as images of coastline changes and the helioviewer data tool, provide access to data that teachers and students may not typically have.

The resources also visually represent science phenomena. For example, in 30 Sunsets - Summer to Winter, students can use a time lapse video to observe how the sun appears to set in different locations along the horizon at different times of the year. In Moon Phase Simulation Viewed from Earth and Space, students can use a model of the Earth-Sun-Moon system to view the pathway of the Moon and Sun in the sky from an Earth perspective as well as the phases of the Moon. This media allows students to observe patterns in phenomena that take place over long periods of time, more clearly or quickly than otherwise possible.

Finally, the media resources provide students with the opportunity to explore phenomena that only occur at certain times of the year, or even every few decades such as the Saros Eclipse. Video like Eclipses Over America NOVA videos also allow students to engage in phenomena and see artifacts (e.g., maps, physical artifacts) in their homes or in their classroom without having to travel to museums.

Opportunities to Strengthen Diversity & Equity

As discussed in the previous section, any single standalone media resource probably cannot meet all of the design principles. Instead, GBH producers should think about developing resources and support materials holistically so that, *together*, they support diverse and equitable science learning. To that end, we have identified opportunities for strengthening diversity and equity within different layers of the organizational structure of PBS LearningMedia, mentioned earlier:

1. **Bringing the Universe to America's Classrooms Collection.** This *PBS LearningMedia* Collection includes more than 250 digital resources for earth, space and physical science. The Collection resources are organized by Grade band and then Topic Collections, detailed below.

2. **Topic Collections.** Topic Collections vary by grade level but include Earth, Space, Waves, Earth's Systems, and Story (or History) of Earth. Each topic collection consists of digital resources related to the individual topics.

3. **Resources. BUAC resources include Lesson Plans, Interactive (Self-paced student) lessons, and Individual media with accompanying support materials**. Media types include videos, games, images and simulations. Supporting materials include Background Readings, Teaching Tips, Discussion Questions, and Lesson Plans.

Suggestions for BUAC-level Supports

While there are opportunities to strengthen Diversity & Equity in media and in support materials, it could be helpful to frame learning at the collection level. We suggest adding overview materials to the BUAC collection, specifically:

- **An Introductory Reading** focused on leveraging student knowledge, experiences, and practices. This reading can focus on ways to bring an anti-deficit perspective to science teaching and learning. It can include information about the wealth of knowledge, experiences and practices that students bring to the classroom and how it is important to leverage and build on these resources when teaching science.

- **An Introductory Reading** about the Academic Language of Science. The introduction can discuss the importance of teaching the academic language of science. It could include information about how research has shown that pre-teaching vocabulary words is not effective, but that students should be first provided experiences with science phenomena and practices prior to introducing academic language.

Suggestions for Topic Collection-Level Supports

Currently, most topic collections lack any introductory or overview materials. In addition, almost all support materials are nested within individual resources. While there are opportunities to strengthen Diversity & Equity in media and in support materials, it could be helpful to frame learning at the collection level. We suggest adding to each Topic Collection:

- **An Introductory Reading or Video** focused on the historical process by and purposes for which diverse scientists contributed to knowledge about the topic area. This introduction might include information about both the scientists who have researched the scientific phenomena in the past, as well as those currently researching it in the present. This introduction should also highlight the contributions minoritized communities have made to the topic area.

- **A "Science and Society" Discussion Guide** focused on the societal implications of scientific phenomena. This might include examples of how science in this topic area can impact communities in different ways. For example, data about how hurricanes have impacted coastlines or how precipitation causes flooding and landslides, can help certain communities better prepare. The discussion guide could include more general questions that can help teachers guide students in considering how science and science knowledge is used in various communities. It could also include types of questions teachers can ask to support students in thinking about how science, it's knowledge-generating tools, and processes can be used to help create world(s) they, their families, and communities want to live in. For example, a Discussion Guide for the Climate & Weather topic collection might prompt students to think about how precipitation impacts their daily lives and communities, e.g. drinking water supply, landslides, etc.

Suggestions for Media

It may be difficult and/or too costly to make changes to media (e.g. interactives, videos). However, the following suggestions may help strengthen diversity and equity of existing media:

- **Language translations.** Only some of the resources have Spanish language translations, such as the subtitles for the 30 Sunsets - Summer to Winter time lapse video and the Moon Phase Simulation Viewed from Earth and Space. Expanding Spanish translations to all resources would increase accessibility for English Learners. It would also be helpful to expand translations to other languages.[28]

- **Language transcriptions.** If it is not possible to provide Spanish translation for the media resource itself, a Spanish transcription, such as the ones provided in the videos for the Eclipse Over America NOVA videos will also increase accessibility for English Learners. In fact, providing a Spanish transcription in addition to the Spanish version of the video may be helpful, as is the case for the Eclipse Over America videos. It would also be helpful to expand transcriptions to other languages.

- **Option to slow down speed of media.** It would be helpful to be able to slow down the speed of the media. The ability to slow down the media may make it easier to notice important visual cues in the video. For example, in the 30 Sunsets - Summer to Winter time lapse video, the slowing down the video may allow students to observe changes in where the sunset occurs over time, which is important to seeing a pattern. This resource includes this option, but there could be a description that accompanies the video that points out this option to teachers and students.

- **Increase size of text and legends.** Increasing the size of the text and legends in the media can help with readability and use of the information. For example, the North American Monsoon Weather Pattern video includes a legend for rain and soil moisture that is clear and easy to read. However, the date and time below the legend is much smaller and difficult to read. Students are asked to use the video to look for patterns related to time. Increasing the size of the text could help students more easily observe the changes in time, rain, and soil moisture.

[28] Additional translations of student materials to Spanish are planned as English language materials are finalized. Note that translation is expensive and potentially cost-prohibitive for producers.

Suggestions for Support Materials

Support materials (e.g. Teaching Tips, Background Readings) offer rich opportunities to deepen learning and strengthen the diversity and equity of a learning experience. We suggest emphasizing:

- **The people who do science.** Due to the nature of the media resources, it may be difficult to include representation of who does science, but *Background Readings* could include information about the scientists who have researched the science phenomena in the past, as well as those who are currently researching the phenomena. *Background Readings* can also highlight the contributions minoritized communities have made to the study of specific phenomena. *Teaching Tips* might prompt students to discuss the diverse ways in which children, teens, adults, and intergenerational groups do science around the specific phenomena. Of course, BUAC producers should include a representation of people from diverse backgrounds, including those from various races, ethnicities, genders, and socio-economic backgrounds.

- **The different motivations behind, processes, and underlying biases of science.** While *Background Readings* generally include information *about* the phenomena that is being investigated, they neglect to discuss *why* phenomena is investigated. Are there different purposes for studying phenomena? For example, who first studied seasonal temperatures and precipitation and for what purposes? Did they need to understand soil moisture to determine where to build towns, villages and cities and what materials to use for building? Why do people study when the sun rises and sets? Why do people study the phases of the Moon? Do some communities study coastline changes because it impacts the safety of the people who live in coastal communities? *Teaching Tips and Discussion Questions* might also prompt students to consider why and how certain phenomena are studied by particular communities.

  Background Readings can also discuss the *various* ways in which phenomena could be and historically have been investigated. For example, the North American Monsoon Weather Pattern *Background Reading* explains that precipitation data was measured with radar and the soil moisture was measured using instruments on satellites that detect moisture. It neither discusses other ways of collecting precipitation and soil moisture data, nor how data collection may have changed over time due to changes in technologies, gaps in data that may be related to location or time, and different cultural ways of knowing. Overall, the Eclipse Over America resource does a nice job of including the cultural and historical nature of science. It includes both the people who studied eclipses, why, and how this has changed over time. *Teaching Tips and Discussion Questions* might also prompt students to think about the process about individual and societal bias in researching the phenomena.

- **The significance of context.** *Teaching Tips*, *Discussion Questions, and Activities* could encourage students to consider place and context in their exploration of phenomena, or compare and contrast the impacts of a phenomenon on more than one location and/or for more than one community.. For example, the Investigating Seasonal Temperature and Precipitation Variation Lesson asks students to examine temperature and precipitation data and look for patterns in two different locations. The 30 Sunsets - Summer to Winter time lapse video shows sunsets in Seattle, WA, which has bigger differences in sunrise and sunset times than other places in the U.S. *Discussion Questions or Teaching Tips* might prompt students to examine sunrise and sunset data in their own contexts as a point of comparison, and then consider how this phenomena may vary depending on location.

- **How theories are developed/ how scientific knowledge evolves.** The Eclipse Over America *Background Reading* is unique in that it describes how people observed the Saros Cycle, and explores how people's understanding of eclipses have changed over time. Similar information about the historical evolution of theories and knowledge about phenomena could be applied to all *Background Readings*.

- **The science practice of argumentation.** While support materials sometimes ask students to provide evidence for their explanations, they often stop short of connecting to the reasoning part of Claim, Evidence, Reasoning, the Next Generation Science Standards science practice of argumentation. The support materials could ask students to make connections to the science phenomena/concept. As part of the practice of argumentation, the students could be encouraged to consider what type of evidence they are using to support their arguments, including discussions about what counts as evidence (e.g., Do community observations count or only those from professional scientists)?

- **Opportunities for building upon students' experiences.** *Teaching Tips, Lesson Plans, and Discussion Questions* might start with students' experiences and knowledge about a science phenomenon or practice. They can also include prompts for students to think about how the phenomena and/or practice relates to their lives. This can help answer the "so what?" question: why should students learn and/or care about a science phenomenon/practice? For example, the *Teaching Tips* for PEEP Observes the Moon suggest asking students to describe what they know about the appearance of the Moon. They also suggest taking students outside to observe the Moon. Other resources could include similar prompts and activities.

Other Considerations

Overall, *Bringing the Universe to America's Classroom* resources offer visual, auditory, and physical ways for students to engage with phenomena and demonstrate their understanding, encouraging discussion, writing, and drawing. However, we see some opportunities for improving accessibility, particularly in the *Background Readings*. We suggest:[29]

[29] As these recommendations also resulted from the project years 3 and 4 product testing with educators, these changes are in process and will be implemented to the extent project budget allows.

- **Break up and highlight text**. Text can be dense and might be challenging, particularly for teachers who are unfamiliar with a science phenomena. Headings or bolding can be effective in signifying the important ideas in sections and the important ideas overall.

- **Include visuals.** In PEEP Observes the Moon, animated characters Peep, Chirp, and Quack observe the different perceived shapes of the Moon. The *Background Reading* includes one visual of the orbit of the Moon around the Earth. It would benefit from including additional visuals depicting, for example, how the sun reflects off the Moon's surface.

- **Bold or italicize vocabulary words**. in the Background Readings by italicizing or bolding them. Some Background Readings, but not all, do italicize vocabulary.

Recommendations for the individual media and supporting materials reviewed are included in Appendix A.

Appendix A. Review of BUAC Media Resources

Appendix A consists of a review of selected Media Resources from GBH's Bringing the Universe to America's Classrooms (BUAC) using the Design Principles for Diversity and Equity in K-12 Science Educational Media. The resources reviewed were selected by the BUAC Leadership team and represent a range of grade bands and types of media resources. Each review includes both strengths and opportunities for improvement. It also includes some general notes for each resource that may not be included in the table.

30 Sunsets- Summer to Winter - Grades K-2

The media resource is a time lapse video of 30 sunsets from summer to winter. Due to the type of resource, it is difficult to include representation of who does science in the time lapse video. Representation could be included in the supplementary materials; some suggestions are included below.

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	In the Background Reading, there could be information about how day and night was first measured. Who were some of the first people to record day and night?
Resources include representation of people who have a variety of interests, values, and cultural practices	See suggestion above.
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	Other criteria in this category are better suited for this particular resource.
Resources include the contributions that minoritized people and communities have made and are making in science	In the Background Reading, there could be information about how day and night was first measured. Who were some of the first people to record day and night?
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	Background Reading: "Daily sunrises and sunsets are patterns in the sky that remind us of the movement of our planet. The Sun remains in a relatively fixed position with respect to the solar system. Yet Earth is in constant motion: it rotates daily and revolves around the Sun annually, which results in regular patterns in the sky." This could be connected to other purposes for why knowing patterns and when the sun rises and sets is important to people's lives like agriculture, calendars, etc. Discussion Questions can also ask why we study patterns of daily sunrises and sunsets? Why would people want to know when the sun will rise and set (agriculture, daily activities, etc)? These motivations would
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	
How theories are developed	

	help students make connections between science and their daily lives.
How scientific knowledge evolves	Not addressed. The support materials could include how knowledge about sunrises and sunsets has changed over time.
How contextual factors matter	Not addressed. Background Reading could include how sunrise and sunset vary in different parts of the world. Discussion Questions might ask students about their experiences, especially since the video takes place in Seattle. Seattle has bigger differences in day and night depending on time of the year than other places.
The cultural and historical nature of science	Not addressed. See comments in the first row in this section.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	The Activity could provide prompts for teachers to encourage student questioning. It could also ask students to think about their experiences with sunrise and sunset at different times of the year before doing the Activity. Some of the Discussion Questions could be incorporated into the Activity and modified to connect to students' experiences and lives.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	The Activity provides students with an opportunity to develop a model for how the sun changes position.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Students are not involved in the planning of the investigation, but are involved in carrying out the investigation. There could be Discussion Questions that ask students to think about how often they are collecting data and how this might impact their results. They could be involved in the planning if they are involved in planning how often they collect data.
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	The Activity could include questions prompting students to think about how they might be interpreting data differently. Supports could be added for teachers to facilitate perspective and bias in data analysis and interpretation (e.g., does where the sticky note is placed affect our pattern? In the center of the spot, on the edge).
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	Other criteria in this category may be better suited for this particular resource. However, students could be asked to measure the distance of the sun from the ground.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	In the time-lapse video and activity, the students' draw on the data to construct explanations - how can their knowledge be incorporated?
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	This could be incorporated into the Activity and Discussion Questions (or perhaps this could be something added at the collection level)

Obtaining, evaluating, and communicating information through individual modes of representation	The Activity could provide students with multiple opportunities to communicate their understanding.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The Activity and Discussion Questions could address why we look for patterns in sunrise and sunset (e.g., calendars, agriculture) and how it impacts different communities.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	The Activity and Discussion Questions could prompt students to think about how the sunrise and sunset impacts their lives (but this doesn't get at the world they want to live in part).
Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	The Activity provides an opportunity for students to investigate the Sun's movement in their context. It could also include prompts for students to think about why learning about the Sun's movement is important to their lives. The Discussion Questions could also do this.
Resources build on students' and their communities' experiences	The Activity and Discussion Questions could ask students to think about their experiences with the phenomena. The Activity could start with this in order to build on their experiences as they track the Sun's movement. The Teaching Tips should prompt teachers to ask students about their experiences. For example, instead of telling students about time-lapse, ask students: if they know what it is? ask them if they have ever fast forwarded the video on their TV?
Resources show multiple examples of how phenomena occur in different contexts and why	The Activity allows students to investigate the Sun's movement in their context. It could also build in discussion and examples of how it looks in other geographic locations.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	The time-lapse video and activity provide different ways for students to engage with the materials. The video has English and Spanish label options. You can slow video speed.
Resources allow students to use multiple ways to demonstrate their understanding	The Activity currently doesn't provide multiple ways for students to demonstrate their understanding. The Activity could provide opportunities for students to demonstrate their understanding in multiple ways.
The academic language of science	Before the Activity: "misconception that a day refers to a 24-hour time span," Many people refer to a day being 24 hours. Instead of calling this a misconception, the resource can distinguish between everyday terminology, where "day" refers to 24 hours, and science terminology, where "day" refers to sunlight.

Other Suggestions

- Slow default setting in time lapse video; currently, it is too fast for readers to process date.
- Include more visuals in the *Background Reading*; currently a lot of text.
- Clarify text by bolding key concepts/ideas or somehow calling out key ideas. For example, day and night are caused by the rotation of the Earth on its axis.

PEEP Observes the Moon (interactive) - Grades K-2

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	Include some of the first people who studied the Moon in the Background Reading. The interactive shows the characters Peep, Chirp, and Quack who are each different colors and sizes.
Resources include representation of people who have a variety of interests, values, and cultural practices	See suggestion above.
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	The Teaching Tips ask youth to do science practices. Also see suggestion in first row.
Resources include the contributions that minoritized people and communities have made and are making in science	Include some of the first people who studied the Moon in the Background Reading.
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The Moon phases - the Moon looks different at different times of the month/year. The Background Reading could discuss why scientists study the Moon and how this might be important to people in their everyday lives (e.g., This could be related to something like tides? People living on the coast know when there is a full moon, the tides are more extreme and this could impact their daily lives, e.g. when they go swimming in the ocean, or when they should harvest food).
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Background Reading could include information about how people investigate the Moon phases in different cultures and parts of the world.
How theories are developed	See comments above.
How scientific knowledge evolves	This isn't addressed. If there is information, this could include how our understanding of the Moon has changed over time?1I'm guessing as technologies have improved, we now know more about Moon phases and/or why we can see Moon phases?
How contextual factors	This isn't addressed. It could be addressed in the Background Reading or Discussion Questions (if this is within the scope of the materials) how the Moon looks different in different locations (orientation?).1
The cultural and historical nature of science	This isn't addressed. See comments in first and fourth rows in this section.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	

Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	The Discussion Questions include a question asking students if they have any questions about how the Moon appears to change. There could be questions that also ask students to draw on their experiences to ask questions.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	Not addressed. Other criteria in this category may be better suited for this particular resource. Students are learning that the Moon looks different at different times. They are not learning about why.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Students are asked what the characters observed (What did the Moon look like to Peep/Chirp/Quack?). Information could be included in the Teaching Tips to point out the amount of time that has passed. Students can have initial discussions about data collection (e.g., type of data collected, how often).
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	Not addressed. Other criteria in this category may be better suited for this particular resource.
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	Not addressed. Other criteria in this category may be better suited for this particular resource.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	The resource does not investigate why the Moon looks different - only that it looks different at different times. The Teaching Tips suggest asking students about their experiences with the Moon. Instead, the tips could prompt teachers to draw on students' experiences to explore the patterns in Moon phases.
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	The Teaching Tips and Discussion Questions could build in argumentation by asking students to provide evidence around how the Moon looks at different times. However, it doesn't get into the reasoning part.
Obtaining, evaluating, and communicating information through individual modes of representation	The Activity could provide students with multiple opportunities to communicate their understanding.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The Background Reading could include information about how knowledge about the moon is used and can impact communities in different ways.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	The Teaching Tips and Discussion Questions could prompt students to think about how the Moon impacts their lives (but this doesn't get at the world they want to live in part).
Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	The Teaching Tips suggest that teachers ask students to draw on their experiences with the Moon.

Resources build on students' and their communities' experiences	The Teaching Tips suggest asking students to describe what they know about the Moon before engaging with the interactive.
Resources show multiple examples of how phenomena occur in different contexts and why	The Teaching Tips/Discussion Questions could ask students if the Moon looks the same if they're in different locations (but unsure if this is in the scope of this interactive).
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	The interactive allows students to replay a scene multiple times. Students can also go back to previous scenes. The interactive has closed captioning. It could include Spanish captions or a Spanish language version.
Resources allow students to use multiple ways to demonstrate their understanding	The Activity could suggest multiple ways students could demonstrate their understanding.
The academic language of science	The Background Reading could include a definition for satellite and more visuals to help the teacher understand the science phenomena. For example: ● provide definition for satellite ● could include a graphic of how the sunlight reflects off the Moon's surface ● could include how the amount of the illuminated half of the moon that is visible from earth gives it its apparent shape ● could provide a visual to support understanding for the section, The Moon's appearance is due to constant motion in the sky paragraph ● could include graphics to show the phases of the moon in the last section

Other Suggestions

- If affordable, producers might include narration asking students to do science (or ask them about their experiences) after they see the characters observe. For example, the voice asks students, "What did the Moon look like to Peep?" After students describe this, the voice could ask students if they have ever seen a Moon that looks like that.

Investigating Season Temperature and Precipitation - Grades 3-5

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	The interactive includes a video of a Black woman who is sharing the weather forecast.
Resources include representation of people who have a variety of interests, values, and cultural practices	The lesson could include information about why scientists study weather and how this may differ depending on context.
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	Students are asked to explore and analyze data. Students could be explicitly positioned as scientists.
Resources include the contributions that minoritized people and communities have made and are making in science	The lesson could include information about why scientists study weather and how this may differ depending on context, which would include minoritized communities.
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The lesson could include information about why scientists study weather and how this may differ depending on context.
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Background Reading could include information about how people investigate precipitation and temperature in different parts of the world and from different cultures.
How theories are developed	See comments above.
How scientific knowledge evolves	See comments above. It could also include how this has changed as technologies have changed (e.g., collecting precipitation in a physical container to more sophisticated methods of data collection).
How contextual factors	Students explore temperature and precipitation in two contexts. The lesson could ask why it might be important to study temperature and precipitation in different locations (e.g., studying precipitation in areas that flood or have droughts and why this may be important to those locations)
The cultural and historical nature of science	Students could explore how and why people historically collected weather data (e.g., impacts growing seasons, types of crops, drinking water, type of housing).
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	Students explore the question, "How does weather change with the seasons?" It could include asking the question, "Why do we care that the weather changes with the seasons?" The Engage portion of the lesson could also include support for teachers to ask students questions like, "What is the weather like in January? April? July? October?" "Why do you think scientists study the weather?" "Do you

	care about the weather? Why or why not?" to encourage students to ask their own questions about weather.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	Students could collect temperature and precipitation data through the school year to explore patterns in seasons and compare with NASA data.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Before starting the interactive, students discuss why it might make sense to use data from one month.
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	Not addressed. Other criteria in this category may be better suited for this particular resource.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	The students are asked to use data from their location. Students could be asked to consider if the data makes sense based on their experiences. They could also look at other sources of data from their lives (e.g., they could collect data at school prior to starting this lesson, look at weather websites and precipitation data and compare).
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	Students are asked to make claims and provide evidence. They are not asked to make connections to the reasoning (science concept). The lesson could connect to reasoning. Before starting the interactive, students discuss why it might make sense to use data from one month. The lesson could also go into how the data is collected.
Obtaining, evaluating, and communicating information through individual modes of representation	Students explore, evaluate, and communicate information through writing, graphing, and discussion. In the Average Monthly Temperature and Precipitation handout, students are asked to support the argument with evidence, but not asked to connect to reasoning.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The lesson could include information about how and why scientists study the weather and how the information is used. How do we collect temperature and precipitation data?1Why? For example, areas that receive a lot of precipitation vs. little precipitation may grow different foods and develop cities/towns in different ways.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	The students could be encouraged to think about why weather matters to them? (e.g., are houses/buildings built with different materials, in different locations due to weather? Could they use different sources of energy like solar panels? Different ways of collecting and accessing drinking water?)
Access and Engagement	

Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	Students explore weather in their location. The lesson could make connections to why weather matters to students' and their communities' lives.
Resources build on students' and their communities' experiences	In the Engage section, Students are asked to think about weather in their location. Pages 2 and 3 of the interactive ask students to make temperature and precipitation predictions for their location. You may consider starting this lesson asking students what weather they experience rather than showing them pictures. Pictures can be used if they don't mention a type of weather. Probing questions can be included to encourage students to think about their experiences.
Resources show multiple examples of how phenomena occur in different contexts and why	The students are asked to compare precipitation and temperature in two locations. The lesson does not get into why.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	Student handouts are provided in Spanish. A Teacher Handout is included that provides language (vocabulary and sentence starter) supports for EL.
Resources allow students to use multiple ways to demonstrate their understanding	Students are able to write, graph, and discuss their understanding.
The academic language of science	The EL Supports ask students to make connections between their experiences and vocabulary in their first/home language and then the science term in English. In the interactive, the hyperlink includes definition of weather is great, but may think about rewording the definition, especially for ELs. Weather Across the Country Interactive includes a hyperlinked definition of "weather"; consider rewording the definition for less density, especially for ELs.

Moon Phases Simulation Viewed from Earth and Space (Interactive) - Grades 3-5

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	While it may be more challenging to represent people in the simulation, the landscape appears to represent a certain image of middle-class people. The houses and landscape could be changed to represent various images of homes and towns (e.g., apartment building). In the Background Reading, there could be information about how the movement of the Moon and Sun were first measured, which would most likely include people from diverse backgrounds?1
Resources include representation of people who have a variety of interests, values, and cultural practices	See comments above.
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	As part of the support materials, the students can collect data about the Moon. Teachers can point out how many people do science, including students.
Resources include the contributions that minoritized people and communities have made and are making in science	The lesson could include information about why scientists study the Moon and Sun's path and how this may differ depending on context, which would include minoritized communities.
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The simulation shows the path the Moon travels and the phases of the Moon. The Background Reading and Teaching Tips could include information or prompts related to why scientists study this (e.g., related to telling time/calendars or could relate to tides or other phenomena?)
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Daytime and Nighttime student handout asks students to record when the Moon is in the day sky and when it is in the night sky. I'm guessing this is how scientists first studied the Moon? If so, this could be made explicit in the handout.
How theories are developed	The supporting materials could include information about how theories about the Earth-Sun-Moon system were discovered and studied.1It could also go into how the orientation of the Earth, Sun and Moon to each other and orientation (N, S, E, W and/or northern or southern hemisphere) on Earth were decided/impacted(s) how we perceive phenomena?
How scientific knowledge evolves	See comments above. Also, students can learn about how scientific knowledge has evolved as we've created new technologies.
How contextual factors	Support materials could include why scientists study the path of the Moon and Moon phases and how this might differ depending on location.

The cultural and historical nature of science	See comments in the first and third rows of this section re: Why and which phenomena are investigated and for what purpose and how theories are developed.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	The Teaching Tips include suggestions for how the simulation can be used. The Teaching Tips and handouts could start with asking students what they know about the Moon and what questions they have.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	The simulation is a model, so the students are not developing a model, but they are using a model to investigate phenomena. The students could discuss how the model was developed and the benefits/drawbacks of this model vs. another type of model (e.g., physical model)
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	The Teaching Tips suggest having a discussion with students about the orientation of the model and why the model was developed from a particular perspective. Students could discuss/investigate what the moon phases look like from different locations (e.g., northern or southern hemisphere).
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	The simulation (and support materials) state the model is not to scale. The students could discuss scale and for the purposes of this simulation, why it was not created to scale. They could also discuss how time was developed (although this may be beyond the scope of this work).
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	Not addressed. Other criteria in this category may be better suited for this particular resource. In the simulation, the students' draw on data from the simulation to construct explanations - I'm not sure about the funds of knowledge part here
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	The Daytime and Nighttime Moon handout asks students, "Why can you see the Moon during the day and night? Use evidence (data and observations) from the model to support your answer." and The Moon's Path in the Sky handout also does something comparable. They could ask them to think about the1type of evidence they are using and why.
Obtaining, evaluating, and communicating information through individual modes of representation	In the handouts, the students can communicate their understanding through writing and drawing.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The Teaching Tips and handouts could address why we study the Moon-Sun-Earth system and how it impacts different communities.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	Not addressed. Other criteria in this category may be better suited for this particular resource.
Access and Engagement	

Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	The Daytime and Nighttime Moon handout asks students to collect Moon data from their lives. The support materials could suggest that teachers start with asking students about their experiences with the Moon - what they have observed, what questions they have and include some probing questions for teachers to use or for students to answer.
Resources build on students' and their communities' experiences	
Resources show multiple examples of how phenomena occur in different contexts and why	The support materials to ask students to think about if the Moon, its pathway, and how it looks in appearance is different depending on context.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	More visuals could be included in the *Background Reading*. The handouts offer different ways to engage with the simulation. Using the handouts, the students can write, draw, and discuss their learning.
Resources allow students to use multiple ways to demonstrate their understanding	
The academic language of science	Depending on how the simulation is used, the materials can suggest that the teachers follow these principles related to the academic language of science.

North American Monsoon Weather Pattern (video) - Grades 3-5

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds Resources include representation of people who have a variety of interests, values, and cultural practices	The support materials could include who studies this phenomena and why, including who first noticed the phenomena. This would most likely include people from diverse backgrounds?
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	As part of the support materials, the students can collect data about the precipitation and soil moisture and learn about how many people study this, including professional scientists and community members (i.e., citizen science efforts).
Resources include the contributions that minoritized people and communities have made and are making in science	See comments in row 1 of this section.
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The Background Reading includes information about why it's important to track soil-moisture levels and precipitation. It could also include other perspectives for why it's important (see example for this principle).
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Background Reading states that data was collected by radar and satellite. It could include information about other ways the phenomena has been studied before radar and satellite data was available.
How theories are developed	The Background Reading describes that scientists identified the North American Monsoon through years of observations and explains that pattern. It includes information about how the data was collected. If applicable, it could also include if data was collected in other ways besides radar and satellites and in different communities. If data was only collected in some communities, it could discuss why.
How scientific knowledge evolves	The Background Reading describes how years of data were collected to identify the North American monsoon. It could include information about why this information and/or pattern was first noticed and why data was first analyzed related to this phenomena and how the theory evolved as scientists gained more data.
How contextual factors	The Background Reading explains how a monsoon occurs in southern Asian and North America. It includes information about why it's important to track soil-moisture levels and precipitation. The Background Reading could also include information about/ask students to consider if monsoons affect all people the same or if it impacts

	people/communities in different ways (getting at inequities in how people are impacted by weather).
The cultural and historical nature of science	The materials do not address the cultural and historical nature of science. See comments in rows 3 and 4 of this section. I also would guess there is Indigenous knowledge of monsoons that could be included.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	The Teaching Tips, Discussion Questions, and activity include questions the students are asked to investigate. The support materials could also encourage students to ask their own questions based on their experiences, observations, or questions that arise during their investigations.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	Not addressed. Other criteria in this category may be better suited for this particular resource.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Students are not involved in the planning of the investigation, but are involved in carrying out the investigation. The support materials could encourage teachers to ask students to think about the type of data collected, how often, and consider how the data presented in the video may different from other time periods.
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	Not addressed. Other criteria in this category may be better suited for this particular resource. The students are asked to think about how the data they're asked to observe in the video compares to their own location and other regions in the U.S. I'm not sure how to address individual and societal bias in this resource.
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	I don't know enough about how radar and satellite data work to offer suggestions for this principle. There are other principles that may be more appropriate to address than this one.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	Students are asked to construct explanations based on evidence. They are also asked to compare the data in the video to their own experiences.
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	Students are asked to construct explanations based on evidence. They could also be asked to connect to the reasoning aspect so they are engaging in argumentation. They could be asked to examine the type of data used as evidence and consider if there are other sources of evidence they could use to support their argument.
Obtaining, evaluating, and communicating information through individual modes of representation	The Activity could provide students with multiple opportunities to communicate their understanding, such as drawing.
Resources address the relationship between science and society:	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The Background Reading and activity include why it is important to predict monsoons.
Provides opportunities for students to ask questions about how science and	The Teaching Tips asks students to consider what happens to the environment when we get a lot of rain or not very much

its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	rain. The Discussion Questions ask students to consider the impact of soil moisture on the environment and their daily lives. The support materials could also ask students to consider how they/communities can mitigate changes in soil moisture and precipitation.
Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	The Background Reading and activity include why it is important to predict monsoons. The Teaching Tips suggest asking students about seasonal weather patterns before observing the visualization. They could start by asking students to consider weather patterns in their location and then expanding to other locations.
Resources build on students' and their communities' experiences	See comments above.
Resources show multiple examples of how phenomena occur in different contexts and why	Students are asked to observe the weather patterns in multiple locations.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	Students can engage in the phenomena through the visualization, the diagram on the Activity sheet, and discussion.
Resources allow students to use multiple ways to demonstrate their understanding	Students can demonstrate their understanding through discussion and written responses on the Activity sheet. They could also have the option to draw their understanding.
The academic language of science	The Activity includes definitions for moisture, precipitation, and satellite. It also explains what a monsoon is. Maybe the students can explore the phenomena looking at the pattern and then make the connection to the academic language (monsoon).

Other suggestions

- The *Background Reading* would benefit from:
    - a diagram or screen captures that shows how the Monsoon moves would be helpful, perhaps similar to the one in the Activity sheet.
    - a key that shows the precipitation along with a screen capture
    - screen captures of the times and dates mentioned

  Such additions would support teachers in understanding how to explain phenomena through multiple modes of representation. They would also allow teachers to share the background reading with students who may be visual rather than auditory learners.
- Increase the font size of the time under the key.
- Include an outline/labeling of AZ and NM in the video since the focus is on monsoons that happen in those states.

Coastline Change (Interactive) - Grades 6-8

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	The Background Reading includes information about how the data was collected, but not who figured out how to collect the data. Also, are there other local people who collected this type of information who may come from diverse backgrounds?1It may not be from this specific location, but there could be information about people who collected coastline data in other locations.
Resources include representation of people who have a variety of interests, values, and cultural practices	
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	
Resources include the contributions that minoritized people and communities have made and are making in science	In the Background Reading, there could be information about how coastline data has historically been collected. I'm guessing this would include people who are minoritized in the US, including Indigenous communities?
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The interactive shows the change in the coastline due to the effects of waves, currents, and tides. The Background Reading and Teaching Tips could include information or prompts related to why scientists study this (e.g., could relate to hurricanes and how changes in barrier islands change how the mainland is impacted)
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Background Reading includes information about how the photos were taken. It could also include other ways to record coastline data.
How theories are developed	The Teaching Tips include information about how the media could be used to help students visualize erosion and deposition because it occurs over long periods of time. It also suggests students can transfer their learning to a particular context. The Background Reading could include information about how erosion and deposition was originally studied, where, and why.
How scientific knowledge evolves	Not addressed. Other criteria in this category may be better suited for this particular resource.
How contextual factors	The Teaching Tips suggest that students can transfer their learning to a particular context. The Background Reading or Teaching Tips could provide some examples.
The cultural and historical nature of science	This isn't addressed. The background resources and Teaching Tips could include information about why coastline changes are investigated, why, and how this has changed over time.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering)	The Teaching Tips could include prompts for teachers to ask students what questions they have.

that are relevant and connected to students' lives	
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	Coastline changes can take place over long periods of time. Could the Background Reading or Teaching Tips ask students to develop a model for erosion and deposition? Sometimes erosion and deposition will be taught using sand/substrate and water in containers. or perhaps they could draw models of how they think it works and refine these models based on what they learn?
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Students are not involved in the planning of the investigation or data collection and representation.1There could be Discussion Questions that ask students to think about how the data is collected.
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	Not addressed. Other criteria in this category may be better suited for this particular resource.
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	Not addressed. Other criteria in this category may be better suited for this particular resource.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	If students live on coastlines (or have knowledge of coastlines), they could draw on their own, their families, and their communities' knowledge of how the coastline has changed due to the effects of waves, currents, and tides.
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	See comments above. Students could use community knowledge as evidence.
Obtaining, evaluating, and communicating information through individual modes of representation	The Background Reading could encourage teachers to allow for multiple opportunities and modes to communicate their understanding.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The Teaching Tips include a discussion question asking, "What impact might people have on the process of coastline change over time." The Background Reading and Teaching Tips could address why we study coastline and how changes in coastlines impact communities (e.g., changes how much protection provided to the mainland, impact on communities who live on barrier islands, etc.)
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	The Background Reading and Teaching Tips could address how understanding about coastline changes impacts the communities who live there and ask them to consider what actions they might consider taking to mitigate changes in coastline.
Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the	The Background Reading and Teaching Tips could start by asking students what they know about erosion, weathering, and deposition and the function of barrier islands. They could

phenomena and allows them to make connections	also ask students to consider why it's important to learn about erosion, weathering, and deposition in the context of coastlines or other contexts related to where they live. See comments above.
Resources build on students' and their communities' experiences	
Resources show multiple examples of how phenomena occur in different contexts and why	The Background Reading could include other examples of the phenomena in different contexts.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	I'm not really sure how to address this. Perhaps an arrow could be used to help point out visual changes could be included. Or perhaps the Background Reading could include suggestions for physical models of the phenomena?
Resources allow students to use multiple ways to demonstrate their understanding	The Background Reading could ask teachers to provide multiple ways for students to demonstrate their understanding.
The academic language of science	The Background Reading and Teaching Tips could include suggestions for asking students to make observations using the interactive first, and then apply the science terms to the phenomena they're observing and give students opportunities to use the terms erosion, weathering, and deposition. Helpful that "weathering" is italicized to emphasize the word and definition. Should do the same for "erosion" and "deposition."

Other notes

- The Teaching Tips on what the media assets can be used to teach (both content and practices) is helpful.
- In this resource, the questions are included as part of the Teaching Tips, which is helpful.1In other resources, questions are separate documents.

Eclipse Over America / Predicting Eclipses (explanatory video) - Grades 6-8

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	The Babylonians and the Saros Cycle video explains how Ancient Babylonians studied eclipse patterns and shows artifacts that include recordings of data.
Resources include representation of people who have a variety of interests, values, and cultural practices	See comments above. The Babylonians and the Saros Cycle video also talks about why it was important to the Babylonians to study eclipse cycles and how it was embedded in cultural practices.
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	The videos include representations of how scientists throughout history have studied eclipses. They do not include representations of youth, communities, professional scientists, and intergenerational groups doing science. Support materials could include these representations by providing other examples of people who study eclipses.
Resources include the contributions that minoritized people and communities have made and are making in science	See comments above.
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The videos explain why eclipses were studied by Babylonians and a British scientist, Halley. The video, How Halley Predicted the 1715 Eclipse, does not include why he studied eclipses. It shows how he used mathematics and new knowledge to predict the 1715 eclipse. If known, the support materials could include information about why he studied the phenomena.
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The two videos explain how eclipses were investigated in two different contexts.
How theories are developed	The two videos explain how the eclipses were studied and how the Saros cycle was discovered in two different contexts.
How scientific knowledge evolves	The Babylonians and the Saros Cycle video shows how the Babylonians studied eclipses and the second video, How Halley Predicted the 1715 Eclipse, shows how the Saros cycle was rediscovered and used to predict an eclipse using mathematics and new understandings.
How contextual factors	The Babylonians and the Saros Cycle video includes information on how the cultural practices of the Ancient Babylonian kings influenced the study of eclipses. The second video showed how context (i.e., Newton's new theory of gravity) influenced understanding of eclipses.
The cultural and historical nature of science	The Babylonians and the Saros Cycle video includes information on how the cultural practices of the Ancient Babylonian kings influenced the study of eclipses. The second

	video showed how new information that arose during that time led to new understandings of the Saros Cycle. Together, they also show the historical nature of science.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering) that are relevant and connected to students' lives	Not addressed. However, the supplement resources could ask students if they have any questions after watching the videos. The Teaching Tips suggests students can do research projects, but defines the research topics. Instead, students could come up with their own research questions to investigate.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	The Teaching Tips suggest that students can build a physical model of eclipses.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	The videos are explanatory. The Teaching Tips suggest that students can build a physical model of eclipses. If they do, or if they conduct research projects, which is also suggested in the Teaching Tips, they can plan and carry out investigations and consider the implications of various aspects of their investigation.
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	The How Halley Predicted the 1715 Eclipse video explained some of the assumptions that went into Halley's model to predict the eclipse.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	Students are not asked to construct explanations. The videos explain the eclipse patterns.
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	Students are not asked to construct arguments. The videos explain the eclipse patterns and make connections to the Saros Cycle.
Obtaining, evaluating, and communicating information through individual modes of representation	The Teaching Tips ask students to explain their understanding of eclipses. If they develop physical models, it would provide another way to communicate information. They could also be asked to draw to communicate information.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	The video on the Babylonians explains how eclipses impacted their lives. The support materials could include how they impact other communities.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	Not addressed. Other criteria in this category may be better suited for this particular resource. I'm not sure how learning about eclipses could help create the world(s) they, their families and communities want to live in.

Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	The video on the Babylonians includes why they were interested in eclipses. The support materials could include why scientists study eclipses now and how they might be related to students' lives.
Resources build on students' and their communities' experiences	
Resources show multiple examples of how phenomena occur in different contexts and why	The videos explain how eclipses were studied in two contexts. The video about the Babylonians explains why the phenomena was studied. If known, the second video could also include this information (or this could be included in the Background Reading). The video describes how eclipses are experienced in different parts of the world (not everyone will see an eclipse at the same time).
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	The videos allow students to engage in the phenomena both visually and audibly. The videos have closed captioning and transcripts of both videos are provided in English and Spanish. If the students develop physical models, that offers another way for them to engage with the materials.
Resources allow students to use multiple ways to demonstrate their understanding	Students can demonstrate their understanding through discussion and thorough building physical models. They could also have the option to draw their understanding.
The academic language of science	The Teaching Tips suggest teachers elicit students' prior knowledge before watching the videos. If they do not know what eclipses are, after watching the videos, they could introduce the science language and then rewatch the videos. They could also watch over videos of eclipses to have multiple opportunities to see what eclipses look like and be asked questions about what they observe and understand about them.

Other notes

- Visuals would be helpful in understanding the concepts in the Background Reading so that the reading could also be shared with students.
- Headings and bold font could be used to help break up the text and signify the importance of sections.

Student Helioviewer Data Tool (Interactive) - Grades 9-12

Anti-deficit perspective	
Guiding Principles	**Analysis of How Resource Aligns/ Could Better Align with Guiding Principles**
Representation: Who does science?	
Resources include representation of people from diverse backgrounds	In the Background Reading, there could be information about who historically studied the Sun. This may include diverse communities and peoples.
Resources include representation of people who have a variety of interests, values, and cultural practices	
Resources include representation of youth, communities, professional scientists, and intergenerational groups doing science	
Resources include the contributions that minoritized people and communities have made and are making in science	
Representation: What is science?	
Resources show the different motivations behind, processes and underlying biases of science:	
Why and which phenomena are investigated; for what purposes?	The Background Reading explains the purpose of the Helioviewer Project is to make Sun data easily accessible to the public and provides information about the type of data. It could also include why scientists collect these types of data (why they study these phenomena). Helioviewer Project aims to make data accessible to the public - can it also include why and maybe give examples of how people use the data and why?
How phenomena are investigated Rather than presenting science as facts, students learn how scientific knowledge is created in different cultures and ways.	The Background Reading includes information about the type of data that are collected but does not address how this data is used to develop theories. It could also include information about how data about the Sun has been collected in the past and how the data has been used and is currently being used.
How theories are developed	
How scientific knowledge evolves	The Background Reading states that heliophysicists are continually learning more as they gather more data.1It also includes information about how data collection has changed (but does not include information about how scientists used to collect data). It could include some examples of how understanding of the Sun has changed due to changes in technologies.
How contextual factors	Not addressed. Other criteria in this category may be better suited for this particular resource.
The cultural and historical nature of science	The support materials could include information about who has studied the Sun and why.
Resources offer opportunities for students to draw upon individual and community resources to engage in the practices of science:	
Asking questions (for science) and defining problems (for engineering)	Students are asked questions, but not prompted to ask their own questions. They could be encouraged to ask their own questions and try to answer them using the Helioviewer. The

that are relevant and connected to students' lives	support materials could also include information about how studying these particular phenomena of the Sun is connected to their lives.
Developing models using resources in the community and/or using or seeing models that show what is possible with more advanced equipment	Not addressed. Other criteria in this category may be better suited for this particular resource. I'm unsure how students could develop models of these phenomena.
Planning and carrying out investigations, including understanding the implications of the design of the study, the type of data collected, data representation, etc.	Students can use the Helioviewer to carry out investigations. They could be encouraged to think about the type of data they're examining, how the data is represented, and the time periods they use to investigate questions (e.g., hours, days, months, years).
Analyzing and interpreting data through personal frames of reference, understanding that data analysis and interpretation always carries individual and societal bias	Students could discuss how the data collection tools were developed and interpreted (color, types of measurements) and how this impacts the data analysis and interpretation.
Using and understanding the underlying assumptions and parameters of mathematics and computational thinking	The Background Reading and the User Guide includes information about the data. It could also include assumptions and parameters that went into the data collection and representation.
Constructing explanations (for science) and designing solutions, based in students' funds of knowledge, (for engineering)	The Teaching Tips suggest students make evidence-based claims about the dynamic nature of the Sun. I'm unsure how to draw on their funds of knowledge in this context.
Engaging in different modes of argument from evidence and considering the types of evidence and what counts as evidence	This could be incorporated into student investigations. They could be asked to make connections to reasoning (the science concept).
Obtaining, evaluating, and communicating information through individual modes of representation	Students can use the Helioviewer to visually observe changes of the Sun. They can create movies and take photos to communicate information and can discuss with other students.
Resources address the relationship between science and society	
Considers how the process of science and science knowledge is used and can impact communities in different ways	This is not addressed. The support materials could address how studying the Sun in these ways can impact our lives on Earth.
Provides opportunities for students to ask questions about how science and its knowledge-generating tools, and processes can be used to help create the world(s) they, their families and communities want to live in	Not addressed. Other criteria in this category may be better suited for this particular resource.
Access and Engagement	
Resources provide examples that are relevant to students' lives and why they need to learn about the phenomena and allows them to make connections	This is not addressed. The support materials could include why studying the Sun is relevant and connected to students' lives.
Resources build on students' and their communities' experiences	The Teaching Tips ask students to think about their knowledge about the Sun.

Resources show multiple examples of how phenomena occur in different contexts and why	Not addressed. Other criteria in this category may be better suited for this particular resource. I'm unsure how studying these phenomena impacts different contexts.
Resources were developed with the help of youth and communities	N/A
Resources provide multiple ways for students to engage with the materials	Students can engage visually with this resource. The user guide could be translated into other languages.
Resources allow students to use multiple ways to demonstrate their understanding	The tool allows students to take pictures and create a movie. They could also be encouraged to write or discuss their understandings.
The academic language of science	There are many terms that may be unfamiliar to students. The students could view something like the sun flares, discuss what they are, and then learn what they are called. They could then be provided opportunities to use the language as they continue to use the tool.

Other suggestions

- It would be helpful to have a diagram of the layers of the Sun's atmosphere.
- Italicizing or bolding the layers would be helpful to call out the names of the layers. These layers could also be numbered.
- Headings to break up sections would be helpful.

Appendix B. Resources Reviewed

Resource	Grade Band	Type	Categorical Note	Support Materials	Spanish Translation
30 Sunsets-Summer to Winter	K-2	Media Gallery	Observational videos to engage kids with phenomena	Activity, Background Reading, Teaching Tips, Discussion Questions	Yes
PEEP Observes the Moon	K-2	Interactive	Interactive storybook	Background Reading, Teaching Tips, Discussion Questions	no
Investigating Seasonal Temperature and precipitation Variations	3-5	Lesson Plan	Lesson Plan	Handouts, EL Supports	Yes
Moon Phases Simulation Viewed from Earth and Space	3-5	Interactive	interactive model to investigate phenomena	Background Reading, Teaching Tips, Discussion Questions, Handouts	yes
North American Monsoon Weather Pattern	3-5	Video	data visualization of regional weather patterns and soil moisture	Background Reading, Teaching Tips, Discussion Questions, Student Activity	No
Coastline Change	6-8	Interactive	Slideshow/observational images to engage with phenomenon	Background Reading, Teaching Tips, Discussion Questions	No
Eclipse Over America | Predicting Eclipses	6-8	Video	Explanatory Video (NOVA)	Background Reading, Teaching Tips, Discussion Questions	No
Student Helioviewer Data Tool	9-12	Interactive	live data visualization tool; access real solar data from NASA	Background Reading, Teaching Tips, DQs, Handout (User Guide)	no

Appendix C. References

Aikenhead, G. S. (1996). Science education: Bordering crossing into the subculture of science. Studies in Science Education, 27, 1-52.

Aikenhead, G. S., & Jegede, O. J. (1999). Transcending cultural borders: Implications for science teaching. Journal for Science and Technology Education, 17, 45-66.

Alim, H. S., & Paris, D. (2017). What is culturally sustaining pedagogy and why does it matter? In D. Paris & H. S. Alim (Eds.), Culturally sustaining pedagogies: Teaching and learning for justice in a changing world (pp. 1-21). New York: Teachers College Press.

Annie E. Casey Foundation. (2006). Race matters: How race affects education opportunities. Accessed at: https://www.aecf.org/resources/race-matters-how-race-affects-education-opportunities/#findings-and-stats

Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B., & Willis, B. (2013). ASPIRES: Young people's science and career aspirations, age 10-14. London, England: King's College London. Retrieved from http://www.kcl.ac.uk/sspp/departments/education/research/aspires/ASPIRES-final-report-December-2013.pdf

Au, W. (2016). Meritocracy 2.0: High-stakes, standardized testing as a racial project of neoliberal multiculturalism. Educational Policy, 30(1), 39-62.

Bang, M., Brown, B., Calabrese Barton, A., Rosebery, A., & Warren, B. (2017). Toward more equitable learning in science: Expanding relationships among students, teachers, and science practices. In Schwarz, C., Passmore, C., and B. J. Reiser (Eds.), Helping students make sense of the world using Next Generation Science and Engineering Practices (pp. 33-58). Arlington, VA: NSTApress.

Bang, M., Marin, A., & Medin, D. (2018). If Indigenous people stand with the sciences, will scientists stand with us? Daedalus, 147(2), 148-159

Bang, M., Warren, B., Rosebery, A.S., & Medin, D. (2012). Desettling expectations in science education. Human Development, 55(5-6), 302-318.

Banks, J.A., et al. (2007). Learning in and out of school in diverse environments: Life-long, life-wide, life-deep. Seattle, WA: The LIFE (Learning in Informal and Formal Environments) Center and the Center for Multicultural Education – University of Washington. Accessed at: http://education.washington.edu/cme/cenpub.htm#learning

Barnhardt, R., & Kawagley, A. O. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. Anthropology & Education Quarterly, 36(1), 8-23.

Bohrmann, M. L., & Akerson, V. L. (2001). A teacher's reflections on her actions to improve her female students' self-efficacy toward science. Journal of Elementary Science Education, 13(2), 41-55.

Bonta, M., Gosford, R., Eussen, D., Ferguson, N., Loveless, & Witwer, M. (2017). Intentional Fire-Spreading by "Firehawk" Raptors in Northern Australia.1Journal of Ethnobiology, 37(4), 700-718 https://doi.org/10.2993/0278-0771-37.4.7001

Brooks, D., & Hebert, L. (2006). Gender, race, and media representation. In Dow, B. J., and J. T. Wood (Eds.), The SAGE Handbook of Gender and Communication (pp. 297-318). Thousand Oaks, CA: SAGE Publications.

Brown, B. A. (2019). Science in the City: Culturally relevant STEM education. Cambridge, MA: Harvard Education Press.

Calabrese Barton, A., & Tan, E. (2009). Funds of knowledge and discourses and hybrid space. Journal of Research in Science Teaching, 46(1), 50-73.

Calabrese Barton, A., & Tan, E. (2018). STEM-rich Maker Learning: Designing for Equity with Youth of Color. Teachers College Press.

Calabrese Barton, A., & Tan, E. (early view). Beyond inclusion: Equity as establishing rightful presence. Educational Researcher. DOI: 10.3102/0013189X20927363.

Center for Disease Control and Prevention. (n.d.). U.S. Public Health Service Syphilis Study at Tuskegee. https://www.cdc.gov/tuskegee/timeline.htm

Cheryan, S., Drury, B., J., & Vichayapai, M. (2012) Enduring influence of stereotypical computer science role models on women's academic aspirations. Psychology of Women Quarterly, 37(1), 72-79.

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representation as a barrier to inclusion for women. Sex Roles, 69, 58-71.

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. Stanford Law Review, 43(6), 1241-1229.

Crossley, S. A., & Skalicky, S. (2019). Making sense of polysemy relations in first and second language speakers of English. International Journal of Bilingualism, 23(2), 400-416.

Evans, M. A., Whigham, N., & Wang, M. C. (1995). The effect of a role model project upon the attitudes of ninth-grade science students. Journal of Research in Science Teaching, 32(2), 195-204.

Finson, K. D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. School Science and Mathematics, 102(7), 335-345.

García, O., Johnson, S. I., & Seltzer, K. (2017). The translanguaging classroom: Leveraging student bilingualism for learning. Philadelphia, PA: Caslon, Inc.

Gee, J. P. (2008). What is academic language? In Rosebery, A. S., and B. Warren (Eds.), Teaching Science to English Language Learners: Building on students' strengths (pp. 57-70). Arlington, VA: NSTApress.

Gonzalez, N., Moll, L. C., & Amanti, C. (Eds.). (2005). Funds of knowledge: Theorizing practices in households, communities, and classrooms. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Gruenwald, D. (2003). Foundations of place: A multidisciplinary Framework for place-conscious education. American Educational Research Journal, 40(3), 619-654.

Gutiérrez, K. D., & Rogoff, B. (2003). Cultural Ways of Learning: Individual Traits or Repertoires of Practice. Educational Researcher, 32(5), 19–25.

Harding, S. (1986). Women, science, and society. Science, 281(5383), 1599-1600.

Harding, S. (1997). Women's standpoints on nature: What makes them possible? Osiris, 12, 186-200.

Harmon, J. M., Hedrick, W. B., & Wood, K. D. (2005). Research on vocabulary instruction in the content areas: Implications for struggling readers. Reading & Writing Quarterly, 21(3), 261-280.

Hudicourt-Barnes, J., & Ballenger, C. (2008). Using students' conversational styles. In Rosebery, A. S., and B. Warren (Eds.), Teaching Science to English Language Learners: Building on students' strengths (pp. 21-30). Arlington, VA: NSTApress.

Hughes-Hassell, S., Koehler, E., & Barkley, H. A. (2010). Supporting the literacy needs to African American transitional readers. Teacher Librarian, 37(5), 18-23.

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. Journal of Research in Science Teaching, 48(4), 339-366.

Kozol, J. (1991). Savage inequalities: Children in America's schools. New York: Crown.

Ladson-Billings, G. (1995a). But that's just good teaching! The case for culturally relevant pedagogy. Theory Into Practice, 34(3), 159 – 165.

Ladson-Billings, G. (1995b). Toward a theory of culturally relevant pedagogy. American Educational Research Journal, 32(3), 465-491.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. schools. Educational Researcher, 35(7), 3-12.

Lee, C. D. (1995). A culturally based cognitive apprenticeship: Teaching African American high school students skills in literary interpretation. Reading Research Quarterly: 30(4), 608-631.

Lee, O. (1999). Science knowledge, world views, and information sources in social and cultural contexts: Making sense after a natural disaster. American Educational Research Journal, 36(2), 187-219.

Lee, O., Miller, E., Januszyk, R. (Eds.). (2015). NGSS for All Students. Arlington, VA: NSTA Press.

Malsbary, C. B. (2016). Youth and schools' practices in hyper-diverse contexts. American Educational Research Journal, 53(6), 1491-1521.

Mason, C. L., Kahle, J. B., & Gardner, A. L. (1991). Draw-a-Scientist test: Future implications. School Science and Mathematics, 91(5), 193-198.

Mejia, J. A., Ruiz, D., Popov, V., Esquinca, A., & Gadbois, D. (2019, June). Asset-based Practices in Engineering Design (APRENDE): Development of a Funds-of-Knowledge Approach for the Formation of Engineers. In ASEE annual conference & exposition proceedings.

Moje, E., Ciechanowski, K. M., Kramer, K., Ellis, L., Carrillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. Reading Research Quarterly, 39(1), 38-70.

Moje, E. B., Collazo, T., Carrillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Language, literacy, and discourse in project-based science. Journal of Research in Science Teaching, 38(4), 469-498.

Moll, L. C. (1992). Bilingual classroom studies and community analysis: Some recent trends. Educational Researcher, 21(2), 20-24.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. Theory into Practice, 31(2), 132-141.

National Academies of Science. (2012). A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas. Washington, D.C.: The National Academies Press.

National Academies of Sciences, Engineering, and Medicine. 2018. English Learners in STEM Subjects: Transforming Classrooms, Schools, and Lives. Washington, D.C.: The National Academies Press.

NGSS Lead States. (2013). Next Generation Science Standards: For states, by states. Washington D.C.: The National Academies Press.

National Center for Educational Statistics. (2020). "English Language Learners in Public Schools." The Condition of Education. Retrieved from: https://nces.ed.gov/programs/coe/indicator_cgf.asp

National Center for Educational Statistics. (2020). "Racial/Ethnic Enrollment in Public Schools." The Condition of Education. Retrieved from: https://nces.ed.gov/programs/coe/indicator_cge.asp

National Center for Educational Statistics. (2020). "Students with Disabilities." The Condition of Education. Retrieved from: https://nces.ed.gov/programs/coe/indicator_cgg.asp

National Center on Education and the Economy. (2019). Child Poverty and its Impact on Education in the U.S. National Center on Education and the Economy. Retrieved from: https://ncee.org/2019/12/child-poverty-and-its-impact-on-education-in-the-u-s/

National Research Council. 2009. Learning Science in Informal Environments: People, Places, and Pursuits. Washington, D.C.: The National Academies Press. https://doi.org/10.17226/12190.

National Science Foundation, National Center for Science and Engineering Statistics. (2019). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019. Special Report NSF 19-304. Alexandria, VA. https://www.nsf.gov/statistics/wmpd.

Orellana, M., & García, O. Language brokering and translanguaging in school. Language Arts, 91(5), 386-392.

Petersen, E. E. , Davis, N. L., Goodman, D., et al. (2019). Racial/Ethnic disparities in pregnancy-related deaths — United States, 2007–2016. MMWR Morb Mortal Weekly Report, 68(35), 762–765. DOI: http://dx.doi.org/10.15585/mmwr.mm6835a3external icon.

Pray, L., & Zhaurova, K. (2008). Barbara McClintock and the discovery of jumping genes (transposons). Nature Education, 1(1), 169.

Rosebery, A. S., & Warren, B. (Eds.) (2008). Teaching Science to English Language Learners: Building on students' strengths. Arlington, VA: NSTApress.

Rosebery, A. S., Warren, B., & Conant, F. R. (1992). Appropriating scientific discourse: Findings from language minority classrooms. The Journal of the Learning Sciences, 2(1), 61-94.

Schwarz, C., Passmore, C., & Reiser, B. J. (2017). Moving beyond "knowing about" science to making sense of the world. In Schwarz, C., Passmore, C., and B. J. Reiser (Eds.), Helping students make sense of the world using Next Generation Science and Engineering Practices (pp. 3-21). Arlington, VA: NSTApress.

Snow, C. E. (2010). Academic language and the challenge of reading for learning about science. Science, 328(5977), 450-452.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. American Psychologist, 52(6), 613–629.

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM fields: Girls' narrated and embodied identities-in-practice. Journal of Research in Science Teaching, 50(10), 1143-1179.

Tolbert, S., Stoddart, T., Lyon, E. G., & Solís, J. (2014). The next generation science standards, common core state standards, and English learners: Using the SSTELLA Framework to prepare secondary science teachers. Issues in Teacher Education, 23(1), 65-90.

Tatum, Beverly Daniel. (2007). Can we talk about race?: and other conversations in an era of school resegregation. Boston, MA: Beacon Press.

Tsurusaki, B. K., Calabrese Barton, A., Tan, E., Koch, P., & Contento, I. (2013). Using transformative boundary objects to create critical engagement in science: A case study. Science Education, 97(1), 1-31.

Vertovec, S. (2007). Super-diversity and its implications. Ethnic and Racial Studies, 30(6), 1024-1054.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A. S., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense-making. Journal of Research in Science Teaching, 38(5), 529-552.

Warren, B., Vossoughi, S., Rosebery, A.S., Bang, M. and Taylor, E.V. (2020). Multiple ways of knowing:1Re-Imagining disciplinary learning. In Nasir, N.S., Lee, C.D., and Pea, R. (Eds.), Handbook of the cultural foundations of learning (pp. 277-294). New York: Routledge.

White, M.J., Risse-Adams, O., Goddard, P. et al. (2016). Novel genetic risk factors for asthma in African American children: Precision Medicine and the SAGE II Study. Immunogenetics, 68, 391–400. https://doi.org/10.1007/s00251-016-0914-1

Wright, C. G. (2019). Constructing a collaborative critique-learning environment for exploring science through improvisational performance. Urban Education, 54(9), 1319– 1348.