Zero Barriers in STEM Education

Accessibility & Inclusion Workbook

Smithsonian
Science Education Center

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Smithsonian Science Education Center

The Smithsonian Science Education Center (SSEC) is an organization of the Smithsonian Institution dedicated to transforming K-12 Education through Science™ in collaboration with communities across the globe. To achieve our mission, we have four goals: (1) we promote authentic, inquiry-based, integrated K-12 science, technology, engineering, and math (STEM) teaching and learning; (2) we ensure diversity, equity, accessibility and inclusion (DEAI) in K-12 STEM education; (3) we advance STEM education for sustainable development (STEM4SD); and (4) we translate the research and collections of the Smithsonian into meaningful tools and convenings for K-12 teachers and students. We achieve our goals by: (a) building awareness for science education among school leaders; (b) promoting Leadership and Assistance for Science Education Reform (LASER); (c) supporting the professional growth of K-12 teachers and school leaders; (d) developing exemplary K-12 curriculum materials and digital resources (including our comprehensive research-based science curriculum programs: *Smithsonian Science for the Classroom*; Science and Technology Concepts for Middle School (STCMS); and Smithsonian Science for Global Goals); and (d) engaging in research. At the heart of our work is the idea that all youth—regardless of gender, geography, race, native language, ability, or socio-economic status—should be given the opportunities to learn about the socio-scientific issues that challenge us. The Smithsonian, through the Smithsonian Science Education Center, plays an active role in sparking students' and teachers' interest in STEM to ensure a scientifically literate global citizenry.

Smithsonian Institution

The Smithsonian Institution was created by an Act of Congress in 1846 "for the increase and diffusion of knowledge…" This independent federal establishment is the world's largest museum, education, and research complex and is responsible for public and scholarly activities, exhibitions, and research projects nationwide and overseas. Among the objectives of the Smithsonian is the application of its unique resources to enhance elementary and secondary education.

Preface
From the Smithsonian Science Education Center

Smithsonian Secretary Lonnie Bunch once wrote, "Learners, particularly those facing equity or access-based challenges, are failed when they are not embraced in the full breadth of learning resources in their communities. The Smithsonian has a responsibility to lead thinking, action, and change in this area, especially for that critical cohort of pre-K through grade 12 students."

To address these challenges, the Smithsonian Science Education Center, through a public-private partnership with General Motors and 18 talented experts from across the country, established an innovative initiative to address diversity, equity, accessibility, and inclusion (DEAI, as defined by the American Alliance of Museums in Figure 1) in K-12 Science, Technology, Engineering, and Math (STEM) education (science, technology, engineering, and math) education so that all students at all education levels see high-quality STEM education and STEM careers as accessible to them. In partnership with General Motors, the Smithsonian has developed this resource, which includes strategies for you and other K-12 STEM teachers to integrate inclusive and universal design practices into your instructional practices. Please look for "Teacher Tips" throughout this Workbook to help you more easily implement these strategies in your STEM classroom.

Research has shown that nearly seven million students with disabilities in the U.S. make up 14 percent of national public school enrollment, and one in five students have learning and attention issues (National Center for Learning Disabilities [NCLD], 2017; Schaeffer, 2020). With this in mind, we want to ensure all students, including students with disabilities, know and understand that STEM can be made accessible to everyone, no matter what their ability level, and that teachers know to use inclusive and universal design strategies with their students when investigating scientific problems or designing solutions for engineering problems.

Science museums are resources for educators (Feinstein & Meshoulam, 2014). With tens of millions of visitors from around the world, and millions of students reached through the Smithsonian's education efforts and programs, the Smithsonian has the opportunity to work closely with you to make K-12 STEM education accessible and relevant to diverse audiences—not only in-person and online but in your community and school. Advancements in STEM are occurring more rapidly now than in other times in history. The introduction of STEM to students early in their education allows educators the opportunity to identify students with strong interest and nurture growth. As a nation, it is advantageous to have a rich pipeline of individuals educated and trained in technical fields. As you train the future generation of scientists and scholars, you can ensure a diverse, equitable, inclusive, and accessible classroom by using the strategies and Teacher Tips in this, *Zero Barriers in STEM Education Accessibility and Inclusion Workbook*.

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General Motors has been pushing the limits of transportation and technology for over 100 years. As an open, inclusive company, we're also creating an environment where everyone feels welcomed and valued for who they are. One team, where all ideas are considered and heard, where everyone can contribute to their fullest potential, with a culture based in respect, integrity, accountability and equality.

That is why we are invested in accessibility and inclusionary practices in STEM education. We believe that all individuals can share meaningful perspectives that serve our dynamic and diverse world. Our unique partnership with the Smithsonian Science Education Center is an opportunity for us to continue actively, and intentionally, engage in social projects that will improve the lives of everyone, everywhere. It also provides a chance for us to learn and keep a pulse on what is happening in STEM education so that we have knowledge about how to best support the future generation entering the STEM workforce.

Through partnerships like this one, we are making investments in immersive, hands-on learning that encourages youth from all communities to explore their STEM identities. Forming a strong STEM foundation allows students to explore their natural curiosities in STEM education through the guidance of their educators. In creating workbooks like this, our hope is to help equip teachers with new resources, skills, and the confidence needed to teach STEM concepts in their classrooms that are accessible to each and every one of their students. This in turn will inspire the next generation of leaders and innovators in STEM.

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Table of Contents

Defining Terms: DEAI

Figure 1 – Definitions of Diversity, Equity, Accessibility and Inclusion

Term	Definition
Diversity	All the ways that people are different and the same at the individual and group levels
Equity	Fair and just treatment of all members
Accessibility	Giving equitable entry to everyone along the continuum of human ability and experience
Inclusion	Ensuring diverse individuals fully participate in all aspects of the work including decision making and engineering solutions

American Alliance of Museums. (2018). Facing Change. Available from https://www.aam-us.org/programs/facing-change1/

Definitions of Diversity, Equity, Accessibility and Inclusion from American Alliance of Museums.

Chapter 1:
Our Rationale for Zero Barriers in STEM Education

Workbook Overview

The *Zero Barriers in STEM Education Accessibility and Inclusion Workbook* is a collaborative effort with the District of Columbia Public Schools and the Smithsonian Science Education Center, funded in part through a grant provided by General Motors with additional funds from the Smithsonian Accessibility Innovation Funds (SAIF).

The goals of this collaborative effort are to:

- ☐ Create STEM classrooms that are inclusive of all learners.
- ☐ Reduce barriers for students who may not otherwise have access to robust STEM experiences.
- ☐ Raise teachers' awareness of inclusive design practices by using museum exhibits as exemplars.
- ☐ Encourage all students who engineer solutions to problems to use universal and inclusive design practices.

The Smithsonian has developed this *Zero Barriers in STEM Education Accessibility and Inclusion Workbook* with the help of experts from the Smithsonian and around the country. The workbook is designed to help educators like you integrate inclusive instructional strategies into your STEM curriculum and actively embed universal design into your teaching practices. Our goals are to empower you to structure lessons to address the needs of all students, including those with disabilities; raise your awareness of inclusive design practices used in museum exhibits during highly immersive onsite learning experiences; and engage you as a school leader to create a culture of inclusivity in all disciplines taught.

Barrier-free Access to STEM

Nearly 26 percent of adults in the U.S. (nearly one in four) have some type of disability, representing 19.4 percent of the U.S. population (Centers for Disease Control and Prevention [CDC], 2018). Today, many individuals with disabilities experience great difficulty gaining access to venues, print, technology, and the like. (Anderson & Perrin, 2017). The *Zero Barriers in STEM Education Accessibility and Inclusion Workbook* is premised on an inclusive design instructional approach that ensures those with varying ability have full equitable access to learning as well as the opportunity to help others solve problems related to technological designs that are needed to provide barrier-free access to STEM.

Why Do We Need STEM Education to Be Inclusive and Accessible to All Learners?

Nearly 7 million students with disabilities in the US make up 14 percent of the national public school enrollment (Schaeffer, 2020). Students with disabilities often display very low levels of science achievement. For example, 82 percent of 4th-grade students with disabilities performed at or below the basic level on the 2015 NAEP Science assessment (National Assessment of Educational Progress [NAEP], 2015). Yet "little research exists regarding how students with disabilities learn science concepts, even though science content linked to grade-level, general education science standards has been mandated for all students since 2004 (Individuals with Disabilities Education Act [IDEA], 2004)" (Andersen & Nash, 2016). Additionally, "limited expectations have been observed in the enacted science curriculum for students with disabilities (Karvonen et al., 2011)" (Andersen & Nash, 2016); this could be due, in part, to the lack of awareness of biases within teachers when it comes to understanding what students with disabilities are capable of achieving. Many teachers and schools lack the resources to create an inclusive culture that is accessible to all learners along the continuum of human ability, experience, and interest. By providing equitable entry for everyone, we can reduce barriers for students who may not otherwise have access to robust STEM education (Basham & Marino, 2013). For years, STEM teachers have been bringing object-driven learning into their STEM classrooms and encouraging participation in group work as a key element of learning. But today, with technological advances and more diverse classrooms, we also recognize the importance of using multimodal/multisensory activities, intentional planning for learner variability, flexible methods and experiences, and universally designed learning experiences (Basham & Marino, 2016; Schreffler et al., 2019; Zhuhadar, 2015).

Most often educational support for struggling students and students with disabilities is focused on developing reading, writing, and math skills that facilitate growth in English language arts and mathematics. Yet, science is sometimes viewed as a subject that students can be pulled out of to receive additional one-on-one and/or small group educational support. This focus of the *Zero Barriers in STEM Education Accessibility and Inclusion Workbook* is designed to help you to provide opportunities for all students by providing equitable access to STEM through the use of inclusive design strategies that actively engage all students in learning and promote the development of a growth mindset.

Why This Work is Important to School and District Culture

1.   STEM Pipeline and Workforce Opportunities in Your Community

Not that long ago if you were planning a trip to another town, state, or country, you would probably go to a bookstore or library to do research on things to do, hotels to stay at, restaurants to visit, etc. With the significant advances in technology, now all you need to do is use a search engine on your smartphone or other device to explore and find all the information you desire.

Alternatively, you can adorn virtual reality goggles and experience your destination without leaving the comforts of your home. Significant innovations in technology have taken place in a very short period of time, and we have become accustomed to smartphone

applications, online shopping, and the like made possible by the women and men working in STEM occupations.

According to the most recent report of the US Department of Commerce Economic and Statistics Administration (2017), employment in STEM occupations grew much faster than employment in non-STEM occupations over the last decade (24.4 percent versus 4.0 percent, respectively). Furthermore, STEM occupations are projected to grow by 8.9 percent from 2014 to 2024; this is compared to 6.4 percent growth for non-STEM occupations. The over 9.0 million STEM workers continue to command higher wages, earning approximately twice as much as their non-STEM counterparts. With as many as 2.4 million STEM jobs expected to go unfilled by 2025, according to the Bureau of Labor Statistics, the opportunity for students to be gainfully employed is hopeful. (US Bureau of Labor Statistics, 2020). There is a sense of urgency for school districts across the nation to adopt STEM curricula in order to expose, teach, and provide equitable access for all students, including those most underrepresented (e.g., females, African Americans, Latinx, American Indians, Alaska Natives, students with disabilities) to pursue degrees in these fields. While women have reached parity with men among science and engineering degrees, women remain underrepresented in science and engineering occupations (National Science Foundation, 2019).

2.   Ensure Teachers Understand What STEM is and Why it is Important

STEM is essential for the United States to maintain its global competitiveness (Carnevale et al., 2011; Hossain & Robinson, 2012) and important for our schools and classrooms because it infiltrates every part of our lives. Science is everywhere in the world around us. Technology is continuously expanding into every aspect of our lives. Engineering is the design of roads, bridges, airplanes, rockets, computers, and self-driving cars; it tackles the challenges of changing global weather and environmentally friendly and computer-managed homes and businesses. Mathematics is in every occupation, every activity we do in our lives, and is another way of communicating.

Exposing students to STEM affords them the opportunity to develop a passion for it and an awareness of STEM-based careers, potentially leading to more of them pursuing a job in a STEM field. Skills attained through STEM education include problem solving, critical thinking, creativity, curiosity, decision making, leadership, entrepreneurship, acceptance of failure, and more—all valuable attributes for pursuing careers of interest. These 21st century skills build a STEM literate society and significantly benefit typically underserved students (Bybee, 2010; Kennedy & Odell, 2014; Zielezinski & Darling-Hammond, 2016). As STEM curricula are being implemented across the country, more and more teachers are moving away from lecturing and moving toward hands-on instruction (Holstein & Keene, 2013; Hu & Garimella, 2014). Hands-on learning provides opportunities for students to see how STEM concepts relate to life. Making math and science both fun and engaging helps students enjoy learning and hopefully sparks an interest for a future career in a STEM field.

3. Ensure Teachers Understand What Accessibility is, Why it is Important, and What Universal Design Practices Make STEM Education More Inclusive

In today's fast-moving world of innovation, STEM provides endless opportunity and potential occupation for our youth. STEM education helps bridge the ethnic and gender gaps sometimes found in math and science fields and the disparities of those with disabilities. With this in mind, it is critical to ensure equitable access to learning experiences for all students, including those from underrepresented student populations. We know the next generation of innovators will be formed through STEM education (Corlu et al., 2014). It is critical that schools have courageous conversations about the belief gap adults hold, incorrectly, about students around them, and the aptitudes or traits young people must have to belong and thrive in STEM careers (e.g., STEM jobs do not all require higher education or even a college degree; less than half of entry-level STEM jobs require a bachelor's degree or higher).

For STEM learning and opportunities to be available to all students, we must ensure that all students have equitable opportunities to access, belong, engage, and actively participate in an inclusive environment. It is important for educators to celebrate diversity, consider learning differences, and provide equitable learning opportunities for each and every learner. Within this inclusive community, students' needs are accounted for and support is provided that ensures an equal opportunity for academic success. Without full access, students with disabilities will continue to be plagued with poor educational outcomes. For example, when STEM learning activities are offered online, they should be delivered with accessible technology. Following the Web Content Accessibility Guidelines (WCAG) published by the Web Accessibility Consortium (https://www.w3.org/WAI/standards-guidelines/wcag/) ensures that all digital learning tools and content are perceivable, operable, understandable, and robust. The result includes videos that are closed captioned and audio described as well as documents that are accessibly designed and can be read by assistive technology devices that individuals with disabilities commonly use. Basic principles of Universal Design (UD) developed by North Carolina State University also provide guidance, including when it comes to science labs and other physical spaces in which learning occurs.

Another way to ensure equitable access to STEM curriculum and instruction for all learners is through the implementation of Universal Design for Learning (UDL). UDL provides flexible goals, methods, materials, and assessments in order to provide effective instruction to all learners, including those with diverse needs. Rather than approaching accessibility as an afterthought or only on a case-by-case basis, UDL principles help educators design lessons and/or courses that address the needs of learners from the start so that all students may have equitable access. The UDL principles focus on ensuring equity in access through providing multiple ways of representing content (e.g., text-to-speech, audible passages), providing multiple ways for students to demonstrate their knowledge and skills (e.g., verbal, speech-to-text), and providing multiple strategies for student engagement (e.g., instructional choice). UDL allows all students equitable access to STEM content and learning.

The three UDL principles provide accessibility to STEM as they directly address the why (i.e., engagement), the what (i.e., representation, multiple approaches to instruction), and the how (i.e., expression, multiple ways for students to demonstrate) of learning. We know students differ in the ways they can be engaged or motivated to learn. UDL provides students different ways to engage (e.g., video, book on tape). Taking into consideration how students perceive and comprehend the information that is presented is also important. Students with language and/or cultural difference, sensory disabilities (e.g., blindness or deafness), and learning disabilities all require a different way of approaching content. Other students may learn more efficiently (e.g., reading fluency) through visual or auditory versus the printed text. Using multiple representations (ways of presenting instruction) when teaching allows students to make connections within and between concepts and facilitate the transfer of learning. Providing students different ways to express their learning (e.g., a speech vs. test and vice versa, making a collage, interview) allows them to express their learning in ways that reduce or eliminate barriers to showing what they know and can do.

Our Call to Action

STEM education is equipping the next generation with skills to solve complex challenges of today's world. It is up to all educators to understand and utilize strategies for creating equitable educational environments so all learners can contribute to that future.

Now is the time to prioritize diversity, equity, accessibility, and inclusion to ensure struggling students and students with disabilities are considered in the design of STEM offerings. Committing to prioritizing this work in your instructional and educational practices can be accomplished in the following ways:

- ☐ Seeking out opportunities to learn about barriers to educational experiences
- ☐ Working with an open mindset to understand diverse experiences
- ☐ Serving as a champion and ally for this work in your educational community
- ☐ Setting specific and tangible goals with clear success criteria around making steps to improve diversity, equity, accessibility, and inclusion

Doing the work of furthering diversity, equity, accessibility, and inclusion in educational settings is a journey and not a destination—there is always more to consider in the design of learning experiences and innovation. The needs of diverse learners must be a central consideration in the conceptualization, design, and creation of STEM learning opportunities. The important thing is to get started where you are and set specific, tangible goals for making steps to achieve diversity, equity, accessibility, and inclusion in your work and throughout STEM education. The *Zero Barriers in STEM Education Accessibility and Inclusion Workbook* is designed to guide you along your path.

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Chapter 2:
Strategies for Teaching All STEM Learners

A Universal Design Approach to Inclusive STEM Learning

Universal Design (UD) can provide a framework for inclusive practices. The definition of UD developed by the Center on Universal Design and North Carolina State University defines universal design as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Center for Applied Special Technology [CAST], n.d.). The idea that we design for diversity from the beginning and reduce retrofitting of existing designs is why newer buildings have multipurpose drinking fountains or drinking fountains of different heights. Products and environments that are universally designed apply all or some of the basic principles of UD: equitable use, flexibility in use, simple and intuitive, perceptible information, tolerance for error, low physical effort, and size and space for approach and use. Basic principles of UD can provide guidance for decisions in STEM education, including decisions concerning the physical spaces where learning occurs.

When the UD approach is applied to information technology, such as computers and Internet resources and tools, it allows for individualized user engagement, better access to information, and more choice in how a user responds. For example, the common flexible features found in cell phones makes it possible for an individual user to change the font or background color of a phone screen, adjust the font size, listen to text instead of reading it, and to have spoken words convert to text.

When STEM learning activities are offered online, they should be delivered using learning management systems and other technology that is accessibly designed and capable of interfacing with assistive accessible technologies such as alternative keyboards and screen readers that read aloud text presented on the screen (Burgstahler, 2019). As noted earlier, following the principles that underpin the Web Content Accessibility Guidelines (WCAG) published by the Web Accessibility Consortium (https://www.w3.org/WAI/standards-guidelines/wcag/) leads to specific practices that ensure that all digital learning tools and content are perceivable, operable, understandable, and robust. The result includes videos that are closed captioned and audio described, as well as documents and websites that are accessibility designed and can be read by assistive technology devices that individuals with disabilities commonly use.

Another way to ensure equitable access to STEM opportunities for all learners is through the implementation of Universal Design for Learning (UDL). UDL extends the UD principles

to more specifically address teaching and learning practices (Rose et al., 2002). Applying UDL results in flexible goals, methods, materials, and assessments in order to provide effective instruction to all learners, including those with diverse needs. Rather than approaching accessibility as an afterthought or only on a case-by-case basis, UDL principles help educators design lessons and/or courses that address learners' needs from the start so that all students can have equitable access. The UDL principles focus on ensuring equity in access through providing multiple ways of representing content (e.g., text-to-speech, audible passages), providing multiple ways for students to demonstrate their knowledge and skills (e.g., verbal, speech-to-text), and providing multiple strategies for student engagement (e.g., instructional choice). In concert with UD and WCAG guidance, UDL applications give all students equitable access to STEM content and learning.

UDL is based on what teachers have known for a long time: all learners are different, and that education is more effective for a diverse student population when educators plan for those differences and for inclusive learning environments, curriculum, and materials from the beginning. We know students differ in the ways they can be engaged or motivated to learn, how they most efficiently process new information, and how they express what they know.

CAST built the UDL framework upon the following three overarching principles:

1. Teachers provide multiple ways for students to **engage** with learning. This is the why of learning.

2. Teachers provide multiple ways for **representing** information to students. This is the what of learning.

3. Teachers provide multiple ways for students to **express** their understanding of the content. This is the how of learning.

    (CAST, 2018)

If curriculum, instruction, and materials apply the principles of UD, WCAG, and UDL, more students have opportunities to learn without teachers having to make accommodations and add supports for individual students (Burgstahler, 2020a). The next sections will explore these principles more deeply, including how they apply to inclusive classrooms and ideas for reviewing science lessons for the principles of UDL.

Multiple Means of Engagement

Engagement is based in the affective neural networks that control emotions. This is the network that looks for patterns and assigns emotional relevance to them and it is the beginning of learning. Teachers need to activate the affective neural networks to support student attention, motivation, and perseverance (Gregory & Kaufeldt, 2015). When teachers support students in this way, it ensures that students are paying attention because they are interested in new learning material, willing to keep trying, and have ways to regulate their attention. Students who are not engaged in learning have fewer

opportunities to learn (Fredricks et al., 2004). Engagement includes providing options for recruiting attention, sustaining effort and perseverance, and options for self-regulation (CAST, 2018). The UDL framework provides options for students to engage, such as choices about how to access information, what information to access, opportunities to take a break when frustrated, or whether to work independently or with a group.

Multiple Means of Representation

Representation is how the learner accesses information through the recognition networks of the brain to support what the student will learn (CAST, 2018). The recognition networks of the brain include the areas that take in information, such as sight, sound, and touch, and identify patterns from that information (Rose & Strangman, 2007). This is the what of learning (CAST, 2018). Representation encompasses the concepts, ideas, and skills that are important for students to learn. Representation needs to take into account differences in language and/or cultural backgrounds; sensory or physical needs; as well as differences in processing, reading levels, and differences related to a disability. Some students may learn more efficiently through visual or auditory representation versus the printed text. Other students may learn better when concepts are connected to real-world situations and physical models. Using multiple representations when teaching allows students to make connections within and between concepts and facilitate the transfer of learning.

Multiple Means of Action and Expression

Action and expression are the ways the learner demonstrates what they know and can do through the strategic networks of the brain. The strategic networks of the brain include the amygdala and prefrontal lobe, which "...oversee mental and motor patterns" (Rose et al., 2002). The how of learning includes physical action, expression and communication, and executive functions (CAST, 2018). Providing students different ways to express their learning, such as speech or text, making a collage, or being interviewed, allows them to demonstrate their learning in ways that reduce or eliminate barriers to showing what they know and can do.

The Inclusive Classroom

One of the key ideas is that the barrier to learning is not with the student; it is with the curriculum, instruction, and materials—the students' environment. For instance, imagine a person who uses a wheelchair or has mobility issues trying to access a building that has only stairs. The problem is not the person. The architect's design has created the barrier. Setting up a science lab using UD ensures that it is usable for a diverse student body. Similarly, using the UDL framework to design learning activities has positive implications for improving outcomes for all students, including students with disabilities (Rao et al., 2017).
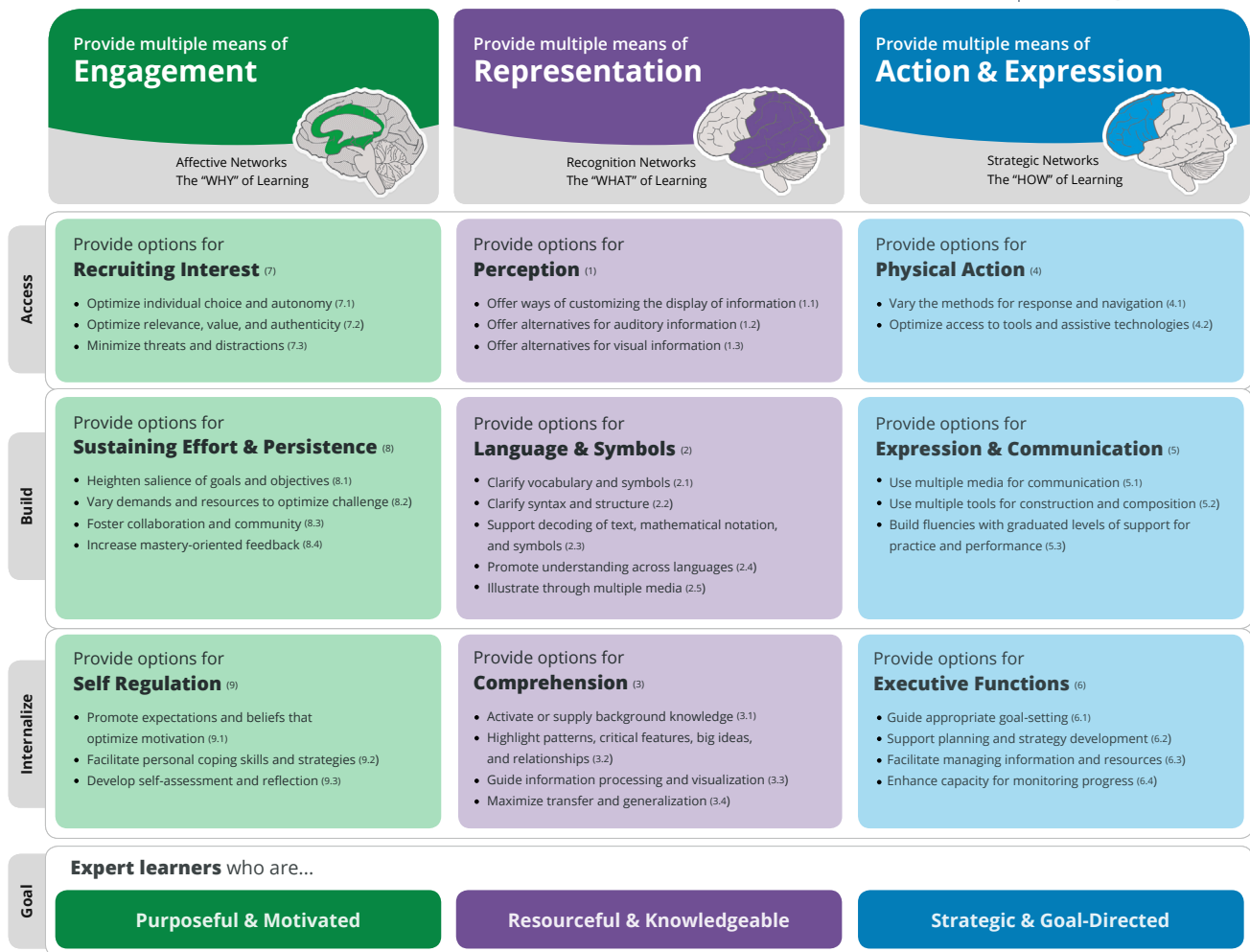
UDL practices may require that a teacher make a shift from viewing the student as the limiting barrier to learning to see barriers in the design of curriculum and instruction. This shift should change how educators plan for, teach, and assess student learning.

It also moves educators away from a deficit model to a strengths-based model of viewing students. Rather than focusing on students as needing remediation, UDL supports a strengths-based model of curriculum, instruction, and materials. A result of the remediation focus in educating students is that large groups of people have been marginalized and labeled as "stupid" because of choices in how education instructs and assesses learning. This shift is reflected in moving from a question such as, "How can I provide remediation for Joe because he doesn't have the same background knowledge as other students in my class?" to, "How will the learning experience be designed to provide additional background information for students who need it?"

Planning for Inclusive Teaching

Planning for multiple ways for students to be engaged with, access, and respond to information allows educators to consider student variability from the beginning. When supports, accommodations, and scaffolds are designed as a part of the curriculum, instruction, and materials, fewer students require individualized supports and specially designed instruction. For example, student choice builds engagement and ownership over learning, and it is a powerful tool for building self-determination skills and may be an Individualized Education Plan (IEP) goal for students. Building choice into learning opportunities is powerful for all students and should not be relegated to those students who have a disability. Presenting information through video may be a great way to introduce a problem or phenomenon, and if videos chosen are closed captioned or have a written script, then more students are able to access the information, even students who are deaf or hard of hearing. It also supports English learning for reading skills for students. Rather than having to find a different video for different students, considering these issues from the beginning of lesson development reduces the need for adaptations and supports later. And those considerations may be helpful for students that do not have IEPs, such as English learners or students who prefer to read than listen to information.

CAST has developed an interactive tool to support using UDL to plan instruction. The UDL Guidelines illustrate the components of the three principles and provide nine guidelines and 31 checkpoints under those guidelines for consideration for planning instruction and choosing curriculum and materials.

CAST | Until learning has no limits

Provide multiple means of **Engagement**

Affective Networks
The "WHY" of Learning

Provide multiple means of **Representation**

Recognition Networks
The "WHAT" of Learning

Provide multiple means of **Action & Expression**

Strategic Networks
The "HOW" of Learning

Access

Provide options for
Recruiting Interest (7)
- Optimize individual choice and autonomy (7.1)
- Optimize relevance, value, and authenticity (7.2)
- Minimize threats and distractions (7.3)

Provide options for
Perception (1)
- Offer ways of customizing the display of information (1.1)
- Offer alternatives for auditory information (1.2)
- Offer alternatives for visual information (1.3)

Provide options for
Physical Action (4)
- Vary the methods for response and navigation (4.1)
- Optimize access to tools and assistive technologies (4.2)

Build

Provide options for
Sustaining Effort & Persistence (8)
- Heighten salience of goals and objectives (8.1)
- Vary demands and resources to optimize challenge (8.2)
- Foster collaboration and community (8.3)
- Increase mastery-oriented feedback (8.4)

Provide options for
Language & Symbols (2)
- Clarify vocabulary and symbols (2.1)
- Clarify syntax and structure (2.2)
- Support decoding of text, mathematical notation, and symbols (2.3)
- Promote understanding across languages (2.4)
- Illustrate through multiple media (2.5)

Provide options for
Expression & Communication (5)
- Use multiple media for communication (5.1)
- Use multiple tools for construction and composition (5.2)
- Build fluencies with graduated levels of support for practice and performance (5.3)

Internalize

Provide options for
Self Regulation (9)
- Promote expectations and beliefs that optimize motivation (9.1)
- Facilitate personal coping skills and strategies (9.2)
- Develop self-assessment and reflection (9.3)

Provide options for
Comprehension (3)
- Activate or supply background knowledge (3.1)
- Highlight patterns, critical features, big ideas, and relationships (3.2)
- Guide information processing and visualization (3.3)
- Maximize transfer and generalization (3.4)

Provide options for
Executive Functions (6)
- Guide appropriate goal-setting (6.1)
- Support planning and strategy development (6.2)
- Facilitate managing information and resources (6.3)
- Enhance capacity for monitoring progress (6.4)

Goal

Expert learners who are...

Purposeful & Motivated	**Resourceful & Knowledgeable**	**Strategic & Goal-Directed**

udlguidelines.cast.org | © CAST, Inc. 2018 | Suggested Citation: CAST (2018). Universal design for learning guidelines version 2.2 [graphic organizer]. Wakefield, MA: Author.

Source: http://udlguidelines.cast.org/binaries/content/assets/udlguidelines/udlg-v2-2/udlg_graphicorganizer_v2-2_numbers-yes.pdf

This tool may look overwhelming at first. Rather than try to read through and do each of these pieces for everything you do, begin with just one principle and one guideline. As you gain expertise with this one, add an additional guideline or principle to your planning process. At the same time, remember that the goal of this tool is not to have each guideline and checkpoint addressed in everything you do! Think of them as hints if you are struggling with how to provide options for engagement, representation, or action and expression. This tool is there to help as you develop your UDL planning skills and identify and remove or reduce barriers for students.

Remember, one of the primary shifts in UDL thinking is that the barriers are not within the student but rather in the environment, curriculum, instruction, or materials that are currently available. The checkpoints may be useful as you consider where barriers may be and considering ways to remove or reduce those barriers. At the CAST website, each of these checkpoints is clickable and will provide suggestions for how to include options for each idea.

UDL is a general education framework. As such, it is not something that teachers do for their students with IEPs or Section 504 Plans. Instead, by considering the range of human variability rather than a narrow construct of "normal," UDL supports access and engagement for a wider range of students. When making decisions about multiple means of engagement, representation, or action and expression, consider what is vital to the goal of the learning experience. For instance, lab reports are an important skill and thought process for scientists to learn. However, there are multiple ways for learners to demonstrate that skill and process that do not all involve using paper and pencil or even a keyboard to write up the report.

The CAST Science Writer tool (http://sciencewriter.cast.org) is an example of a way to provide multiple entry points and scaffolds for writing a science lab report, yet maintaining the same overall goal for all of the learners. There are a variety of supports and options built into the tool to provide individualized support for documenting an experiment. The difference between a tool like this and creating a graphic organizer for one person is that all the learners have the ability to access these options rather than the teacher deciding who needs what. Examples of the Science Writer flexibility include the option for the computer to read the text to the learner, sentence starters for those who need additional supports, or checklists for those who may not need as much support. It also includes options for individualization in terms of choices of an animated helper or embedded dictionary and translator tools. Universally designed tools are ones that all students could use for more support as needed without the teacher having to create new materials or modify the overall goal of the lab writing process. There may still be a few students who need individualized supports.

Some Possible Guiding Questions for UDL

There are hundreds of questions that could be used to guide lesson development and instructional practices. Below are a few general questions educators may use as they plan instruction.

- ☐ What environmental barriers exist for my students in this learning environment?
- ☐ What assumptions am I making about my students?
- ☐ How can I adapt this lesson or activity to allow my students different opportunities to engage and connect with the learning material?
- ☐ What is the objective of this lesson or activity? What can be changed about the lesson or activity to make it inclusive to all learners while still meeting the objectives?
- ☐ What flexible measures can I offer to my students so that they can demonstrate their understanding?

The Web Content Accessibility Guidelines may be used to review online resources for ease of use for students with a wide range of needs and strengths. Another excellent resource is Equal Access: Universal Design of Instruction, which includes some basic etiquette rules for working with people with disabilities.

Teacher tips

Classroom Climate: Engagement

- ☐ Welcome all students as they enter the room
- ☐ Connect instruction to people, scenarios, and experiences that reflect human diversity (e.g., race, gender, ethnicity, ability)
- ☐ Evaluate instructional practices for unconscious bias (e.g., racial or gender stereotypes, differing expectations based on sex or physical abilities, etc.)

    - "I need some strong men to come move this equipment."
    - Assuming people with the same skin color, sex, etc., have similar likes and dislikes (stereotypes)
    - Images and lessons include predominantly male or white scientists
    - Expecting male students to problem solve and work through incorrect answers, while providing the right answer to females immediately if they get the answer wrong
    - Assuming students with a particular disability are automatically unable to participate or accomplish specific goals (e.g., "She can't write. She has Down's Syndrome." "He'll never understand sound waves. He's deaf.")

- ☐ Ensure the physical environment and materials are accessible for all students
    - All students are able to use the tools and materials and if not, the tools have been adapted or there is another way to do the same thing
    - All students are able to physically sit with peers, reach materials, and join centers
    - Sensory input is thoughtfully evaluated (flickering lights, classroom noise, uncomfortable seats, etc., may all be a challenge for students with sensory needs to navigate enough to be able to focus on learning)
    - Allow fidgets, chew necklaces, choices in seating positions, stretches, etc., to help students self-regulate
    - Provide breaks and movement opportunities
    - Use checklists and schedules to visually organize the time

Instructional Opportunities: Representation

- ☐ Use kinesthetic movements to support understanding and memory
- ☐ Repeat information and directions as well as writing them down
- ☐ Use jargon thoughtfully to understand the concepts
- ☐ Include access to dictionaries, translators, and glossaries
- ☐ Program key words into communication devices
- ☐ Communicate with students, not adult supporters, interpreters, or translators
- ☐ Face students when talking
- ☐ Use wait time
- ☐ Provide student choices for seating, partner or collaborative work or individual work, and how to approach a design solution or phenomenon

- ☐ Materials and tools are accessible
    - Texts may be accessed through reading or text-to-speech
    - Videos have closed captions or scripts
    - Materials and visuals are described for students with low/no vision
    - Modified scissors
    - Measuring tools with large print
    - Tools that auditorily report results
    - Materials with large-grip options for students with fine motor issues
    - Black-and-white and high-contrast colors for texts and models
    - Physical models for students to experience tactilely
    - Text paired with meaningful pictures

- ☐ Use natural supports such as peers

Demonstrating Understanding: Action and Expression
- ☐ Allow student choice for how to demonstrate understanding
    - Typing vs. pencil and paper
    - Creating models and drawings
    - Presentations
    - Videos
    - Choices of color and writing utensils
    - Sentence starters, multiple choice, word banks, close reading activities
    - Limit number of questions

- ☐ Provide supports for organizing information
    - Graphic organizers
    - Mind maps
    - Models
    - Supported note taking such as fill in the blanks, visuals already provided, shared notes via online documents
    - Color coding, highlighting, outlines
    - Reading manipulatives such as index cards with key terms and ideas that students may physically organize

- ☐ Students have access to assistive technology to support communication
    - Augmentative and Alternative Communication devices (AAC) such as tablets, Proloquo2, PODDs, picture symbols
    - Word prediction
    - Spell and grammar check
    - Speech-to-text
    - A scribe
    - Sign language

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Chapter 3:
Instructional Strategies for All STEM Classrooms

I. Strategies that Utilize Digital Tools

Technology is embedded in our daily life more than ever before. Today, different technological devices are used to help students solve personal problems (Green, 2014). Technology is an important facet of STEM because "digital literacy" has become an important skill to meet the requirements of the future job market and to actively engage as a citizen. (Executive Office of the President, Office of Science and Technology Policy, 2018).

Teaching with technology implies three interrelated core components: content, pedagogy, and technology (Koehler & Mishra, 2009). Integrating technology in the classroom makes it possible to better prepare for the changing demands our schools and students will face (Vockley, 2007).

Thanks to the technological advances in the last decades and the development of different digital tools, teachers can now develop new ways for their students to engage, reason, represent, and communicate their thinking and boost their problem-solving skills (Wimmer et al., 2017). For this reason, the proper use of technology in the classroom is a tool that could improve motivation and provide different settings for differentiated instruction.

So, in the natural continuum of teaching strategies in STEM, the use of technology and digital tools is the logical implementation to empower teachers through a student-centered paradigm, where active learning is enhanced and supported (Green, 2014).

This section provides Teacher Tips to embed digital tools into the STEM learning environment and then provides specific examples of seven digital tools available to you to enhance accessibility in your STEM classroom: video conferencing, quick response (QR) codes, simulation programs, collaborative digital tools, digital libraries, quiz platforms, and add-ons and extensions.

Teacher Tips to Embed Digital Tools into the Learning Environment:

☐ **Provide tutorials/walkthroughs**
Invest time in orienting students on how to create an account, and use the platform, ask questions, test things out, and learn the adaptive features (e.g., speech-to-text, screen rotation, voice command, word magnification, etc.) available. Spending ample time thinking about how your student will interact with different digital tools will hopefully help you sort out which tools are best for your class.

☐ **Establish norms**
You will be able to create an environment that is predictable and invites students to connect with one another more seamlessly when you make certain decisions ahead of time. Plus, it gives students a reference point to assess the decisions they make when guidelines have been provided at the onset. Reminding students of your expectations will also help to ensure they are being productive when using digital tools.

☐ **Encourage engagement**
While students are growing confident using digital tools, make sure to encourage them to engage with their peers, where it makes sense to do so.

☐ **Enable closed captioning**
Ensure every student has the ability to understand and access conversations in the learning environment using the built-in accessibility features on the digital tool(s) of your choosing.

☐ **Provide students multiple means to participate and show their knowledge**
Consider how the digital tool that you use allows students to contribute their thoughts and share what they have learned in a multitude of ways (e.g., voice recordings, typing, oral presentations, video).

☐ **Learn the adaptive features**
Explore what unique capabilities your digital tool has that will allow it to be more accessible to students.

Pick Your Plate, Smithsonian Science Education Center

[Pick Your Plate! A Global Guide to Nutrition](#), an educational nutrition game developed by the Smithsonian Science Education Center that will help teach students about building healthy meals while using nutritional guidelines from countries around the world. It has a text-alternative version that allows visually impaired students to understand the concepts behind the game.

Video Conferencing

Students are offered opportunities to interact with others (peers, educators, etc.) using different collaborative platforms. This strategy encourages community and relationship building through learning while improving student digital proficiency (Vancouver Island University, 2020).

☐ **Commit to learning the unique features**
Every video conferencing platform is unique and requires a user adjustment period to understand its full functionality. Spend some time learning the different features and making sure it's the right choice for your students.

☐ **Consider Internet limitations**
Although there are a great deal of opportunities to interact through video conferencing, internet limitations are important to consider and plan for in advance.

Quick Response (QR) Codes

Students are offered a code to bring visuals of their primary language(s) to a tablet and/or mobile device. Providing easy-to-access language support allows students to participate in an activity with their full selves and keep up with their learning (Boschen).

☐ **Determine the type of QR code**
There are some variances in the type of QR code you can use. Determine ahead of time whether the content linked to your QR code will be assigned a static code, used repeatedly to perform the same task (e.g., listen to a single audio book), or if the QR code will be a dynamic code, allowing you to update links so that students can use the same code to perform a variety of activities over time (e.g., accessing tutorials that are updated at different times of the year to align with curricular scope and sequence).

☐ **Supplement physical books with audiobooks**
You can provide QR codes that link to audiobooks to support readers at all levels who display a wide range of language abilities.

☐ **Provide an answer key using QR code**
When students complete an assignment, you can direct them to a QR code to check their work.

☐ **Ensure devices can read QR code**
Before directing students to use a code, be sure that the devices students will have available to them have QR code reading capabilities.

Simulation Programs

Students gain valuable learning knowledge through highly stimulating visual experience(s). Simulating science experiments allows students to focus on observing and making connections to build their conceptual knowledge of STEM. Additionally, "with appropriate teacher support and careful selection and review, ... simulations can be effective for introducing young students to simple physical science concepts, and for providing them with opportunities to engage in higher order thinking processes" (Davenport et al., 2018).

☐ **Include teacher support (it is still essential)**
It may be enticing to leave students to their own devices when utilizing simulation programs, but research indicates that these programs are not meant to be independent learning tools (Falloon, 2019). You should still serve as a facilitator to address any misconceptions your students may have.

☐ **Use simulation as a reinforcement method**
Simulation programs may not be able to teach your students everything they need to know about a particular concept, but when used alongside other instructional methods they can be useful in helping your students to retain new information in a fun and alluring way (Falloon, 2019).
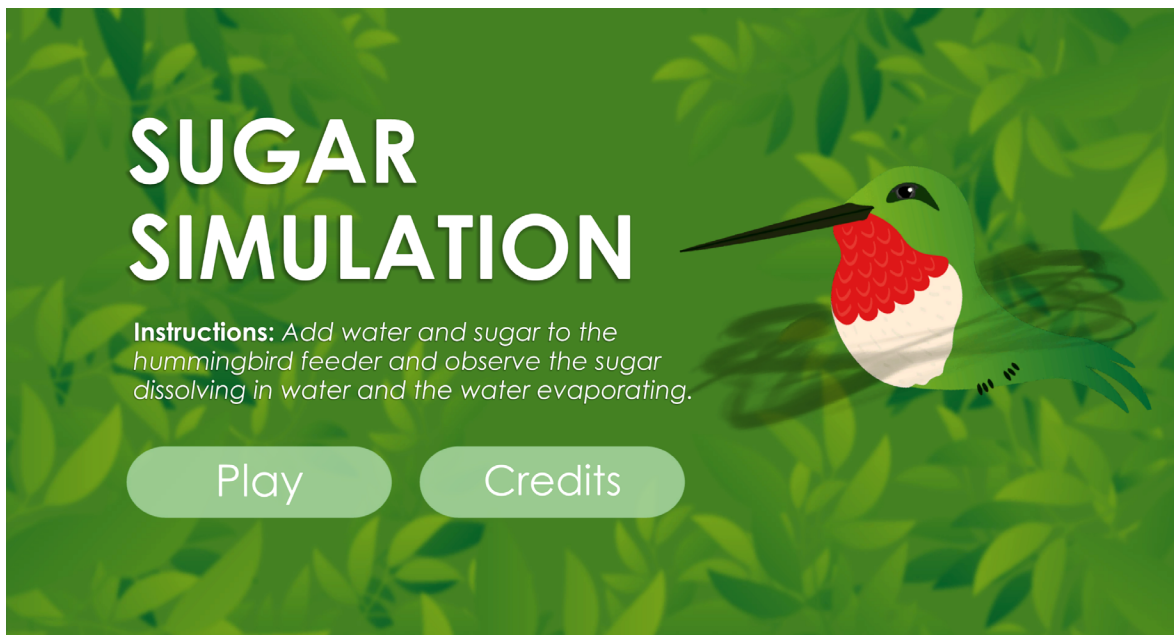
Sugar Simulation, Smithsonian Science Education Center

This Sugar Simulation from the Smithsonian Science Education Center helps students explain what happens when they dissolve sugar in water and leave the solution out uncovered for several days. This resource is aligned with the Smithsonian Science for the Classroom grade 5 physical science module, "How Can We Identify Materials Based on Their Properties?"

Sugar Simulation is available as a website for desktop and laptop computers.

Collaborative Digital Tools

Students will have access to living documents and recordings with smart-editing features and styling tools that support collaboration. The use of collaborative digital tools can help you support students to write, present and collect data to share, and receive feedback more efficiently and accessibly.

☐ **Allow typed assignments instead of writing**
This reduces the barriers to entry (e.g., activities that require note taking, and reflections) so that students can focus on capturing new knowledge instead of mastering the traditional routines to complete an assignment.

☐ **Allow speech-to-text instead of writing**
Students may feel more supported when they are able to record themselves to complete an assignment and providing a speech-to-text option makes that possible for them to participate in a task using their preferred method of engagement.

☐ **Assign group work**
Using collaborative digital tools for group work can help a team stay organized and hold each member of the team accountable to complete the assigned work.

Digital Libraries

Students impacted by reading barriers such as dyslexia, blindness, cerebral palsy, and other impacts, will receive customized learning experiences to meet their specific learning needs. Customization provides an opportunity for students to comfortably take part in reading activities in ways that best serve their needs.

☐ **Customize reading experiences**
Customize your students' reading experience by pre-selecting a few titles, based on their interest, to get them started on eBooks in audio, audio-highlighted text, braille, large font, and other formats.

☐ **Create digital libraries**
If available, allow students access to digital libraries so that they can engage in content. You can also provide e-readers, student-selected books, and, books that are culturally relevant and customized to meet the needs of your students.

☐ **Utilize reading groups and independent reading**
You can use digital libraries to bring your students together around a story or you can allow your students to self-select and build their own library of digital books. Either way, your students will have positive experiences with books.

☐ **Support reading comprehension**
Digital libraries can reinforce comprehension because many include assistive technologies that can reduce some challenges related to reading.

Quiz Platforms

Students will be provided variable feedback for assessment by being presented with a game-based learning platform that generates multiple-choice quizzes accessible via web on the various quiz platforms.

- □ **Recognize the benefits**
    - Allows for reviewing and introducing topics, providing accuracy, and checking for understanding in any subject area
    - Allows for multiple engagement and representation of the content and enables students to express and demonstrate their understanding of the content in multiple formats and question designs

- □ **Implement in the classroom**
    - Check for understanding by asking a series of questions before, during, and after a lesson
    - Preparing for a test or exam
    - Accessing prior knowledge before giving content

Add-Ons and Extensions

Students will be provided digital, mechanical writing support to communicate more effectively, and possibly even more proficiently, over time. Utilizing *scripts* that run inside your classroom slides, documents, and spreadsheet programs allows student users to modify and enhance the functionality of their selected resources and improve their ability to create compelling pieces of writing. The benefits of using these add-ons include: spelling—text prediction; reading—text-to-speech, speech-to-text, highlights text, providing summarization; writing—speech-to-text, editing, spell check, and access to math supports—calculators, and visuals.

- □ **Implement in the classroom**
    - Grammar support tools that assist with writing, spell check, editing sentence structure
    - Speech-to-text and text-to-speech add-on, collects highlights for summarizing and research, voice notes, highlights text
    - Add-ons or extensions that assists with graphing, geometry, algebra, and probability in one add on group work and note-taking

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II. Strategies that Encourage Student Choice and Engage Multiple Sensory Functions

A. Strategy: Station-Based Learning

Target audience: Pre-K through 12

Standards alignment:

Next Generation Science Standards

- Planning and carrying out investigations (Grade K-2)
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

Common Core

CCSS.ELA-LITERACY.CCRA.SL.1

Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

Universal Design for Learning anchor:

Optimize individual choice and autonomy (Checkpoint 7.1)

Optimize relevance, value, and authenticity (Checkpoint 7.2)

Objective

Students are offered multiple representations to provide them choices in how they prefer to access information or activities. This strategy also allows them to take on more ownership of their learning as they make connections to new material and manage how they will facilitate the transfer of new knowledge.

Background

The use of stations is a strategy that involves differentiated instruction, where students go to different spots in classrooms to work in diverse tasks simultaneously (Tomlinson, 2014). They invite cooperation between all students because groups are flexible and support peer practice, allowing student engagement and response and improving communication, collaboration, and the use of scientific skills (Metcalf et al., 2009; Miller, 2016; Stanford et al., 2018).

According to Moorehead and Grillo (2013), stations provide opportunities to individualize instruction and teach skills necessary for some but beneficial for all students. Stations also provide students freedom of choice because every student is not required to attend every station or spend the same amount of time in each task. By implementing stations as an instructional UDL strategy in the classroom, a teacher can layer in supportive materials (e.g., prompts) to meet a variety of student academic and social needs. Stations offer teachers moments to provide quick and accurate feedback and permit the right balance between teachers' choice and students' choice (Metcalf et al., 2009; Tomlinson, 2014).

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

☐ **Establish a routine for how stations will be used**
Deciding how many stations students need to visit and sharing the learning objective(s) you want them to achieve upfront will help students know what is expected of them when they visit stations.

☐ **Utilize various grouping strategies** (TeachHub, 2019)
Students often learn a great deal from their peers. Providing variety in student pairings allows you to experiment with different means of engagement and encourages students to explore interaction with their peers in a new way.

  - **Grouped to mix skill levels.** By using this grouping strategy, you can make sure that students performing at different levels learn from one another.
  - **Grouped using a rotational system.** To manage this grouping strategy, you will set students up in two circles, one inner circle and one outer circle. Then instruct one circle to rotate clockwise while the other stays in place.
  - **Grouped by day-of-the-week.** You can assign each student to a specific partner, or group, for each day of the week. For example, if it's a Tuesday, have them get together with their Tuesday group, which will be different from their groups on other days of the week. In this strategy, you can also let students have input in creating each day's defined group. If all students go to all the stations, there is no singling out of students and all students benefit from every station.
  - **Multiple modalities.** Determine which modalities (i.e., kinesthetic, visual, auditory, or touch) students will focus on at each station. Modalities may be the same in different stations if one specific modality is the learning objective.

Potential Challenges

Stations encourage students to socialize and participate in the class community, but without proper management they can also serve as an opportunity for students to get off task.

Students that have difficulties with relationship-building skills and/or conflict-resolution skills may not receive the full benefit of stations because they require students to maintain some level of independence, and productivity, with minimal support.

Example
You can categorize stations based on the type of educational experience students will receive. (e.g., teacher led, collaborative, tech-dependent or independent work time)

Teacher Led   Independent Work Time

Online Learning   Collaborative
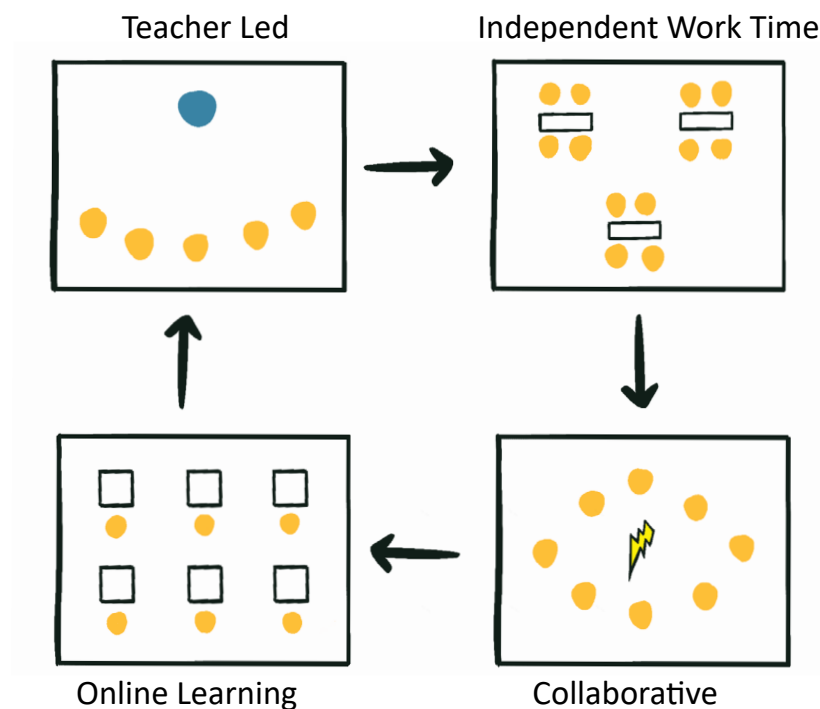
Stations can also allow students to increase their understanding of a concept by seeing multiple illustrations, for example by observing the different ways that motion energy can change.

Noisemaker Station

Turn the handle of the noisemaker.

- Look closely inside the metal box. What do you see?
- What do you hear?

Flashlight Station

1. Hold the flashlight about 10 cm above the paper. The bulb should be pointing down.
2. Press the lever up and down quickly several times.
   - Look carefully inside the flashlight. What do you see?
   - What do you see on the paper?
   - What do you hear?

Stay Safe! Keep the flashlight pointing down. Don't shine the flashlight into people's faces.

Source: https://ssec.si.edu/collisions

Noisemaker Station Card, How Does Motion Energy Change in a Collision? Smithsonian Science for the Classroom, Smithsonian Science Education Center

Flashlight Station Card, How Does Motion Energy Change in a Collision? Smithsonian Science for the Classroom, Smithsonian Science Education Center

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B. Strategy: Concrete-Representational-Abstract Method (CRA)

Target audience: Pre-K through 12

Standards alignment:

Common Core

Math Based

Kindergarten: CCSS.MATH.CONTENT.K.G.B.5
Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes.

High School: CCSS.MATH.CONTENT.HSG.MG.A.1
Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).*

Literacy Based
CCSS.ELA-LITERACY.CCRA.SL.5
Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

Universal Design for Learning anchor:

Offer ways of customizing the display of information (Checkpoint 1.1)
Illustrate through multiple media (Checkpoint 2.5)

Objective

Students can be presented with highly engaging manipulatives to learn STEM concepts. The Concrete-Representational-Abstract (CRA) method of instruction is an effective way of presenting new concepts because its use of manipulatives makes it easier for all learners to gain access to abstract material. (Hinton, V., et. al., 2013; Fuchs, 2007).

Background

The use of manipulatives as a teaching strategy is well recognized in literature (Carbonneau et al., 2013). Manipulatives are any materials or concrete objects that help students understand different abstract concepts by moving and rearranging them (Carson & Bostick, 1988). The purposes for using materials include the following: providing students with concrete ways to understand the meaning of abstract ideas, supporting students to learn new concepts, connecting their prior knowledge to new thoughts, assisting students to formulate problem-solving strategies, fostering creative thinking, actively engaging students in activities by capturing their interest, motivating students, and helping students

to adapt to individual learning styles, among others (Mitchell, 1991). When students use manipulatives, they have the chance to apply concrete experiences to logical thought.

Additionally, the constructivist theory emphasizes student involvement and participation as students interact and manipulate materials to develop knowledge according to their learning styles and experiences (Midkiff & Thomasson, 1993).

The use of manipulatives can prove to be effective for retention and has a positive impact on learning outcomes when used with appropriate instructional strategies (Carbonneau et al., 2013).

Moreover, the Nation's Report Card from the US Department of Education (2012) indicated that students who participated frequently in hands-on projects scored higher on the National Assessment of Educational Progress (NAEP), stating that using manipulatives and allowing students to participate in the learning process, by doing, supports their understanding of STEM concepts (Green, 2014).

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

□ **Use manipulatives to represent phenomena across all STEM subjects**
There might be a natural inclination to use manipulation in one core subject area; however, there are ways and benefits to integrating the use of manipulatives into all areas of STEM. For example, using manipulatives to represent energy transfer when discussing the law of conservation of energy or using tangible items to represent the number of things in a math equation are both equally beneficial in providing a student with tactile experiences to gain new knowledge.

□ **Pre-expose students to manipulatives**
When it's possible, students should be given time to play with any manipulatives that will be used in the classroom before formal instruction takes place.

□ **Prep manipulatives in advance**
Manipulatives should be prepared ahead of instruction to maintain a flowing lesson that is enhanced by the use of manipulatives.

□ **Setting norms and expectations**
Without proper guidance on how to use manipulatives, students can find less productive uses for them. Setting clear expectations for how and why manipulatives will be used in the classroom might deter students from using the materials inappropriately. A sample series of lessons integrating manipulatives could go as follows:

Day 1:

Introduce and explain manipulatives. Students will be guided in discussion about manipulatives, how they help us to learn about math or science concepts, and spend time understanding how the manipulatives work.

Day 2:

Step 1: Review why we use manipulatives and discuss expectations

for independent and small group use. Students will review what they learned on day 1 and be led in discussion regarding how manipulatives should be used in the classroom. (e.g., Like toys at home, manipulatives can be fun to get creative with, but, unlike toys at home, most of the times that we use manipulatives, they will help us to solve a specific problem.)

Step 2: Allow students time to explore the manipulative.

Step 3: Model solving an equation or an engineering problem that students will replicate using their individual set of manipulatives.

☐ **Whole group, small group, and individual instruction**
Depending on the type of manipulative being used, you can introduce students to a specific manipulative within a whole group, again during a small group discussion, and over time build their capacities to use manipulatives independent in one-to-one interactions (e.g., within a station).

Examples

☐ **Fractions**
Fraction bars, fraction circles, and pattern blocks can all be used to learn fraction concepts. These materials are helpful because they add a tactile element to the mathematical concept, allowing students to clearly visualize and touch the changing parts. Students who have appropriate manipulatives to help them learn fractions outperform students who rely only on textbooks when tested on these concepts (Jordan et al., 1998; Sebesta & Martin, 2004).

☐ **Place value**
Using manipulatives increases students' understanding of place value (Phillips, 1989).

☐ **Ratios**
Students who have appropriate manipulatives to help them learn fractions also have significantly improved achievement when tested on ratios when compared to students who do not have exposure to these manipulatives (Jordan et al., 1998).

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III. Strategies to Reinforce Literacy and Language Skills in STEM

A. Strategy: Student-Created Dictionaries

Target audience: 3rd through 8th

Standards alignment:

Next Generation Science Standards

- Obtaining, Evaluating, and Communicating Information (Grades 3-5)

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.

Common Core

CCSS.ELA-LITERACY.CCRA.W.2

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

Universal Design for Learning anchor:

Clarify vocabulary and symbols (Checkpoint 2.1)

Objective

Students log new words and create definitions within their own context to reinforce spelling, reading, and literacy skills at their own pace. This strategy employs multiple means of expression, which allows students to not just explain what they know but do so in a way that will reinforce their desire to retain new information.

Background

Literacy in STEM education is one of the goals that the Committee on STEM Education of the National Science & Technology Council stated in their report (Executive Office of the President, Office of Science and Technology Policy, 2018). New Common Core Standards of Literacy in Science, developed by the National Governors Association Center for Best Practices, explicitly target the use of different strategies to teach literacy in science (Green, 2014), as does the K-12 Framework for STEM Education (NASEM, 2010) which led to the Next Generation Science Standards (NGSS Lead States, 2013).

Student dictionaries improve student awareness of STEM vocabulary by increasing the frequency of their interactions with new words, thereby improving retention, internalization, collaboration skills, and overall engagement in STEM. Student dictionaries can enrich learning and support students along their educational and professional pathways (Green, 2014; Executive Office of the President, Office of Science and Technology Policy, 2018).

This strategy aligns with one of the most relevant skills for the success of students in STEM-related careers: the development of STEM content literacy (Soules et al., 2014).

According to the National Research Council (1996), "scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. A sound grounding in science strengthens many of the skills that people use every day, like solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force."

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

☐ **Introduce a student dictionary**

Explain to your students that their dictionary is a place where they can write down unfamiliar words and it can assist them in creating definitions that are most relevant and meaningful to them.

☐ **Provide options for how to organize a dictionary**
- You can instruct your students to label pages in a notebook from A to Z, leaving a few blank pages between each letter.
- You can instruct your students to keep a running list (by date or topic) if you are not worried about alphabetical order.
- Using a three-ring binder, you can guide students to make each new page a new entry.
- You can also show your students how to keep note cards on a ring or in a recipe card box to manage their new words.

☐ **Set expectations, or provide a template, for what could be included in their dictionary**
- You can assist your students by guiding them through how to enter new words and how to create working definitions.
- You can also encourage students to make connections between new words and their existing knowledge, which may include pictures, diagrams, and/or words from their native language.

☐ **Use student dictionaries as a pre-reading activity**
In advance of an activity, students can add new words to their dictionaries and brainstorm potential definitions.

☐ **Use student dictionaries as an assessment tool**
Student dictionaries can help you to track student achievement and measure their proficiency in general STEM subjects or within a specific area of STEM.

☐ **Allow students to include pictures**

☐ **Determine whether dictionaries will be general or subject-specific**
It will be helpful to students to know in advance whether they will use their dictionaries to obtain in-depth knowledge about a specific subject or if they will use their dictionaries to capture vocabulary for a broader understanding of STEM. Ensure that dictionaries are adaptable and can grow with students over time. Student dictionaries can serve as a literacy support that has timeless benefits if they are designed properly. Try to avoid focusing solely on the short term and spend a little time planning how your students' dictionary can be used to assist them in the future.

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B. Strategy: Total Physical Response

Target audience: Pre-K through 5th

Standards alignment:

Common Core

CCSS.ELA-LITERACY.CCRA.L.4
Determine or clarify the meaning of unknown and multiple meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

Universal Design for Learning anchor:

Vary the methods for response and navigation (Checkpoint 4.1)

Clarify vocabulary and symbols (Checkpoint 2.1)

Build fluencies with graduated levels of support for practice and performance (Checkpoint 5.3)

Objective

Total Physical Response (TPR) pairs a student-created motion with a word to increase interest and retention of vocabulary. TPR provides opportunities to use visual, auditory, and motor perceptions that bring a better understanding of language, creating strong association and improving auditory learning skills (Wu-Yuin et al., 2014).

Background

Different researchers have demonstrated that providing varied opportunities to know the material of different subjects can promote interest and bring life to the content (Scrabis-Fletcher, 2014). Moreover, when there are opportunities to integrate activities between two or more areas, the learning process can be improved and give possibilities to solve problems with different views (Misiewicz, 2016).

Physical education and physical activity classes are an ideal forum for integrating STEM information because of the variety of outlets for practice and broad topics that can be covered. With creativity and flexibility, basic knowledge in a wide variety of content areas can be reinforced through physical activity tasks allowing students to truly engage with content (Scrabis-Fletcher, 2014).

In this area, Total Physical Response (TPR) is one teaching method that connects this interaction between different subjects (Wu-Yuin et al., 2014). According to Asher (1966), TPR is a strategy that uses body motion while listening to concepts to understand them

in a practical context. This has a great impact on the retention of words to learn foreign languages and can be replicated in STEM literacy, as the specialized vocabulary of science is a common challenge for learners of all ages (Smith-Walters et al., 2016).

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

- **Have a plan**
  Plan what words you want to have students create actions for, how you will present the word and definition, and how much movement you want them to use (e.g., arms vs. full body), keeping in mind UDL strategies to ensure your plan is fully inclusive and meets the needs of all of your students along the continuum of human ability.

- **Begin with examples**
  Introduce the practice with an example. Choose a word, provide the definition, and provide an action. For the next word, read the word and definition but have students suggest movements to use for the word.

- **Choose motions that are accessible to everyone**
  To make sure that you have full participation from your students, choose motions that everyone in your group can do.

- **Utilize repetition**
  Repeat the words and motions regularly to assist in retention.

Review vocabulary with TPR

- A fun way to review is to use a game where students pick out vocabulary words for other students to define and/or show the motion for. For example, have one student in the center of the circle and call out a vocabulary word. The rest of the students will then call out the definition. Then the next student goes in the middle and calls out a different word. Continue until all students have had a chance.
- Adding physical action breaks allow students to move and use their minds in different ways. Using Total Physical Response provides an action break while reviewing vocabulary.

Example

For a lesson on energy, the vocabulary words are criterion, device, engineer, and evidence. When the discussion comes to criterion, the teacher will post the word where everyone can see it and its definition: a list of requirements. The teacher will then demonstrate a motion to pair with the word criterion, such as putting a hand up to your face and pretending to read a list.

Students will then repeat the word and definition while doing the action. When the word criterion comes up again, the whole class will be prompted to do the action and repeat the definition.

When the next vocabulary word or device comes up in the lesson, the teacher will post the word and the definition but have students suggest movements. The group will then assign one motion to represent the word. This continues for all the words. Throughout the week, the class can take activity breaks and review the words with the actions as a group.

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IV. Strategies to Create a Classroom Culture that Adopts Principles of Inclusivity and Accessibility

The following strategies are aligned to competencies found in the CASEL SEL Competency Framework.

A. Strategy: Identity Mapping

Target audience: 3rd through 12th

Standards alignment:

Next Generation Science Standards

Nature of Science: Science is a Human Endeavor (Grades 6-8)

☐ Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers
☐ Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination, and creativity.
☐ Engaging in Argument from Evidence (Grades 9-12)
☐ Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

CASEL SEL Competency

<u>Self-awareness</u>: The ability to accurately recognize one's own emotions, thoughts, and values and how they influence behavior. The ability to accurately assess one's strengths and limitations, with a well-grounded sense of confidence, optimism, and a "growth mindset."

Universal Design for Learning anchor:

Optimize relevance, value, and authenticity (Checkpoint 7.2)

Objective

Students create identity maps to deepen their understanding of themselves and their classmates. An identity map is a graphic tool that can help people better understand the many things that shape who they are as individuals. These are also things that can influence

a person's thoughts or the decisions they make in different situations (Smithsonian Science Education Center [SSEC], 2018).

Background

The classroom is an environment where the personalities and identities of the people interacting evolve. Understanding these identities and helping them grow is a source for teachers to recognize the possibilities and develop strategies that address the unique learning needs of their students (Conrad & Blackman, 2018; Marino, 2010).

A strategy where teachers can represent these identities and support students' self-reflection about their characteristics and accommodate new content knowledge is called identity mapping. It is a graphic organizer strategy where students put their ideas and knowledge in a visual manner to think about the concepts and how the information is related to their own knowledge and individuality (Smithsonian Science Education Center [SSEC], 2018).

They help teachers and students make visible their thinking representing abstract information in a concrete and organized way, allowing for a significant learning opportunity for the children (Janney & Snell, 2013). Also, as the children gain knowledge, teachers benefit from the information of students' background to help to communicate expectations and show care and concern (Ladson-Billings, 2009).

There is evidence that the use of graphic organizers is effective to improve learning of basic and higher-level skills, like inference, for students with and without disabilities in elementary, middle, and high school and particularly for children with learning disabilities (Dexter & Hughes, 2011).

Particularly, some benefits of the use of mapping as a graphic organizer include the following: allowing students to think about concepts and retain information effectively, promoting creative thinking, improving learning autonomy, helping students to organize concepts and visualize relationships, and providing supports for understanding, storing and retrieving information (Tajeddin & Tabatabaei, 2016).

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

☐ **Brainstorm a list of characteristics as a group**
  - Have students brainstorm a list of categories you might use to describe someone's identity or who they are. This might include things like age, school, grade, race, gender, nationality, family background/origin, role in family (sister, brother, cousin...), ethnicity, interest, hobbies, religion, things you like to do, personality traits (shy, loud, talkative, quiet, funny, sad, etc.) and physical traits (e.g., height, hair color, eye color).

- Have students write their name in the middle of a piece of paper and then circle their name. Around their name, have students use the categories they created to write words around their name that describe them.
- As an alternative, students can create a physical identity map made up of objects they collect that represent their human ability, interests and experiences.

☐ **Host a post-activity discussion**
You can ask your students to reflect on their identity map by answering the following questions:

- Which item on your identity map is most essential to your sense of self (right now, this week, this year, in your life)? Circle it (or point to the object if the map is made up of physical objects)
- Are certain aspects of your identity more influential than other aspects? Why?
- How might your identity map change over time?
- How much control do you have over the things on your identity map?
- How might things on your identity map affect decisions you make in your life?

☐ **Create a whole-class identity map**
Students can create a group or classroom identity map by going around and sharing what characteristic they have circled and adding it to a group identity map. Doing this before an activity can build relationships and break down stereotypes.

☐ **Beginning of the year activity**
This can be a great activity to do when students are just getting to know each other, like in the beginning of the year or before starting a group project/activity. It allows students to understand how everyone is unique and has different characteristics and experiences that affect decisions and their life.

☐ **Focus more on the parts vs the whole**
When having students circle an item on their identity map that is most essential to their sense of self, some students may try to circle their name to essentially choose their whole person, instead of focusing on one characteristic.

☐ **Identity mapping can be tied to other activities**
The identity map can be expanded when starting a new activity or topic. Students can add another circle around the initial identity map and write down everything they know about the topic.

☐ **Allow students to experiment with different forms of expression**
Students can include more than just single words, for example, sentences, stories, or drawing pictures.

☐ **Revisit identity mapping when you have guest**
Encourage guests to your class to create an identity map so that students can compare to their own, creating a stronger connection.

Example
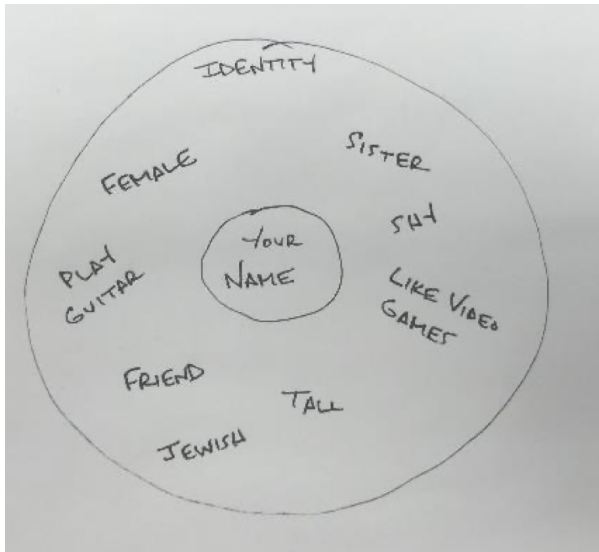
[COVID-19! How Can I Protect Myself and Others?](link) a community research guide developed by Smithsonian Science Education Center

Before learning how to take action to improve nutrition in their community, students do individual and team identity maps. This helps them learn how identity can affect their decision making.

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B. Strategy: Cooperative Groups

Target audience: 1st through 12th

Standards alignment:

Next Generation Science Standards

Nature of Science: Science is a human endeavor (Grades 3-5)
☐ Most scientists and engineers work in teams

Planning and carrying out investigations (Grades 3-5)
☐ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials is considered.

Analyzing and interpreting data (Grades 3-5)
☐ Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.

Common Core

CASEL SEL Competency

Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. The ability to communicate clearly, listen well, cooperate with others, resist inappropriate social pressure, negotiate conflict constructively, and seek and offer help when needed.

Universal Design for Learning anchor:

Promote expectations and beliefs that optimize motivation (Checkpoint 9.1)

Foster collaboration and community (Checkpoint 8.3)

Objective

Students will display an appreciation for positive interdependence and provide mutual support in groups with their peers. Group cooperation offers a wide range of social and academic benefits like increased tolerance for new and different ideas and improved communication skills.

Background

One powerful strategy to promote inclusion with students with varied learning needs is cooperative groups (Tomlinson, 2014). According to data associated with innovative

teaching practices, the cooperative learning model was ranked as the teaching approach that promotes the greatest higher order, thinking, problem-solving, and achievement skills (Joyce et al., 1987).

Cooperative groups teach students to work together to reach common goals and value the contributions made by individual group members, involving them in group activities at academic and social levels (Janney & Snell, 2013; Copenhaver & Rudio, n.d.). Three primary purposes of using cooperative learning are to develop students' social and communication skills, increase tolerance and acceptance of diversity, and improve academic achievement. Students who participate in cooperative learning demonstrate less competitive behaviors and an increase in cross-ethnic participation when compared to peers that only experienced whole-class teaching (Sharan et al., 1985).

There are five core components of cooperative learning (Johnson & Johnson, 1999):

1. Positive interdependence: The students need to rely on one another to reach a common goal.
2. Individual accountability: Each member is responsible for doing their part.
3. Heterogeneous grouping: Grouping maximizes differences and range of skills.
4. Direct instructions of social skills: The teacher actively teaches social interaction, communication, collaboration, and tasks-related skills while students practice them and receive feedback.
5. Group processing: Group members discuss how well they assessed the goal, decided on the required tasks to achieve the goal, and their ability to work together.

This strategy provides opportunities for students to share their thinking and support group members to understand concepts, enhancing reflection in the activity and their thinking process, benefiting from teamwork, sharing, caring, and learning (Ibler, 1997).

Additionally, research supports the idea that students learn best when they collaborate with peers and are provided the opportunity to process information that they perceive to be personally meaningful. For example, Moore's (2005) research found that following a teacher-led lecture, only 5% of the information was retained by students and only 30% of the information presented during a classroom demonstration was retained after a 24-hour period.

However, when students used major components of cooperative learning to apply their learning immediately by practicing their new skills or teaching their new skills to others, 75% to 90% of the information presented was retained by students after a 24-hour time period.

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

- [ ] **When choosing which tasks to use cooperative groups, consider the following five necessary attributes:**
    - Joint tasks for activity suited to group work
    - Teams of five or fewer students
    - Use of cooperative behaviors
    - Positive interdependence
    - Individual accountability and responsibility

- [ ] **Choose what roles need to be filled in the group so every person in the group has an integral job.** Roles might include things such as: recorder, communicator, timekeeper, materials manager, facilitator, or artist.

- [ ] **Depending on the age and independence of your class, group roles can be assigned, or student selected**. For the first time using cooperative groups, you may need to assign jobs or provide scaffolding for groups choosing who does what.

- [ ] **Invest time in preparing students**

    - Provide explicit instructions, responsibilities, and timing
    - Rotate roles regularly
    - Try to give everyone a chance to do each role
    - Have a system in place for assigning roles, e.g., colored dots, role cards, table signs
    - Consider how to make all students successful for each role

- [ ] **Benefit of creating roles for each student**

    - Supports smoother classroom transitions
    - Allows for opportunities to assess non-academic skills such as turn-taking, cooperation, and communication
    - Provides opportunities for student engagement and for students to take ownership over their own learning.
    - Makes every member of the group important because everyone has a job
    - Decreases the amount of time spent waiting for a group to decide or discuss who is going to do what
    - Provides new opportunities for people to develop new skills in controlled situations

Example

For an initial lesson about energy where groups need to design and build one fan model, the teacher decides to use cooperative groups and identifies four interconnected jobs: materials manager, artist, questioner, and speaker.

Since this is the first time using cooperative groups in this class, the teacher puts colored dots on the students' desks. When they are ready to start the lesson, the teacher introduces the jobs by posting the name of the job and a brief description of what the job should do. They then assign a color to each job and provide a reference point by placing a sticky note with the coordinating color next to the jobs.

The teacher then gives time for the group to introduce themselves and their jobs. The teacher sets norms or reminds students of the classroom norms.

The teacher then proceeds with the lesson instruction. When it is time for the groups to start working, the teacher reminds students to consider what their job today is, what they are responsible for, and why they are important to their team.

The teacher then allows groups to work and walks around to check for understanding and to support the groups.

Note: Colored dots can be replaced with physical shapes that can be felt. Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.
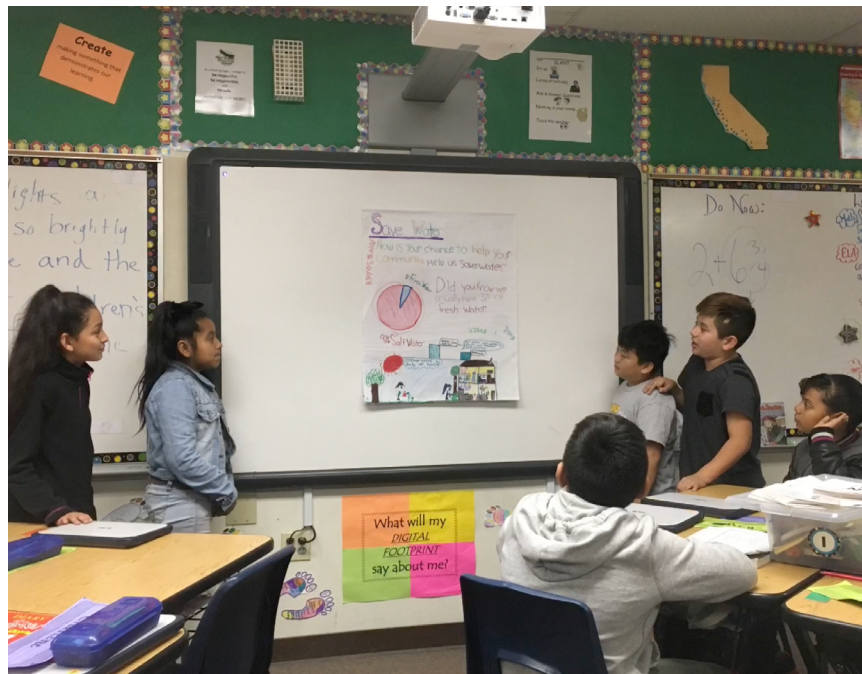
How Do We Provide Freshwater to Those in Need? *Smithsonian Science for the Classroom*, Smithsonian Science Education Center

This is a collaborative group presentation for one of the lessons in *Smithsonian Science for the Classroom.*

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C. Strategy: Peer Support

Target audience: Pre-K through 12th

Standards alignment:

Next Generation Science Standards

Planning and carrying out investigations (Grade K)
☐ With guidance, plan and conduct an investigation with peers

Engaging in argument from evidence (Grades 3-5)
☐ Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posting specific questions.

Common Core

CASEL SEL Competency

Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. The ability to communicate clearly, listen well, cooperate with others, resist inappropriate social pressure, negotiate conflict constructively, and seek and offer help when needed.

Universal Design for Learning anchor:

Foster collaboration and community. (Checkpoint 8.3)

Objective

Students can be paired with a peer to receive some type of assistance. Peer supports and networks achieve the following objectives:

1. Provide natural support within the class community to support academic learning and social engagement

2. Ease students' dependence on paraeducators or teachers, allowing for more independence

Background

Peer support is an evidence-based practice of a community of learners supporting each other academically and socially in a class. Typically, peer supports are assigned and developed by the teacher ranging from 2 to 3 students working together on assignments and activities in class. They are an acceptable form of support that does not ostracize nor call out a specific student (Carter et al., 2016; Carter & Brock, 2015; Carter et al., 2011).

It aligns with the inclusive education practices in at least three ways: it adapts to the learning diversity, readiness, and learning profile; it is an effective method for engaging academic achievement and social development; and it fosters social relationships between peers (Janney & Snell, 2013). The research on peer supports has shown that this flexible and free support model can be implemented at any grade level in an inclusive classroom (Carter et al., 2016).

Also, this strategy provides opportunities for students to actively play in real decision-making for issues they are interested in, giving relevance to both the desired outcomes of the lessons and learner variability inclusion (Basham & Marino, 2013).

For example, teachers who participated in a qualitative study of the effectiveness of peer support in high school settings observed a positive impact in the adaptations of the learners when they participate in the activities with peers and peers supported the learning as they model grade-level expectations (Schaefer et al., 2018). So, peer support can lead to higher levels of social and academic participation, more class participation, and improved goal attainment (Carter & Brock, 2015; Carter et al., 2011).

Note: Adjust the strategy accordingly to ensure it is fully inclusive and meets the needs of all of your students along the continuum of human ability.

Teacher tips

- □ **Flexibly use peer supports**
  Observe students for signs of frustration, over-helping, personality clashes, too much socializing and not enough academic work being completed, or other signs that students may need to change partners or teams.

- □ **Set your expectations**
  - Peer supports are there to help each other learn, not to give the answers or do the work for someone
  - They are there to support everyone's learning and growth
  - Ensure peers know each other's roles
  - Provide models for peers to support each other, "I think (positive), I wonder (constructive criticism)," or sandwich method of feedback (a positive, a constructive criticism, positive feedback)
  - Model using high expectations and scaffolding for all students: "What could you do to get x to happen?" "Do you remember what causes x?" "W causes x. If we want x to happen, what happens first?"

- □ **Set up ways for students to get additional supports or instruction**
  This could be done through:
  - Pre-teaching

- Centers that target specific skills/concepts, etc. to accommodate the different rates at which students comprehend new information. This also allows students to work collaboratively and ask for help when needed.

☐ **Ensure support is reciprocal**
Peer supports should be a reciprocal arrangement. Peer supports are not in place to make someone without a disability feel good that they are helping someone with a disability.

☐ **Match students based on strengths and areas of need**
All students should have the opportunity to be the helper or teacher. For instance, the student with an IEP may offer social support and may be better able to record that information than others.

☐ **Consider how modified student performance goals will play a role in peer support groups ahead of time**

Some students may have modified content or performance expectations, but they should still lead to the grade-level standard and expectations, e.g., class goal is to be able to demonstrate understanding of how planet rotation and revolution affect Earth cycles.

- Modified but still leading to the standards and expectation could be, student is able to express how the movement of Earth around the Sun accounts for day/night
- Modified but NOT leading to the standards and expectations could be: Student is able to identify yellow for day and black for night. This may be PART of an IEP goal that is embedded into the activity, but it is insufficient as a goal in and of itself.

☐ **Peer supports are not the same as buddy programs**
Peer supports have an academic and social component. Buddy programs are strictly socially motivated. Buddy programs also tend to be a one-way model of support where the student without the IEP is always the one providing help and support and the one with the IEP is always seen as needing help.

Example

This sample of strategic grouping offers each student a chance to improve in a specific skill through interaction with their peers.

Ms. A's Student Group

1	Jamal (English language learner; excels when interacting with manipulatives)
2	Barry (Limited mobility; enjoys socializing; excels when assignment includes a public-speaking component)
3	Ujwal (Less social, hard of hearing, prefers to write and share reflections in a small group rather than present to the entire classroom)
4	Danielle (Expresses herself best through visuals, model representations)

Paired reading can be used to provide support for reading informational text. Pair bilingual students with students with very limited English. Suggest students discuss content from the text in both their primary language and in English. This can help them become more familiar with the potential similarities between English and their primary language.

With guidance, students can peer review engineering designs and offer suggestions for improvement. For example, in a grade 1 activity students make reflective signs that enable them to be seen in the dark. They share their designs with peers and explain how the signs solve the problem (from How Can We Light Our Way in the Dark?, a module for Grade 1 students developed by the Smithsonian Science Education Center).

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D. Strategy: Classroom Norms

Target audience: Pre-K through 12th

Standards alignment:

Next Generation Science Standards

Engaging in argument from evidence (Grades K-2)
☐ Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to tell the main points of the argument.

Common Core

Core SEL Competencies

Responsible decision-making: The ability to make constructive choices about personal behavior and social interactions based on ethical standards, safety concerns, and social norms. The realistic evaluation of consequences of various actions, and a consideration of the well-being of oneself and others.

Universal Design for Learning anchor:

Promote expectations and beliefs that optimize motivation (Checkpoint 9.1)

Facilitate personal coping skills and strategies (Checkpoint 9.2)

Objective

Students will be informed of expectations for behaviors that are developed and agreed upon by the group. This strategy focuses on the increased likelihood of students having a vested interest in adhering to classroom expectations because they have contributed to creating the routines and procedures for their classroom.

Background

A classroom is a place where the promotion of academic achievement and the improvement of social and emotional skills is required as a foundation for meaningful employment and engaged citizenship (Elias et al., 1997; Jennings & Greenberg, 2009). To achieve this goal, we need an effective classroom environment, or in other words a classroom with minimal confusion and downtime that maximizes students' learning (Evertson et al., 2003). For that reason, we need to set support structures that allow teachers to have patterns and routines that make clear their expectations through the establishment of rules and procedures (Evertson & Emmer, 2013; Evertson et al., 2003; Wong, 1998).

Rules are expected norms of behavior in general terms, as a single rule can include a variety of expected behaviors. Procedures are expectations for specific behaviors, like the procedure for returning books in the library (Marzano, 2005). Clearly defined and enforced rules and procedures are particularly important for students with "opportunity gaps" (e.g., poverty, ELL, discrimination, homelessness, learning disabilities), as the clarity and consistency of the expectations are a bridge to overcome academic and social-emotional challenges (Milner, 2010; Pratt-Johnson, 2006; Tough, 2012).

As the established rules and procedures become routine in the classroom until the point there is consensus in the application, they evolve into classroom norms (Evertson et al., 2003).

Norms are socially accepted attitudes, values, and behaviors in a given situation (Rutland et al., 2005). It is important for the development of classroom norms as they release space for cognitive processing for teachers and students, allowing a variety of activities to take place and developing students' involvement, reflection, meaningful connections, respect and ownership (Castle & Rogers, 1999; Evertson & Emmer, 2013).

Teacher tips

- ☐ **Come prepared with ideas**
  It is easier to steer conversation if you have a set of norms in your mind but allow the group to add what they think is important if it is relevant and achievable.

- ☐ **Ask questions to prompt thinking about norms**

  - For younger groups, ask leading questions about how students should interact with each other, such as "How will we know whose turn it is to talk?" You may also have to suggest the solution. (e.g., raise your hand to talk.)
  - For older groups, have individuals suggest what rules for interaction should be in place.

- ☐ **When creating the group norms consider the eight guidelines for writing rules,** understandable, doable, manageable, always applicable, stated positively, stated behaviorally, consistent with your own philosophy, consistent with school rules. *Classroom Organization and Management Program,* https://www.comp.org/aboutCOMP.html

  - Consider adding attitude norms as well as interaction norms, e.g., be willing to take risks, be vulnerable, etc.
  - Try to use one set of norms that will be used in every setting to increase the chance for students to become familiar with and internalize class norms.

- Having group members develop the norms will increase buy-in and make sure that the norms address their primary concerns.
- Try to keep the list of norms concise. (e.g., under seven items.)

Example

☐ **For older groups**

1. Stay on task

2. Actively participate by sharing thoughts

3. Ask questions (off topic questions can be put in the parking lot)

4. Challenge yourself to take risks

☐ **For younger groups**

1. Use kind words and actions

2. Speak one at a time

3. Follow safety rules

☐ **Culturally responsive norms**

1. Stay engaged

2. Speak truth

3. Experience discomfort

4. Accept and expect non-closure (From Glenn Singleton - Courageous Conversations about Race: A field Guide for Achieving Equity in Schools)

Discussion norms

Learning how to argue using evidence is an important skill in STEM. Set rules of behavior for discussion such as those shown in the below example.

Discussion Rules

■ Be a good listener.

■ Pause when someone else is talking.

■ Say if you agree.

■ Say if you disagree.

■ Use evidence.

■ Ask for evidence.

Smithsonian Science for the Classroom, Smithsonian Science Education Center

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