HMH

RESEARCH FOUNDATIONS:

EVIDENCE BASE

HMH Into Science™

THE HMH RESEARCH MISSION STATEMENT

Houghton Mifflin Harcourt® (HMH®) is committed to developing innovative educational solutions and professional services that are grounded in learning science evidence and efficacy. We collaborate with school districts and third-party research organizations to conduct research that provides information to help improve educational outcomes for students, teachers, and leaders at the classroom, school, and district levels. We believe strongly in a mixed-methods approach to our research, an approach that provides meaningful and contextualized information and results.

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INTRODUCTION

The *Next Generation Science Standards* (NGSS)[1] embody a call to incorporate what had previously been isolated best practices in science education into a single coherent set of standards informed by the spiraling three-dimensional approach advocated by the National Research Council (NRC)'s *A Framework for K–12 Science Education*. At its core, the *HMH Into Science* program is designed to support educators in providing true NGSS learning and teaching, as described in the NRC's 2015 *Guide to Implementing the Next Generation Science Standards*. While some traditional approaches may remain worthwhile, alignment with NGSS represents a new and different way of delivering science education.

Middle school science learning represents a critical experience in each student's broader education. As noted by the National Science Teaching Association (NSTA; 2016, online), "The middle school years, grades 5 through 9, are a time of tremendous physical, emotional, and cognitive changes for students. It also is a pivotal time in their understanding of and enthusiasm for science." NSTA recommends the curriculum of middle level science programs

- be aligned with the disciplinary core ideas, crosscutting concepts, and science and engineering practices outlined in *A Framework for K–12 Science Education*
- nurture curiosity about the natural world and include opportunities to engage in science and engineering practices
- foster the development of a scientific mindset and an understanding of the nature of science
- incorporate independent and cooperative group learning experiences during the study of science, and integrate science with other curriculum subjects in a multidisciplinary approach, such as through theme-based learning
- engage students in frequent, multiple laboratory investigations
- encourage the development of critical thinking and communication skills and the sharing of ideas and results with peers

NSTA further recommends that the middle school science curriculum offer links to the real world by

- focusing instructional units on subject matter that is relevant to students' lives, interests, and experiences
- applying content and skills learned in science class to explain phenomena, create models, and design solutions to real-world problems
- connecting the classroom to the community through place-based learning opportunities such as field trips, inspiring speakers, and local partnerships
- providing students with real-life experiences (e.g., mentoring and apprenticeships) that enable them to develop an awareness of science-based careers and an understanding of how science is relevant to their lives
- providing opportunities for critical thinking and decision-making activities (e.g., evidence-based argumentation and analysis of authentic data) for involvement in community-based problems
- promoting societal goals for scientific, engineering, and technological literacy

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Embracing such expert guidance and research-based practices, *HMH Into Science* offers the following key pedagogical features in its middle school level program:

- less rote memorization of facts and terminology; more learning of facts and terminology as needed to support scientific sensemaking and the designing of solutions
- less learning of ideas disconnected from questions about phenomena; more systems thinking and modeling to explain phenomena as a context for learning
- less teacher as "sage on the stage"; more student-centered learning with the teacher as a "guide on the side" for activities and discussions
- fewer questions with only one right answer; more open-ended questions that require evaluation of the strength of evidence for claims
- less textbook-centered reading and answering questions at the end of a chapter; more and varied types of reading
- fewer "cookbook" activities with a single correct approach; more investigations with a range of possible outcomes
- less reliance on worksheets; more student writing in different media in order to explain and engage in argumentation about claims, evidence, and reasoning
- greater emphasis on an "asset mindset," which maintains that all students are capable of engaging meaningfully with all the standards, rather than relegating some to less rich activities; more supports so all students engage in sophisticated science and engineering practices

HMH Into Science represents a further refinement of HMH's original approach to NGSS and takes advantage of the latest thinking about anchor phenomena and social emotional learning. The remainder of this document will highlight how the program supports both the original shifts and more-recent thinking on NGSS best practices.

PROGRAM CONCEPT

HMH Into Science was *designed for*—not just *aligned to*—the *Next Generation Science Standards* (NGSS). This dynamic series introduces a comprehensive solution to the market, giving students coherence and continuity in their science curriculum across the elementary and middle school levels.

The *HMH Into Science* program's team of authors and advisors includes key members of the group that drafted the NGSS. Their critical work and feedback ensure that *HMH Into Science* comprehensively meets the letter and the spirit of the NGSS. The organization of content within and across units and lessons provides a coherent storyline and supports the development of deep conceptual understanding and mastery of the standards. *HMH Into Science* uses consistent bundling of the performance expectations to deliver coherence across the grades. Each unit builds on the previous unit, and the sequence guides students to develop an increasingly complex understanding of the disciplinary core ideas (DCIs). In support of the National Research Council's (NRC's) *Framework for K–12 Science Education*, *HMH Into Science* delivers a blend of science and engineering practices (SEPs) and crosscutting concepts (CCCs), woven through the DCIs in overlapping progressions. The authors have created lessons and labs that precisely display the presence and interaction of the three dimensions in and across unit and lesson levels.

The teacher materials explain the integration of the three dimensions of learning in a clear, concise, and direct manner. Preceding each unit, an *NGSS Across this Unit* table shows the specific SEPs, CCCs, and DCIs supported and integrated throughout each lesson, activity, and task in the unit. Each unit opener also includes a *Connecting NGSS Across the Grades* table, which displays the connections among concepts from prior grades, the current grade range, and future grades. The correlated SEPs, CCCs, and DCIs also appear at the lesson level in the *Building to the Performance Expectation* notes.

The online teacher resources include the powerful *NGSS Trace Tool*, which gives teachers a user-friendly view of the standards, their correlations to the lessons and activities, and a view of their spiraling connections across the grade levels. The full-text standards and performance expectations appear along with correlations organized into the DCI, SEP, and CCC categories. A grade-level overview for the scope of the NGSS standards for the entire school year is also available from the *NGSS Trace Tool*.

THREE-DIMENSIONAL, PHENOMENA-DRIVEN LESSONS WITH A STORYLINE APPROACH

At their foundation, the NGSS (NGSS Lead States, 2013) function as an integrative, three-dimensional framework for the teaching and learning of science, with each standard consisting of SEPs, DCIs, and CCCs. The integration of rigorous content and application reflects how science and engineering are conducted in the real world and grows out of the decades of research into science learning behind the *Framework for K–12 Science Education* (NRC, 2012).

Since the publication of the NGSS, researchers and practitioners committed to its profound potential to revolutionize science education in the United States, including the National Science Teaching Association (NSTA; 2018), have called for additional fundamental shifts in how science is taught—shifts vital for the power of the NGSS to be actualized. Essential features of curricula effective in supporting the NGSS enable students to recognize coherence of ideas within and across units and lessons and from one year of learning to the next; to build meaningful conceptual understanding via incremental sensemaking; and to experience phenomena-anchored units that provide ongoing opportunities to question, explain, and evaluate scientific phenomena in the students' own worlds. A storyline approach to instruction infuses a unit and its lessons with added coherence that provides a dynamic approach to unfolding the sensemaking of a phenomenon. *HMH Into Science* delivers on this promise with a very tight storyline woven around anchoring phenomena.

TEACHING SCIENCE IN THREE DIMENSIONS

The learning of science cannot be separated from the doing of science (Duschl, 2012; NRC, 2007). The NGSS outline a vision for a three-dimensional integrated approach to instruction that research demonstrates as necessary in order to provide students with high-quality science education for the 21st century. The three dimensions include SEPs, CCCs, and DCIs. These are accompanied by performance expectations, which are learning outcomes or goals, not instructional activities (Bybee, 2013; NGSS Lead States, 2013; NSTA, 2018).

The integration of rigorous content and application reflects how science and engineering are practiced in the real world—and it is how experts across related fields advocate for teaching science to better prepare students for college and careers (NGSS Lead States, 2013; NRC, 2007 & 2012; NSTA, 2018; Sneider, 2012). This broad initiative promises vital benefits: by developing deeper knowledge on three dimensions, students will be able to apply knowledge in new, challenging ways and to build problem-solving, critical-thinking, communication, and self-management skills while experiencing a sense of wonder and curiosity about science (Krajcik, 2015). Additionally, and with great significance, the NGSS have addressed issues of diversity and equity since inception and, therefore, offer a vision of science education that presents learning opportunities and challenges for all students, particularly student groups historically underserved in science classrooms (Lee, Miller, & Januszyk, 2014).

Science education leaders and experts have provided substantial guidance in how to make the shift to three-dimensional learning within K–12 classrooms. *The Guide to Implementing the Next Generation Science Standards* (NRC, 2015) clarifies that NGSS-aligned science instruction "does not mean the information that a teacher delivers to students; rather, we mean the set of activities and experiences that teachers organize in their classroom in order for students to learn what is expected of them" (p. 24).

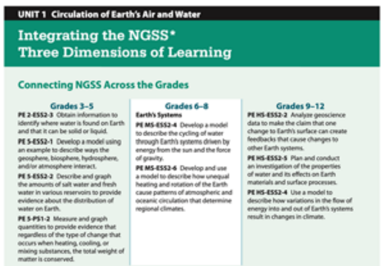
This integrative approach should impact all aspects of teaching science. "Engaging students in three-dimensional learning isn't an item on a checklist; it is an orientation one takes to science teaching, and it should be used every day. Three-dimensional learning involves establishing a culture of figuring out phenomena or designs to problems" (Krajcik, 2015, p. 50).

The capacity of the three-dimensional approach to improve science instruction depends upon a number of factors. Fundamentally, however, teaching that aligns with the approach must feature a coherent progression of learning within and across lessons and units—and from year to year. A lack of coherence has long plagued K–12 science education in the United States and impeded previous standards and reform efforts (NRC, 2012). Critically, the coherence must be clear not just to curriculum developers and teachers but also—just as importantly—to the students themselves. "Achieving the vision of the *Framework* and NGSS in classrooms requires important shifts in teaching approaches and instructional materials to support coherence from the students' perspective . . . organizing learning so that students can build new ideas systematically and incrementally starting from their curiosity and initial conceptions, and supporting students in authentically engaging in science and engineering practices because of a genuine need to make progress on addressing questions or problems they have identified" (Reiser et al., 2017, p. 1).

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science for Grades 6–8 is organized by disciplines aligned to NGSS. Its flexible, unitized curriculum configuration allows teachers to customize content based on district and student needs. SEPs, CCCs, and DCIs are taught within *HMH Into Science* not as discrete program components but in a fully integrated approach—as advocated in a core tenet of NGSS. Also, in its alignment with NGSS, the program focuses on a deeper understanding of fewer science concepts.

HMH Into Science authors infused each lesson with the three dimensions of learning associated with performance expectations that develop science understanding and engagement through an intertwined, three-dimensional approach across grade spans, as the NGSS require. This approach has the added benefit of allowing teachers and districts flexibility in the order they take up different science topics.

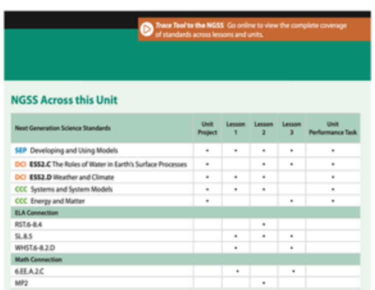

UNIT 1 Circulation of Earth's Air and Water

Integrating the NGSS*
Three Dimensions of Learning

Connecting NGSS Across the Grades

Grades 3–5	Grades 6–8	Grades 9–12
PE 2-ESS2-3 Obtain information to identify where water is found on Earth and that it can be solid or liquid. **PE 5-ESS2-1** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **PE 5-ESS2-2** Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. **PE 5-PS1-2** Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.	**Earth's Systems** **PE MS-ESS2-4** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. **PE MS-ESS2-6** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	**PE HS-ESS2-2** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. **PE HS-ESS2-5** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **PE HS-ESS2-4** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

The NGSS labeling in the *HMH Into Science* Teacher Activity Guide clearly identifies all the performance expectations, SEPs, DCIs, and CCCs of NGSS, including math and ELA connections. These labels help educators recognize the standards covered in any given lesson. The start of each discipline's unit in the Teacher Activity Guide demonstrates how the learning experiences in the unit will support the integrated three-dimensional approach advocated by the NGSS.


Trace Tool to the NGSS Go online to view the complete coverage of standards across lessons and units.

NGSS Across this Unit

Next Generation Science Standards	Unit Project	Lesson 1	Lesson 2	Lesson 3	Unit Performance Task
SEP Developing and Using Models	•	•	•	•	•
DCI **ESS2.C** The Roles of Water in Earth's Surface Processes	•		•	•	•
DCI **ESS2.D** Weather and Climate	•	•	•		•
CCC Systems and System Models	•	•	•		•
CCC Energy and Matter	•			•	•
ELA Connection					
RST.6-8.4			•		
SL.8.5		•	•	•	
WHST.6-8.2.D		•		•	
Math Connection					
6.EE.A.2.C		•		•	
MP2			•		

The *HMH Into Science* Teacher Activity Guide also provides (a) correlations showing how each unit's storyline addresses the three dimensions and (b) a summative overview of where individual dimensions are addressed within the program sequence.


Connect Your Learning

Unit Storyline

In **Engineering Design Unit 1,** students explore the role of engineering and science in society and learn about the tools and processes engineers use to develop solutions. Then, students explore an engineering design process. In **Lesson 1**, students build on their understanding of science, engineering, and technology to explore and practice an engineering design process. In **Lesson 2,** students practice researching and defining an engineering problem and identifying criteria and constraints. In **Lesson 3,** students brainstorm solutions, use decision matrices to evaluate potential solutions, and evaluate data from testing. In **Lesson 4,** students develop and test modifications of a prototype in order to optimize a design solution.

Organizing dimensional learning within the storyline approach lends coherence to the learning experience. Throughout the *HMH Into Science* Teacher Activity Guide are features that aid orientation to the critical dimensions of the EQuIP Rubric, an instrument for evaluating a curriculum's conformance with the contours of an authentic NGSS program. While using *HMH Into Science* ensures that science content and instructional practices closely align with NGSS, the EQuIP Rubric allows evaluation of specific lessons or units, which helps teachers identify and confirm where and how NGSS criteria are being met.

Within each lesson of *HMH Into Science*, the emphasis is on DOING science—most lessons consist of activities designed to elicit questions and answers from students as they embark upon a coherent sensemaking journey related to the anchor phenomenon under consideration.

For the student, the sensemaking journey begins with experiencing an anchor phenomenon. Rather than being told science facts or concepts, students are invited to engage with a phenomenon through a video (in the digital edition) or photos (in print). "I Tell," "Collaborate," and "Analyze" prompts guide students through connecting prior knowledge and observations to the start of the sensemaking journey. Finally, at the end of the lesson, students will revisit their initial explanations to evaluate and possibly revise those explanations using a Claims-Evidence-Reasoning approach.

This approach, summarized in the chart below, describes how the program supports coherence from the students' perspective. For the teacher, each lesson begins with a phenomenon storyline that clearly elucidates how the lesson's sensemaking journey unfolds and also describes what students will achieve in each of the lesson's individual investigative phenomena.

Teacher Guide

The three dimensions of science learning—SEPs, DCIs, and CCCs—are interwoven throughout the learning experiences in the sensemaking journey. Again, the Teacher Activity Guide provides easy-to-digest charts that highlight how these dimensions connect to the performance expectation being supported within a lesson.

ANCHORING, INVESTIGATIVE, AND EVERYDAY PHENOMENA

Fundamentally, science is about explaining the world around us: using evidence to construct explanations for the causes of phenomena (McNeill & Krajcik, 2012; NGSS Lead States, 2013). As explained within *A Framework for K–12 Science Education*, "the goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories" (NRC, 2012, p. 52). Research has yielded compelling evidence that when classrooms function to support real scientific practice, students' understandings of science flourish (Michaels et al., 2008). Just as scientists try to understand how and why different phenomena occur and then develop and critique related explanations, effective instruction must feature similar processes (NRC, 2000 & 2012; NSTA, 2018).

Hands-on, focused, driving questions that contribute meaning and authenticity as well as organize goals and tasks encourage both autonomy and collaboration among students and foster deeper understanding of content (Krajcik & Blumenfeld, 2006; Krajcik & Czerniak, 2014).

Phenomena then become lesson anchors that students use to ask questions or address problems that, through their explanation or resolution, allow for deeper understanding and sensemaking. Anchoring phenomena are also an effective focus of an instructional unit that ties together student learning throughout multiple lessons or extended periods of instruction (Krajcik, 2015; Reiser et al., 2017).

A primary feature of NGSS-driven instruction is enabling students to explore and explain phenomena (Lee, 2020; Penuel & Bell, 2016). Natural, everyday scientific phenomena as well as real-world technological systems can be used effectively to spark interest and engage students in the inquiry process and the engineering design process (Sneider & Ravel, 2021). When students investigate compelling phenomena or work on design problems by engaging in authentic practices within science and engineering, the learning progression is afforded additional coherence (Penuel & Bell, 2016).

Explaining phenomena is a key instructional shift promoted by the NGSS. Rather than focusing solely on mastering discrete science content, the emphasis is on engagement with the process of students working together to figure out answers to questions about phenomena and resolve design problems—a process that helps students construct meaning and make sense collaboratively (Lee et al., 2019). This shift is potentially most impactful and motivating for students from historically underserved backgrounds who have not previously experienced science as real or relevant in their own lives or as a likely prospective career path (Lee, 2020). Making sense of compelling phenomena rooted in everyday experiences and communicating ideas with peers and teachers promotes access to science and supports the inclusion of all students, including English learners, by allowing them to bring individual "funds of knowledge"—their own cultural and linguistic resources and experiences—into the science classroom (Lee et al., 2019).

In a spring 2018 survey, focus on phenomena was cited as a key aspect of a substantial increase in engagement with science resulting from instruction aligned with the standards. Teachers and administrators indicated that making sense of phenomena piqued students' curiosity motivated students to figure what is going on and eagerly answer self-generated questions, and even resulted in students' applying themselves further to deeply engage with a reading or an investigation that would shed light on what they were trying to understand. This process effectively delivers on the NGSS aims to both increase student agency and improve equity. "When initially presented with phenomena, students are often captivated and very curious, and the NGSS are designed to encourage students to ask questions accordingly. Teachers reported that this initial period during which all students are pondering the phenomenon but none of them are yet able to explain it—and there are no shortcuts to the right answer—puts all members of the class on an equal playing field. They have seen that starting a lesson this way can help free students' creativity, confidence, and willingness to engage." (Tyler et al., 2018, p. 5)

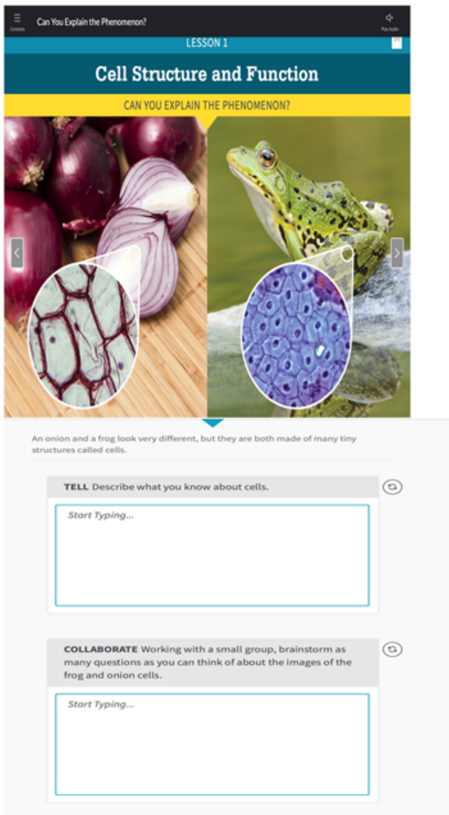
According to Penuel and Bell (2016), an effective anchor phenomenon

- builds on familiar or everyday experiences from students' lives—which means it must also reflect experiences of students from nondominant cultures or groups underrepresented in science, technology, engineering, and mathematics (STEM)
- requires students to develop an understanding of and apply multiple performance expectations while also engaging in activities drawing on math, reading, writing, and communication
- is just beyond the reach of what students can figure out without instruction, has no quick answers, and is too complex for students to explain or design a solution for after a single lesson
- is observable (directly or with the aid of tools or technology)
- accompanies relevant data, images, and text to engage students in the range of ideas needed to understand
- has an audience or stakeholder that cares about the findings or products
- may take the form of a case, puzzle, or wonderment

The recommended process of implementing the three-dimensional approach begins with identifying engaging phenomena or problems that build toward the NGSS performance expectations; from there, consider the questions students are asking about the phenomena, especially ones that can be explored over a sustained period of time and ones for which students can ask and explore sub-questions (Krajcik, 2015).

HOW *HMH INTO SCIENCE* DELIVERS

Anchoring phenomena drive the learning from start to finish in every lesson within *HMH Into Science*. Additionally, sensemaking is a continuous thread woven throughout the program. Each student's learning journey launches and extends from investigative anchor phenomena that meet evidence-based criteria of being relevant and compelling. Intriguing visuals and videos spark interest. Sustained engagement and deeper exploration are then fostered with hands-on labs that take students into further study. Students engage in real scientific practice to understand how and why the phenomenon occurs. This begins immediately after they experience the phenomenon through the feature Can You Explain the Phenomenon?



The student-driven investigation continues throughout the lesson, with hands-on labs that connect directly to some aspect of the anchor phenomenon and carry out the storyline.

Following the hands-on labs, additional learning experiences provide more opportunities for student-driven investigation. Rather than merely providing long passages to read, these experiences offer students videos and pictures of different contexts involving the same concepts. Students interact with and actively respond to the experiences to engage across disciplines and employ SEPs, rather than passively being lectured to or reading about science facts and concepts.

THE CLAIMS-EVIDENCE-REASONING FRAMEWORK FOR SENSEMAKING

"Science process should be a means by which science knowledge is gained. Students who participate in scientific practices, such as questioning, hypothesizing, investigating, developing models, interpreting and analyzing data, linking conclusions to data, and sharing findings with others, are able to develop and provide meaning to knowledge and explanations of the natural world (Michaels et al., 2008)" (Robinson et al., 2014, p. 218).

Engaging students in scientific explanation and argument with the aid of scaffolding can help them view science as a dynamic and social process in which knowledge is constructed (McNeill et al., 2006; McNeill & Krajcik, 2008) as well as motivate them to want to study science (McNeill & Krajcik, 2012). During that process, misconceptions students may form are stepping stones critical to building understanding of the world; science educators are advised to examine and correct students' misconceptions with sensemaking activities (Campbell et al., 2016).

Manz, Lehrer, and Schauble (2020) have highlighted the importance of students' grappling with the collection and evaluation of evidence during investigations to help them build conceptual knowledge as well as develop more sophisticated understanding of science practices. This research team proposes a framework centered around investigation as the locus for constructing alignments among phenomena, data, and explanatory models. Further, they recommend students engage in the following processes, all of which they argue are accessible to students from a young age, support conceptual innovation, and help to make the work that scientists do more visible:

- developing empirical systems
- getting a grip on empirical systems
- determining, defining, and operationalizing data as evidence
- making sense of how results from empirical systems do and do not advance scientific understandings

After conducting research and working with science teachers, McNeill and Krajcik (2012) developed the Claims-Evidence-Reasoning (CER) Framework to (a) support students in developing scientific explanations and arguments; (b) provide explicit guidance for what to include in science writing, oral presentations, and classroom discussions; and (c) encourage students in using evidence from investigation to answer questions or solve problems independently. Following are the sequential components of the CER Framework:

- claim: a statement that answers a question or problem
- evidence: scientific data that supports the claim
- reasoning: justification that describes why or how the evidence supports the claim, often including scientific principles or science ideas that students apply to make sense of the data

A well-established process within science classrooms, CER begins with students' being asked questions that require them to think deeply about what they have observed, experienced, or read; then students integrate their findings into an explanation for a specific purpose or audience (McNeill & Krajcik, 2012). The CER Framework also provides students with a simplified means of communicating their explanations and engaging in argumentation (McNeill & Martin, 2011). CER supports students' learning that, like scientists, they must make critical judgments about their own work and that of their peers, examining the validity of science-related media reports and their implications for individuals and society. "The knowledge and ability to detect 'bad science' are requirements for both the scientist and the citizen" (NRC, 2012, p. 71).

HOW *HMH INTO SCIENCE* DELIVERS

The CER approach is employed in *HMH Into Science* as a key part of the sensemaking journey carried out through the lesson storyline. Students begin the lesson by observing an anchor phenomenon, noticing things about it, collaborating to brainstorm questions about it, and making a claim about it.

As the learning experiences unfold through the investigation of phenomena in the lesson storyline, frequent prompts encourage students to use aspects of CER to gather information, analyze it, and reach conclusions from outset to conclusion.

The lesson storyline culminates with students evaluating their initial claim and reconsidering it in light of all the evidence examination, exploration, and reasoning they have done through the investigative process.

HMH Into Science also has students evaluate their learning through reflection. At the end of a lesson, the Lesson Self-Check encourages students to reflect on the evidence they gathered throughout the lesson and provides another chance to respond to the discrepant phenomenon or problem of the lesson via open-ended questions.

HMH Into Science provides opportunities for students to elaborate on or extend their science learning. Take It Further features information about career paths and related topics.

ARGUMENT-DRIVEN LEARNING

Argument drives and defines much of the work scientists and engineers do: investigating phenomena, testing design solutions, resolving questions about data, developing models, and using evidence to evaluate claims. Argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community (NGSS Lead States, 2013; NRC, 2012).

Both research findings and science standards have called for giving argumentation prominence within science instruction (Grooms et al., 2015; Fakhriyah et al., 2021; Kuhn, 2010; NGSS Lead States, 2013; NRC, 2007 & 2012; Sampson, Enderle & Grooms, 2013). "Argumentation is a central goal of science education because it engages students in a complex scientific practice in which they construct and justify knowledge claims" (Berland & McNeill, 2010, abstract). Engagement in scientific argumentation is critical if students are to understand the culture in which scientists live and how to apply science and engineering for the benefit of society (NGSS Lead States, 2013; NRC, 2012).

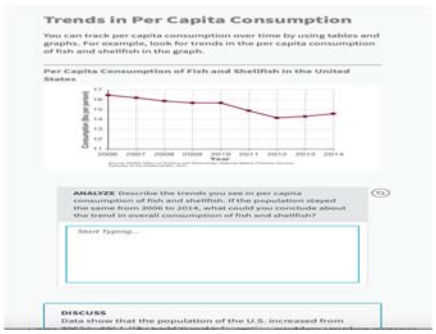
Research has also shown that engagement in scientific argumentation improves the teaching and learning of science (Duschl & Osborne, 2002; NRC, 2012; Sampson & Blanchard, 2012; Weiss et al., 2021). When students argue for their explanations of phenomena or experiences, their explanations are strengthened, and a consensus explanation can be developed (Reiser, Berland, & Kenyon, 2012). To teach science as a process of inquiry without giving students opportunities to construct explanations, evaluate evidence, and engage in argumentation is a failure to represent a core component of the nature of science and to establish an effective means for developing student understanding (Duschl & Osborne, 2002).

Students' views on the dynamic nature of science align with the quality of their arguments (Bell & Linn, 2000). When students develop and critique explanations, it boosts their learning of science content and concepts as well as their ability to reason logically; further, participation in the explanation and argument process can additionally motivate students to study science (McNeill & Krajcik, 2012).

Argumentation also provides rich assessment opportunities. "When students justify their claims with evidence and reasoning, [teachers] gain insight into students' thinking and understanding. You can see how students understand the science concepts and how students apply those science concepts to make sense of the world around them" (McNeill & Krajcik, 2012, p. 11).

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science develops students' argumentation skills with a CER Framework. Students are guided in applying their scientific findings to support their claims and bolster reasoning. The program's argumentation process additionally fosters writing proficiency and critical thinking.



You Solve It simulations provide open-ended opportunities for students to demonstrate their ability to solve problems. Students can explore multiple answers to a problem and learn to develop explanations and defend their answers.

ENGINEERING AND STEM AT K–12

“A quiet revolution is working its way through elementary and secondary public education in the United States. Science education of the 20th century was almost entirely confined to the ‘pure science’ disciplines, but over the past two decades the focus of the school curriculum has gradually shifted from purely science and mathematics towards inclusion of engineering and technology. This movement has been facilitated by a series of new education frameworks and guidelines relevant to society’s 21st-century needs, with the result that engineering is gradually being integrated with the teaching of science for all students from preschool through grade 12” (Sneider & Ravel, from "Insights from Two Decades of P–12 Engineering Education Research," 2021, p. 63).

Students in the 21st century need to understand the interconnectedness and mutually supportive links among science, engineering, technology, and society and how these relationships evolve over time in response to need and impact (NGSS Lead States, 2013). “Science, engineering, and technology permeate nearly every facet of modern life, and they also hold the key to meeting many of humanity’s most pressing current and future challenges. Yet too few U.S. workers have strong backgrounds in these fields, and many people lack even fundamental knowledge of them. This national trend has created a widespread call for a new approach to K–12 science education in the United States” (NRC, 2012, p. 1).

HMH Into Science offers a fully integrated approach to STEM instruction that emphasizes engineering across all scientific disciplines.

BENEFITS OF STEM AND ENGINEERING

In a landscape review of 263 empirical research studies conducted since 2000, Sneider and Ravel (2021) found "there is now a robust collection of studies demonstrating that the integration of engineering into the teaching of science can support deeper learning of science and mathematics concepts and capabilities; that engineering helps students develop 21st-century skills that are essential for daily life and a wide range of jobs; and that learning engineering can increase student motivation and help students develop an identity as STEM learners" (p. 85).

"Science, technology, engineering and mathematics (STEM) workers drive our nation's innovation and competitiveness by generating new ideas, new companies, and new industries. . . . Science, technology, engineering and mathematics workers play a key role in the sustained growth and stability of the U.S. economy, and are a critical component to helping the U.S. win the future" (Langdon et al., 2011, p. 1). And yet compared to their counterparts in other countries, American students in the 21st century, particularly at the secondary level, have shown a limited understanding of what engineers do (Kőycű & de Vries, 2016) and who engineers are, believing that far more males dominate the profession than is accurate (Ganesh, 2011). In findings from a national sample of approximately 10,000 teachers, only 8% of elementary teachers, 10% of middle school science teachers, and 5% of high school science teachers report emphasizing engineering (Banilower et al., 2018). It is not surprising then that, according to Sneider and Ravel (2021), fewer than half of students in the United States are proficient in engineering and technology literacy. "The implication of these findings is that curriculum and instruction at all levels needs to be intentional about helping students become aware of the technologies that surround them, the purpose of engineering in creating and improving the technological world, and the methods that engineers use to solve problems and meet people's needs. While with structured exposure students can readily learn and value the purpose and practices of engineering, implementation is progressing slowly" (p. 71).

A Framework for K–12 Science Education provides a vision for instruction in which technology and engineering are integrated and "students, over multiple years, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields" (NRC, 2012, p. 1–2).

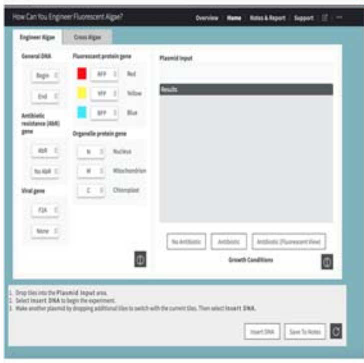
According to Cary Sneider (2012)—contributor to *A Framework for K–12 Science Education*, leader of the Next Generation Science Standards Engineering writing team, and Consulting Author of *HMH Into Science*—the elevation and integration of engineering among the natural sciences within NGSS will likely result in engaging students in engineering practices throughout their K–12 schooling; this will allow students to see how engineering is instrumental in solving many challenges confronting the world today as well as to better understand the dynamic interplay among science, engineering, and technology.

The wide-ranging benefits of integrating STEM and engineering instruction at K–12 include (a) improved achievement in science and mathematics, with these effects potentially more significant for underrepresented minority groups; (b) increased awareness of engineering and the work of engineers; (c) understanding of and ability to engage in engineering design; (d) interest in pursuing engineering as a career; and (e) increased technological literacy (Katehi et al., 2009; Turner et al., 2016; NRC, 2011). Other research demonstrates that engineering education instills critical lifelong skills, such as teamwork, communication, and creativity, as well as persistence, motivation, self-confidence, and STEM identity (Sneider & Ravel, 2021), with the open-ended nature of engineering design challenges in particular fostering collaboration, creative problem-solving, and engagement (Cunningham & Lachappelle, 2011).

Promising findings suggest that specifically females and some ethnic groups that have been historically unrepresented in STEM are more inclined to respond positively to fields, such as medical and environmental engineering, that have relevance and direct beneficial application to people's lives (Cunningham & Lachappelle, 2011; Katehi et al., 2009; Sneider, 2015; Sneider & Ravel, 2021).

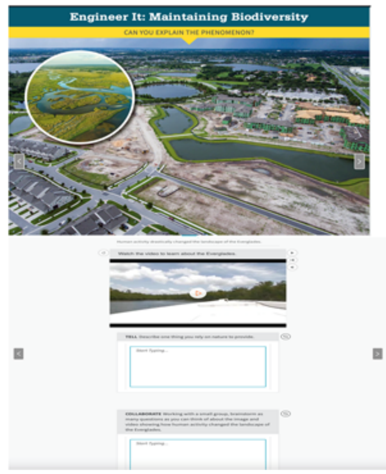
HOW *HMH INTO SCIENCE* DELIVERS

Within *HMH Into Science*, STEM is not treated as an ancillary; rather, STEM is integrated within and across the entire program. Students can experience and apply STEM learning with its inherent connectedness across areas, and teachers are supported with guidance to optimize student learning. An emphasis on STEM is embedded throughout all units at Grades 6–8, not just within Discipline 1: Engineering Design. *HMH Into Science* features interdisciplinary, hands-on, challenge-based activities and performance tasks throughout the curriculum.



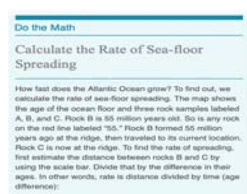
HMH Into Science engages students in engineering and the engineering design process.

The Engineer It performance tasks are elevated, challenge-based activities included throughout the curriculum. Engineer It offers students multiple opportunities to apply the engineering design process by defining a problem and designing a solution within each unit.



HMH Into Science also includes opportunities for students to learn about STEM careers. Take It Further showcases diverse people and careers in science, engineering, and technology. These features show students the real-world applications of what they're learning and seize upon interests ignited by their engagement in simulations of real-world purposes and processes followed by professionals in these fields.

The program's recurring Do the Math feature reinforces mathematical skill development directly within the context of science and engineering, providing cohesive, authentic STEM experiences.



HMH Into Science embeds technology use and supports students' development of technological skills throughout the program. The curriculum leverages the advantages of technology while prioritizing a student-centered learning model. Video-based projects, including some by author and television host Michael DiSpezio, provide practice in engineering.

BEST PRACTICES IN STEM AND ENGINEERING

A strong engineering education during middle school is critical. Research demonstrates that eighth graders' interest in STEM has long-term positive attitudinal and academic effects that extend into high school and beyond. Additionally, opportunities to engage in technology and engineering activities in middle school are a significant predictor of later STEM interest and pursuit of careers in STEM fields (Falk et al., 2016; Sadler et al., 2012; Sneider & Ravel, 2021; Tai et al., 2006).

A Framework for K–12 Science Education calls for technology and engineering to be integrated in students' science learning; to be successful in the science classroom, students must utilize and integrate skills from across STEM areas (NRC, 2012). Research has identified a number of beneficial impacts of an integrated approach to STEM instruction at K–12. One is that students master the individual facts of science content knowledge better when they have a purpose for learning the material. Also, connections among science, technology, engineering, and mathematics are particularly important for raising achievement as students approach the secondary level (Jackson et al., 2021; Russo et al., 2011).

A Framework for Quality K–12 Engineering Education: Research and Development (Moore et al., 2014) emphasizes the importance of having students engage with individual STEM components with high levels of their natural integration, reflecting how science, technology, engineering, and math occur in the real world. Also critical to quality instruction is presenting STEM learning through problem-based activities, with engineering as focus. "Because engineering requires the application of mathematics and science through the development of technologies, it can provide a way to integrate the STEM disciplines meaningfully" (p.2). In addition, placing engineering challenges at the beginning of the unit, to provide context for the learning, results in greater achievement gains than when engineering is incorporated only at the end of a unit (Crotty et al., 2017; Sneider & Ravel, 2021).

While competitive engineering challenges entailing the design and building of devices are an established mainstay in how schools encourage STEM engagement, Sadler, Coyle, and Schwartz (2009) found that reducing competition and boosting cooperation are effective in broadening student interest in engineering design challenges at the middle school level. This team also found that formulating readily recognizable goals helps equitably engage students, both male and female, in stimulating creative processes that build their understanding of scientific methodology.

Real-world contexts for STEM learning are also essential. In industry and research, science, technology engineering, and mathematics are interconnected; in education, these subjects should be taught as they are practiced outside of school settings, in real-life contexts in which the world's issues and economies depend upon them (NRC, 2012). Tapping students' knowledge to analyze and propose solutions for problems in society and emphasizing the human side of science and real-world problems improves students' interest and motivation (McREL, 2010).

Another key to success in science is an understanding of mathematics, the natural language of science. "Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations, and communicating results" (NRC, 1996, National Science Education Standards, Standard A.2.4).

Effective STEM education and programs capitalize on students' interests and experiences; identify and build on what students know; and provide experiences to actively engage students in STEM-related practices and sustain their interest (NRC, 2011). Indeed, research by Falk and colleagues (2016) found that when it comes to sustained engagement in technology and engineering through high school, interest is more critical than aptitude. Sufficient freedom for students to be creative is another important factor in successful STEM units (Crotty et al., 2017).

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science consulting author Cary I. Sneider played a significant role in the development of the engineering standards for NGSS before working on the design and content of *HMH Into Science*. His involvement has ensured that the program properly embeds engineering throughout.

HMH Into Science engages students in engineering and the engineering design processes with integrated STEM activities. One example is found in the Unit Performance Tasks, which are challenge-based activities found throughout the curriculum. Each unit within the program includes a performance task that offers students multiple opportunities to apply the engineering design process by defining a problem and designing a solution, emphasizing the interconnectedness between the scientific concepts being explored and the ability to solve problems.

HMH Into Science engineering challenges are similar to problems students may face in college courses or future careers. But the challenges are provided with scaffolds and supports that break each problem to be solved into smaller, manageable pieces. Engineering is incorporated to allow students to learn the way scientists and engineers learn.

HMH Into Science also features an integrated approach to STEM learning and further supports integrated learning recursively. Program components include ScienceSaurus®, which provides students with clear explanations and dynamic visuals on content ranging from life, earth, physical, and environmental science to natural resources and engineering and technology. ScienceSaurus can be used for presentation, review, or reinforcement of science content.

Also included are interspersed activities for developing students' math skills in the context of science.

HMH Into Science makes the pedagogical transition toward integrative approaches to STEM easier for teachers by providing embedded professional learning support, featuring HMH's authors leading Master Classes in key aspects of STEM.

ASSESSMENT

"Planning, evaluating, and improving the quality of science instruction is contingent on accurately assessing students' knowledge and skills and how these develop over time" (NRC, 2007, p. 344). As reported in *Developing Assessments for the Next Generation Science Standards* (NRC, 2014), the Committee on Developing Assessments of Science Proficiency in K–12 recommends a wide-ranging assessment system to provide all stakeholders—students, parents, teachers, administrators, policy makers, and the public—with the complete and complementary information that each needs about progress in measuring NGSS performance expectations. The Committee further concluded that this new vision of science learning, while challenging, provides unique and valuable opportunities for assessment with new approaches designed to capture three-dimensional learning. In 2018, the NSTA called on science educators to "ensure assessment of students' learning reflects their three-dimensional learning experiences" (p. 2). *HMH Into Science* embraces this integrative approach toward teaching and testing.

FORMATIVE AND SUMMATIVE ASSESSMENT

NSTA (2018) recommends that the assessment strategies used in a middle school level science program include a variety of formative and summative assessment methods to evaluate overall student achievement and guide decisions about instruction and practices. Additionally, NSTA recommends that Grade 6–8 science assessments (a) be frequent, continuous, three-dimensional, and embedded within instructional materials; (b) allow for differentiation, modification, enrichment, and remediation; (c) include questions that are sensitive to gender and diverse cultures and life experiences; and (d) capture students' interests to increase engagement in the assessment process.

To support the NGSS three-dimensional model for science learning, new assessments that demonstrate students' knowledge and competencies and integrate multiple strands of abilities are needed at all levels of evaluation, from informal classroom assessments to high-stakes state testing "Assessing three-dimensional standards means assessing more than just the 'process' of science; it means assessing students' proficiency through integrated use of all three dimensions to explain phenomena and solve design challenges" (Van Horne et al., 2018, p. 1).

Progress on grade-appropriate tasks must be continually monitored so that interventions can be adjusted according to each student's evolving needs (Czupryk, 2020; Steiner & Weissberg, 2020). "Well-designed assessment can have tremendous impact on students' learning . . . if conducted regularly and used by teachers to alter and improve instruction" (NRC, 2007, p. 344). Research also shows that regularly assessing and providing feedback to students and using assessment data to make appropriate adjustments to instruction are highly effective means for teachers to produce substantial gains in learning and achievement (Black & Wiliam, 1998a, 1998b; Stecker et al., 2005).

The phrase "formative assessment" encompasses the wide variety of activities that teachers employ throughout the learning process to gather data to assess student understanding and make and adapt instructional decisions. Effective teachers use formal tools (such as quizzes or homework assignments) and informal tools (such as discussion and observation) to regularly monitor student learning and check student progress (Cotton, 1995; Christenson et al., 1989). By moving testing from the end to the middle of instruction, formative assessment guides teaching and learning as they occur (Heritage, 2007).

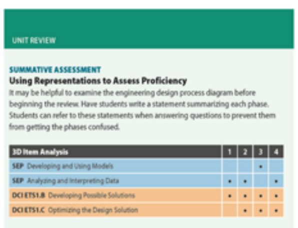
Formative assessment is one of the central instructional approaches needed to ensure that students achieve 21st-century competencies. Curriculum design should use formative assessment to "(a) make learning goals clear to students; (b) continuously monitor, provide feedback, and respond to students' learning progress; and (c) involve students in self- and peer assessment" (NRC, 2012b, p. 182). Formative assessment is especially beneficial for lower-performing students and, as a result, helps to shrink achievement gaps and improve overall achievement (Black & Wiliam, 1998b). After reviewing the body of research on strategies most effective for students with mild learning disabilities, researchers found regular formative assessment to be a shared element of effective interventions with this population (Christenson et al., 1989).

While traditionally associated with higher stakes testing, summative assessment can play a role in the classroom when used as an additional constructive measure demonstrating progress, providing feedback at a particular point in time, and serving as the source for subsequent instructional action (Black & Wiliam, 1998a & 1998b). Historically marginalized students have been further disadvantaged by state and national standardized tests; in the wake of COVID-19 strains on these students and their teachers, high-quality assessment at the classroom level, including diagnostic and needs-based assessment, is essential to determine how students are faring across a range of domains and what they need currently and going forward (Ed Trust, 2020; García & Weiss, 2020; Tarasawa & Samuel, 2021).

HOW *INTO SCIENCE* DELIVERS

As recommended by the authors of NGSS, *HMH Into Science* bundles the treatment of performance expectations across lessons, units, and chapters. Learners can be exposed to multiple performance expectations in a single lesson, but a longer trajectory across an entire unit or even the entire school year is likely to be necessary for full mastery of all aspects of any given performance expectation. *HMH Into Science* aligns questions, prompts, and performance tasks to multiple dimensions to assess more authentically and to reveal a more complete picture of student achievement.

HMH Into Science assessment builds in complexity. It starts with a pretest to assess learners' readiness for the lesson. Then formative assessments and frequent question prompts appear throughout the teacher edition at point-of-use within each lesson's learning experiences. Lesson Quizzes and Unit Tests evaluate students' understanding of the three dimensions of learning. Unit benchmark tests give educators valuable information about learners' progress toward the performance expectations. Lastly, the performance tasks at the end of the unit and the performance-based assessments in the assessment package provide a culminating authentic assessment that emphasizes the application of the SEPs from NGSS. Finally, the open-ended You Solve It interactive simulations are yet another way to assess student performance authentically within the context of a specific challenge.


UNIT REVIEW

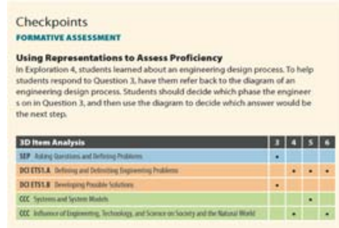
SUMMATIVE ASSESSMENT

Using Representations to Assess Proficiency

It may be helpful to examine the engineering design process diagram before beginning the review. Have students write a statement summarizing each phase. Students can refer to these statements when answering questions to prevent them from getting the phases confused.

3D Item Analysis	1	2	3	4
SEP Developing and Using Models			•	
SEP Analyzing and Interpreting Data	•	•		•
DCI ETS1.B Developing Possible Solutions	•	•	•	•
DCI ETS1.C Optimizing the Design Solution		•	•	•

Lesson Checks and Lesson Summaries show educators how thoroughly their students understand the key three-dimensional points of the lesson. This is usually accomplished by asking students to state claims, evidence, and reasoning that address the discrepant event or problem presented at the beginning of the lesson. These checks and summaries will prepare students for tests based on the NGSS performance expectations. Additionally, interactive no-stakes questions and items at point-of-use within lessons provide students with instant feedback in real-time. For teacher assessment support, evaluation rubrics help teachers evaluate open-ended responses and identify the underlying causes of misunderstanding, therefore supporting targeted remediation.


Checkpoints

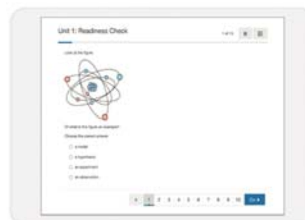
FORMATIVE ASSESSMENT

Using Representations to Assess Proficiency

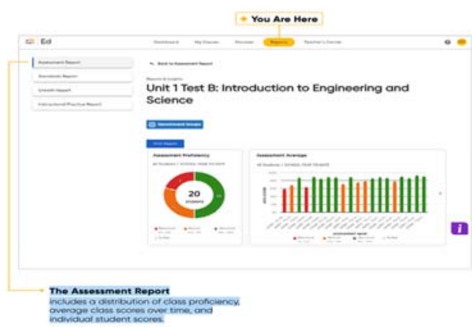
In Exploration 4, students learned about an engineering design process. To help students respond to Question 3, have them refer back to the diagram of an engineering design process. Students should decide which phase the engineer s on in Question 3, and then use the diagram to decide which answer would be the next step.

3D Item Analysis	3	4	5	6
SEP Asking Questions and Defining Problems	•			
DCI ETS1.A Defining and Delimiting Engineering Problems		•	•	•
DCI ETS1.B Developing Possible Solutions	•			
CCC Systems and System Models			•	
CCC Influence of Engineering, Technology, and Science on Society and the Natural World		•		•

HMH Into Science assessments are available online, as printable PDFs, and in an editable Word format. Formative assessments include Beginning-of-Year Readiness Checks, Unit Readiness Checks, and Lesson Quizzes. Summative assessments include Unit Tests and Modified Unit Tests, Cumulative Tests, End-of-Module Tests, and Performance-Based Assessments. Answers, explanations of most answers, and scoring rubrics for constructed-response questions can be found in the Answer Keys.



Within *Ed*, HMH's online learning platform, the Reports tab displays student-performance data and other critical information for teachers. The Assessment Report includes a distribution of class proficiency, average class scores over time, and individual student scores. The Standards Report shows student performance based on standards in the selected subject.



PERFORMANCE-BASED ASSESSMENT

Performance-based assessment is any form of assessment in which students engage in activities yielding products used to evaluate their higher-level thinking abilities (Woolfolk, 2013). Performance-based assessments connect to the important content and process skills emphasized in instruction and offer the opportunity for students to show how well they can use what they know to classify, compare, analyze, or evaluate (Hibbard, 1996). These tasks may take different forms, require different types of performances, and be used for different purposes (formative or summative), but they are typically couched in an authentic or real-life scenario and require high-level thinking. A review of classroom assessment practices in an age of high-stakes testing led Schneider et al., (2013) to conclude that "the value of high-quality performance tasks should not be diminished and should be encouraged as an important tool" (p. 66).

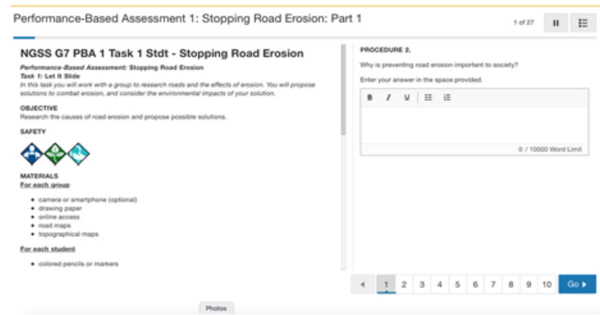
Performance-based assessments look like what we want students to do in the classroom and, as a result, can inform classroom practice in positive ways. Performance tasks allow teachers to engage students in real-world activities; these tasks "emulate the context or conditions in which the intended knowledge or skills are actually applied" (American Educational Research Association [AERA], American Psychological Association [APA], and National Council on Measurement in Education [NCME], 1999, p. 137). They model "what is important to teach and . . . what is important to learn" (Lane, 2013, p. 313). Assessment systems in high-performing nations "emphasize deep knowledge of core concepts within and across the disciplines, problem solving, collaboration, analysis, synthesis, and critical thinking. As a large and increasing part of their examination systems, high-achieving nations use open-ended performance tasks . . . to give students opportunities to develop and demonstrate higher order thinking skills" (Darling-Hammond, 2010, p. 3).

Performance-based assessment also better aligns with most standards—especially the NGSS. In defining the elements of an effective student assessment system, Darling-Hammond (2010) said that such a system must "address the depth and breadth of standards as well as all areas of the curriculum, not just those that are easy to measure" (p. 1). This calls for evaluation of performance on challenging tasks. Performance-based assessments also align more closely with problem- and project-based learning efforts (Lenz, Wells, & Kingston, 2015; Svihla et al., 2019).

Among science educators, there is wide recognition of the limitations of conventional testing methods. Much extant standardized testing of student abilities, such as state achievement tests, mainly include items measuring memory and analytical skills and advantage students of higher socioeconomic backgrounds who are supported with significantly greater financial resources (Sternberg, 2007). According to Zimmerman et al. (2020), performance-based assessments in STEM provide an alternative and complement to standardized achievement tests because performance-based assessments enable a holistic evaluation of the individual student's proficiency. Additionally, performance-based assessments have the potential to identify and support exceptionally talented high school students across all demographic groups, as they narrow disparities in scores among diverse cultural and economic groups and allow students to demonstrate their understanding of scientific principles and their ability to develop solutions during hands-on activities. For these reasons of equity and accurate representation of each student's knowledge and skills, performance-based assessments appropriate for students from low SES levels are essential.

HOW *INTO SCIENCE* DELIVERS

HMH Into Science provides an assessment solution that scaffolds toward true performance tasks called for in NGSS, while also preparing students for a more advanced and challenging assessment environment, including for high-stakes science assessment, with technology-enhanced items. Performance-based assessment is a key program feature both within *HMH Into Science*'s Unit Performance Tasks, referenced in the student e-book and within the formal assessment program.



DIGITAL LEARNING

Over the past decade, policies and practices regarding technology use in classrooms around the country have shifted incrementally to widespread—and widely varying—application. Concurrent with such trends is growing evidence attesting to the positive impacts of technology in education as well as profound advances and innovations within the technology itself. In light of this evidence, many educators are focusing on how to enable technology to deliver improved learning outcomes for all students. Since the start of the 21st century, educators in the United States have broadly adopted the understanding that "technology can be a powerful tool for transforming learning. It can help affirm and advance relationships between educators and students, reinvent our approaches to learning and collaboration, shrink long-standing equity and accessibility gaps, and adapt learning experiences to meet the needs of all learners" (U.S. Department of Education, 2016, p. 1).

But when the global COVID-19 pandemic hit in 2020, digital learning suddenly and profoundly became—rather than a means of improving education—a critical mission, the only way of providing instruction to students remotely. As Fischer, Fry, and Hattie (2020) noted, teaching in 2020 wasn't so much distance learning as crisis teaching. While ongoing health and economic crises create myriad uncertainties for schools in the years to come, one point of clarity is that education increasingly relies on technology—which requires that educators have resources that allow for effective digital teaching.

HMH Into Science leverages findings from the growing field of education-technology research to provide students with quality digital learning experiences.

BEST PRACTICES IN DIGITAL LEARNING

Before COVID-19 drove educators around the United States and the world to suddenly switch to remote teaching in early 2020, the number of students receiving instruction in online and blended learning environments had been steadily growing (Gemin & Pape, 2017; Graham, Borup, Pulham, & Larsen, 2019). While the field of education-technology research is new and changing, findings that emerged over the past two decades indicate that digital learning has enormous potential to positively transform education for diverse groups of students (Abdoolatiff & Narod, 2009; Patrick & Powell, 2009; USDOE, 2016 & 2010). Increases in student-centered, cooperative, and higher-order learning as well as in problem solving and writing skills have been found within computer-intensive classroom settings (Ross, Morisson, & Lowther, 2010). In 2016, the U.S. Department of Education reported that technology-intensive instruction can make education more equitable by closing the digital-use divide and making transformative learning opportunities available to all students.

Blended learning utilizes both device-driven instruction and technology and face-to-face instruction in a conventional classroom context, with the objective of maximizing the advantages of each. Research findings on the effects of blended learning are strikingly positive (Delgado et al., 2015; Graham, Borup, Short, & Archambault, 2019; Osguthorpe & Graham, 2003; Tamim et al., 2011). In a meta-analysis examining online and traditional face-to-face instruction with mixes of both, blended instruction emerged as the most effective of the three approaches (USDOE, 2010). Likely because blended learning teaches students through engaging media and modes that fit with their daily practices and experiences, students tend to view blended learning favorably (Uğur et al., 2011). Blended learning opportunities expand the possibility of growth for all students while affording historically disadvantaged students greater equity of access to high-quality education, in the form of both enhanced, instructionally effective content and more-personalized learning (Molnar, 2014). "Blended learning that combines digital instruction with live, accountable teachers holds unique promise to improve student outcomes dramatically" (Public Impact, 2013, p. 1).

An established body of evidence supports the position that effective technology use in the classroom, through web-based and multimedia learning, increases student engagement and motivation (Abdoolatiff & Narod, 2009; Chen et al., 2010; Reinking, 2001; Taylor & Parsons, 2011; Tucker, 2012). Games, simulations, and virtual worlds are shown to be effective in improving learning outcome gains (Merchant et al., 2012) as well as boosting self-efficacy (Wang & Zheng, 2020). Computer-based instruction in the science classroom has been correlated with increased student self-confidence and overall enjoyment (Ke, 2008). An augmentation to the field of science education, "technology can help learning move beyond the classroom and take advantage of learning opportunities available in museums, libraries, and other out-of-school settings" (USDOE, 2016, p. 12).

Additionally, increased automation can significantly simplify educators' lives by eliminating low-value manual tasks, such as attendance records and student-assessment data entry.

The impact of allowing a digital platform to capture student achievement data in real time frees up resources so that educators can "take advantage of the things that leading brick-and-mortar schools do well, such as creating a strong, supportive culture that promotes rigor and high expectations for all students, as well as providing healthy, supportive relationships and mentorship" (Horn & Staker, 2011, p. 7).

A sizable body of research on digital learning examines science education specifically. Practicing scientists use models—which might include diagrams, replicas, mathematical representations, and computer simulations—to visualize and represent phenomena or systems. Visuals are vital for science learning, as many of the processes and concepts essential to scientific study are not linear by nature; therefore, an image, visual depiction, or animation may provide a more appropriate or effective description for students than a verbal one, aiding their comprehension of content (NRC, 2012). Simulations in learning environments that imitate a real-life process or situation and that allow learners to test effects of their hypotheses on intended outcomes have been shown to boost learning outcomes (Castaneda, 2008; Merchant et al., 2012). Teachers can effectively employ technology-based simulations to represent scientific phenomena or processes. Research has shown that the use of interactive and simulation-based instruction via computer yields higher achievement than when students learn from more traditional instruction (Dani & Koenig, 2008). Evidence also suggests that students learn science content just as well, if not better, from virtual labs as they do from physical labs (Puntambekar et al., 2021).

Following are practices that support powerful STEM learning, as called for by the U.S. Department of Education (2019):

- Dynamic representations: Students can more effectively develop STEM concepts via interactions with digital models, simulations, and dynamic representations of mathematical, scientific, and engineering systems.
- Collaborative reasoning: Technology platforms support students' collaborative discussion and shared construction of STEM concepts, fostering engagement, equalizing participation among group members, and yielding higher performance on test measures.
- Immediate and individualized feedback: Digital tools give students prompt and customized feedback as they practice or demonstrate STEM skills, yielding faster and improved learning outcomes.
- Science argumentation skills: Students use technology to present and evaluate scientific or mathematical claims. Digital scaffolds aid argument development, and platforms allow students to respond to peers' claims dynamically.
- Engineering design processes: Students engage in technology-driven iterative and systematic design processes, with tools similar to those from the engineering field.
- Computational thinking: Students can use technology for formulation, analysis, and solving of problems using algorithms, data, and simulations.
- Project-based interdisciplinary learning: Process and product are enriched when students utilize technology in the context of authentic projects or challenge-based activities that integrate multiple STEM fields.
- Embedded assessments: Digital assessments aligned to ongoing instruction enable students to reflect on and demonstrate understanding of STEM concepts and allow teachers to evaluate student learning. Technology can also foster peer reviews of student work.
- Evidence-based models: Students use technology to reference or create models based on data and evidence.

HOW *INTO SCIENCE* DELIVERS

HMH Into Science gives students a full-fledged online experience that features dynamic multimedia content as well as advanced interactivity. Beyond serving as online editions of the print content that allow for remote access to materials, the *HMH Into Science* Student E-book features additional in-depth materials and explorations for early finishers and/or motivated students, and the Teacher E-book features additional teaching information and strategies that help focus on 3D learning. The program also includes ample opportunities for engagement through digital, open-ended simulations that allow students to use technology like a scientist.

HMH Into Science offers a wealth of additional supporting resources only available online, including

- interactive no-stakes questions and items at point-of-use within lessons that provide instant feedback for students
- the online NGSS Trace Tool that unpacks the standards and displays the connectedness and spiraling within and across grade levels
- You Solve It activities that engage students with open-ended computer simulations and alternative lab options
- Optional Unit Projects that can be used to tie together concepts across a unit
- Hands-On Performance Tasks that provide tactile assessment options as well as interactive and editable assessments

Ed, the HMH learning platform, supports both in-person and online learning. Within this one platform, students can access interactive content and activities and teachers can access activity guides, student materials, and other support and resources for teaching *HMH Into Science* effectively in a blended or fully digital environment. Instruction can be assigned and completed directly within *Ed*, and results can be easily shared from teacher to student.

Video-Based Projects enhance students' understanding through engaging multimedia. These videos are available on *Ed* and include a corresponding Student Worksheet and Teacher Guide.

INCREASED AGENCY AND A MORE PERSONALIZED APPROACH TO INSTRUCTION

Effective learning supports students in improving not only their awareness of the need to self-regulate, self-instruct, and self-evaluate but also their capacity to utilize these skills (Frey, Hattie, Fisher, 2018; Hattie, 2009). As Fisher, Frey, and Hattie (2020) urge, because it is the choice of task that matters in advancing learning—not the medium—teachers should use technology as the means and starting point, not the core of teaching. The same principles of effective instruction that apply in conventional classroom settings apply in digital instruction. Hattie's (2018, with Clarke) ongoing findings about best practices endure. These include the following:

- Foster student self-regulation to encourage deeper learning.
- Increase student agency.
- Include a diversity of instructional approaches (not just some direct instruction and then some offline independent work).
- Include well-designed peer learning.
- Provide feedback within a high-trust environment integrated into the learning cycle.

"Digital learning has the capacity to transform schools into new models for education that are student-centric, highly personalized for each learner, and more productive, as it delivers dramatically better results at the same or lower cost" (Horn & Staker, 2011, p. 2). Blended environments expand the possibility of growth for all students in the form of enhanced, personalized instruction alongside a more consistent and customizable pedagogy that helps each child feel and be successful at school. Digital learning tools can provide individual students more flexibility and support by modifying content, complexity, preferences, and modalities. Further, students enjoy ownership of their overall learning as well as increased agency over its pace. Digital learning tools can also boost the efficacy of differentiation. By offering an array of online and other digital resources, technology can provide learning drawn from real-world challenges and students' personal interests and passions. These blended learning opportunities also afford historically disadvantaged students additional benefits via greater equity of access to high-quality education (Constantine & Jung, 2019; Graham et al., 2019; Horn & Staker, 2011; Imbriale, 2013; Molnar, 2014; Patrick & Powell, 2009; Public Impact, 2013; Tucker, 2012; USDOE 2016).

The best practices in blended learning reflect those of traditional classrooms, but with some critical adaptations within the digital environment (Borup & Archambault, 2018; Fisher et al, 2020; Graham et al., 2019). Blended learning optimizes student learning through facilitating teachers' capacity to be flexible and responsive to students' needs, enabling teachers to provide 1:1 and small-group instruction; to integrate multiple data sources into their constant stream of formative assessment; and to deliberately incorporate more-rigorous learning activities (Anthony, 2019). In a large-scale study, Kwon et al., (2019) found that for online learning to be successful, teaching should be structured so that students make steady attempts to complete learning tasks, ideally with students' own self-regulated learning scaffolded by course pacing guides.

Effective technology use in the classroom motivates students to take charge of their own learning, and that digital learning itself is enhanced when students are given more control over their interaction with media (Horn & Staker, 2011; Patrick & Powell, 2009; USDOE, 2010). Technology is increasingly being utilized in the United States to personalize learning and give students more choice over what and how they learn and at what pace; this will better prepare students to organize and direct their learning in their lives even after formal schooling (USDOE, 2016). Yet a key feature of effective blended learning is that it combines student-driven personalization with teacher-driven differentiation (Graham et al., 2019).

Multimedia learning boosts motivation because of the responsiveness and control these environments allow and the subsequent engagement in active learning they foster (Freeman et al., 2014; Schunk et al., 2008). Zhang (2005) found students in a fully interactive multimedia-based e-learning environment achieved better performance and higher levels of satisfaction than those in a traditional classroom and those in a less interactive e-learning environment, with a lack of control over content diminishing potential benefits. "This study implies that to create effective learning, e-learning environments should provide interactive instructional content that learners can view on a personalized self-directed basis" (p. 160).

HOW *INTO SCIENCE* DELIVERS

The *HMH Into Science* online experience offers not only greater interactivity to boost student engagement and enhance learning but also customizable, adaptable content that allows teachers to better meet the needs of individual students.

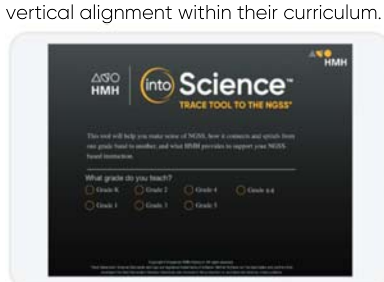
Interactive lessons deliver student content dynamically and with increased agency and personalization. These lessons include videos and links to program features and components. Students can work at their own optimal pace and navigate easily among activities. Providing students with instant feedback in real-time, interactive no-stakes questions and items at point-of-use are included within. Students also have the option of engaging with content and completing tasks directly online or downloading worksheets that are editable and can be further individualized.

HMH's online learning platform, *Ed,* combines the best of technology, content, and instruction to boost agency and support individual students and teachers in virtual and blended classroom environments. Within *Ed*, students can access their own dashboards to review the status and due dates of their current assignments, as well as their scores on those they have completed. Students can also access upcoming virtual classroom sessions and all-digital, student-facing program resources.

Teachers using *Ed* can assign work tailored to each student's needs, track assignments, and view progress and assessment results from any location as well as plan lessons and group students to provide targeted and specific differentiation. The Teacher's Dashboard displays callouts identifying the most important information and items that require action, including assignments that need grading and platform updates. Online assessments can be administered as is or can be adapted and edited to fit specific needs in the classroom.

Auto-scoring is available for all close-ended assessment items provided in the system or built by teachers. Whether customized or not, assessments can be saved to a teacher's plan for easy retrieval in subsequent years.

The NGSS Trace Tool maps the standards, showing connections and spiraling across grade levels. It also identifies HMH resources that support NGSS-based instruction; traces performance expectations, SEPs, CCCs, or DCIs throughout the program; and allows teachers to quickly view what students should already know and what they need to be prepared to learn next. The Trace Tool may be particularly useful for schools or districts working to ensure vertical alignment within their curriculum.



EMBEDDED SOCIAL EMOTIONAL LEARNING

Social emotional learning (SEL) is the process of developing within students the knowledge, skills, attitudes, and behaviors that they need to make choices that support well-being, allow for constructive collaboration with others, and increase college and career readiness. The short- and long-term benefits of social and emotional learning are evidenced by more than two decades of research across multiple fields and measures, including academic achievement, neuroscience, classroom management, psychology, health, learning theory, and the prevention of problematic youth behaviors (CASEL, 2022; Mahoney et al., 2021).

SEL is especially critical at the middle grades. “While early adolescence can pose many challenges for youth, the middle school years may also offer an ideal opportunity to intervene to enhance social and emotional competencies as a means by which to promote positive outcomes for youth” (Green et al., 2021, p. 1057). SEL is also particularly critical in science education. “STEM literacy in grades K–12 is essential for each and every student because it promotes and fosters in students innovative thinking, collaboration, creativity, problem solving and critical thinking, and communication skills” (Jackson et al., 2021, p. 2).

In another innovation, *HMH Into Science* integrates SEL within science instruction and in partnership with the Collaborative for Academic, Social, and Emotional Learning (CASEL). CASEL is dedicated to making evidence-based SEL an integral part of education from preschool through high school. Through its resources, CASEL supports educators and policy leaders and enhances experiences and outcomes for students.

CASEL'S 5 CORE COMPETENCIES

Social-emotional competencies are crucial for the development of healthy coping and problem-solving skills and can be both protective and promotive (Green et al., 2021; Eklund et al., 2018). "[Experts] know that effective teachers do more than promote academic learning—they teach the whole child" (Yoder, 2014, p. 1). Cognitive development is inextricably linked to social and emotional development; success in school depends upon students' social-emotional skills, and schools have widely adopted the practice of fostering such skills (Durlak et al., 2011; Allbright et al., 2019; Osher et al., 2016; Jones & Bouffard, 2012). Systematic SEL is the process of facilitating students' development of the knowledge, skills, attitudes, and behaviors necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, make responsible decisions, and deal effectively and ethically with daily tasks and challenges (CASEL, 2003; Elias, 2006; Yoder, 2014).

Studies have linked childhood measures of social and emotional skills—such as motivation, time management, self-regulation, communication, and pro-social behaviors—to students' later academic achievement as well as to adult outcomes across multiple domains, including higher education, employment, criminality, substance use, and mental health (Heckman, 2008; Jones et al., 2015). Other research demonstrates that social-emotional traits such as grit and self-discipline are greater predictors of academic achievement in adolescence than are cognitive traits such as IQ (Duckworth & Seligman, 2005; Duckworth, Tsukayama, & May, 2010). Research also shows that a common component of SEL, growth mindset, links to attitudes and perceptions regarding success and failure and to the amount of control people have in experiences with those successes and failures throughout life. Growth mindset is a concept pioneered by Dweck (2006 & 2008) corresponding to people's belief that their intelligence, competence, and talents can be developed through dedicated efforts and hard work (in contrast to a "fixed mindset," in which people see their abilities as immutable).

Research also shows that social and emotional skills are malleable and can be intentionally developed (Jones & Bouffard, 2012; Osher et al., 2016; Yeager & Walton, 2011). "Through systematic instruction, SEL skills may be taught, modeled, practiced and applied to diverse situations so that students can use them as part of their daily repertoire of behaviors" (Durlak, et al., 2011, pp. 406). Teaching social and emotional competencies has been associated with cognitive-behavioral engagement at both the student and the school level and shown to engender significant positive perceptions of engagement at the student level, with findings especially strong in elementary and middle school settings (Yang et al., 2018).

There is a growing body of compelling evidence demonstrating that effective SEL interventions yield benefits that have an impact on the trajectories of students' success within school and beyond (Mahoney et al., 2021). In a landmark 2011 metareview of 213 school-based SEL interventions, Durlak and colleagues found that, compared to students who did not participate in such programs, students of diverse backgrounds who participated in social-emotional programs demonstrated the following: increased academic achievement (averaging scores of 11 percentile points higher on standardized tests), increased social-emotional skills, increased motivation, improved attitudes toward self and school community, improved positive social behaviors, decreased conduct issues, and decreased emotional distress. These effects were consistent regardless of students' race, socioeconomic background, or school location.

Other research has shown that within academic settings specifically, students who receive SEL instruction are more motivated to learn and more committed to school (as indicated by improved attendance and graduation rates) and less likely to engage in misconduct or suffer the consequence of behavioral issues, such as class disruption, suspension, and grade retention (Zins et al., 2004). Another study showed that SEL leads to students' seeking help when needed, managing their own emotions, and working through difficult situations (Romasz et al., 2004).

CASEL (2022) has established a research-based integrated framework that promotes interpersonal, intrapersonal, and cognitive competence and comprises five core competencies that can be taught in many ways and across many settings. CASEL's framework, the most widely used approach in schools (Yang et al., 2018), comprises the following competencies:

Self-Awareness
The ability to accurately identify, evaluate, and reflect on one's own emotions, thoughts, and values and how they influence behavior. Also includes self-efficacy and the ability to accurately assess one's strengths and limitations, with a well-grounded sense of confidence and a growth mindset.

Self-Management
The ability to successfully regulate one's emotions, thoughts, and behaviors in different situations—effectively managing stress, controlling impulses, and motivating oneself. The ability to set and work toward personal and academic goals. Incorporates organizational skills.

Social Awareness
The ability to take the perspective of and empathize with others, including those from diverse backgrounds and cultures. The ability to understand social and ethical norms for behavior and to recognize family, school, and community resources and supports. Includes respect for others and appreciation of diversity.

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. Also incorporates social engagement and teamwork.

Responsible Decision-Making
The ability to make constructive choices about personal behavior and social interactions, based on ethical standards, safety concerns, and social norms. Includes the realistic evaluation of consequences of various actions and consideration of the well-being of oneself and others. Skills entail identifying and solving problems, analyzing situations, evaluating, and reflecting.

HOW *HMH INTO SCIENCE* DELIVERS

An important aspect of the *HMH Into Science* experience, SEL is embedded in the program to provide educators with the point-of-use strategies they need to check in on students' connection with and engagement in the content. As students move through the program, they are called upon to set goals, self-reflect, and engage with others empathically and effectively. SEL skills are introduced and reinforced throughout, giving students practice in using the skills in their everyday lives. For teachers, the point-of-use guidance in how to support students' SEL development effectively are explicitly tied to specific aspects of the CASEL framework. This aids internalization and transfer of the skills as well as helps students recognize firsthand the value of social-emotional competence, for themselves and their community.

HMH Into Science SEL activities have students consider the perspectives of peers as well as those of real scientists. Teacher Activity Guides provide support for facilitating such thinking. These activities not only foster empathy but also augment learning with social connections and personal identification with others in similar situations. SEL activities also make the science content more accessible and relevant to students' own lives.

Social Awareness Provide support for students to share and listen to different opinions or claims (e.g., having students paraphrase the last person's statements before giving their own opinions, using sentence stems).

Culturally responsive education support has also been embedded, and it encompasses dedicated learning moments and teaching strategies to help teachers embrace differences, honor home languages, and consciously make cultural considerations when planning and teaching. This feature is designed to ensure all students see themselves as scientists, capable of and belonging in STEM study and careers.

Culturally Responsive Education

Why It Matters These questions provide an opportunity for students to make meaningful connections between the content and real-world issues and topics that may be relevant to their community. These questions can be used with the Unit Project, as discussion prompts, or as a student journaling activity.

- What changes in technology have you seen in your lifetime, and how have they affected you?
- When have you had to redefine a problem or redesign a solution in your life?
- What examples of design optimization do you see in your neighborhood?
- What problem or problems in your community might be solved using an engineering design process?

Encourage students to discuss with family members or members of their neighborhood or community thoughts on how these questions and answers connect to their daily lives or a local issue or concern.

At the end of the unit, provide time for students to share their ideas, especially ideas on how this information could be valuable for students, their families, and communities.

INTEGRATED APPROACH TO SOCIAL EMOTIONAL LEARNING

A growing body of research attests to the efficacy of explicit, embedded approaches to SEL, particularly at the elementary and middle school levels, as a means of promoting the development of these competencies as well as fostering crucial skills that help students' entire developmental process (Allbright et al., 2019; Coelho & Sousa, 2018; Green et al., 2021; Mahoney et al., 2021; Wallender et al., 2020; Yang et al., 2018).

Beyond affective social-emotional skill development, content learning is enhanced for students when teachers integrate social-emotional competencies within academic instruction (Elias, 2006) and when students connect with information not just cognitively, such as through memorization, but socially and emotionally as well (Ensign, 2003). Social, emotional, and contextual factors have significant impact on positive attitudes and behaviors that yield successful science learning and achievement (Ben-Avie et al., 2003; Jackson et al., 2021). An integrated approach to SEL promises to enhance the experiences and outcomes of NGSS-based science instruction. Indeed, researchers point out that the NGSS call for students to work collaboratively and to participate in productive discourse and for classroom climates in which students can respectfully disagree; these elements all rely upon effective social and emotional skills (Rimm-Kaufman & Merritt, 2019; Sneider, 2021). "Engagement in the science and engineering practices requires social interaction and discussion among students. Students need support to learn how to do this productively. The classroom culture will need to support both individual and collaborative sensemaking efforts" (NRC, 2015, p. 30). In a 2018 survey of early NGSS implementers, Tyler and colleagues found that teacher leaders and administrators overwhelmingly reported that students in NGSS classrooms were gaining both a deeper understanding of science and, more broadly, important communication, critical thinking, and teamwork skills.

"Explicit teaching of social and emotional skills and then encouraging students to apply those social skills to their academic work will elevate science instruction" (Rimm-Kaufman & Hunt, 2020, online). Science learning is improved with some specific practices that support social-emotional development alongside instruction. These practices include teachers' cultivation of trust and relationships with students; engagement with and connection to students' life experiences, thereby validating them; helping students build confidence that allows them to take risks; and encouragement of healthy coping skills (Ensign, 2003).

It is crucial that math and science concepts be relevant to students' lives, and collaborative, productive discourse is crucial to science. Students must have the skills necessary to collaborate effectively with others to work toward solutions (Rimm-Kaufman & Hunt, 2020; Sanson et al., 2019). Active listening and facilitated discussions in which all viewpoints are encouraged and valued are key. "In order to collaborate, students need to not just do stuff but also really listen to each other and work as a whole team. Productive discourse lends itself well to building a community where social and emotional learning is supported" (Sneider, 2021, online).

As Yoder (2014) points out, SEL is critical for students to meet the rigorous demands of college- and career-readiness standards that require a greater ability to engage in deeper learning. However, the necessary integration of SEL can happen only if teachers are not additionally burdened: "To bridge the connection between social emotional learning and the work that educators are already doing, educators need access to tools, supports, and resources on social emotional learning that are integrated *into* existing teacher evaluation and professional development systems. Not only does this reinforce the importance of social emotional learning, it avoids overburdening educators by layering on yet another separate initiative" (p. 1).

HOW *HMH INTO SCIENCE* DELIVERS

SEL is fully integrated within the *HMH Into Science* program experience. Every component includes SEL prompts that are embedded at point-of-use within units and lessons and directly related to the activity at hand. Encountering SEL prompts throughout the investigative process allows students to learn social-emotional competencies in real-world contexts and gain practice in applying them—as well as demonstrates for students the positive, essential impact of the SEL competencies.

Activities that improve students' executive functioning and metacognition, engage students collaboratively, and generate for students social and personal connections to content as they learn science augment understanding and retention of concepts and knowledge.

Reflect and Summarize

This section provides students with an opportunity to scaffold their prior knowledge with the knowledge they have gained over the course of the lesson. Students trace how their knowledge has progressed and reflect on what they have learned. At the end of this section, they connect the lesson's content back to the unit phenomenon.

Responsible Decision-Making Have students reflect on this lesson by discussing the following questions with a partner or group:

- *What challenges did I encounter in this lesson, and how did I handle them?*
- *What can I do next time I encounter a similar challenge?*
- *How can I use an engineering design process to solve problems outside of the classroom?*

LESSON 1 SELF-CHECK

Reflect and Summarize

REFLECT Think about how you built on prior knowledge to enhance your understanding of engineering, technology, and society as you respond to the following prompts.

EXPLORATION 1 Modern life is dependent upon technology. Without engineered tools, scientists could not carry out research.

An example of how engineering and science are connected is that engineers need scientific understanding of electrical energy in order to build systems that generate and use electrical energy.

EXPLORATION 2 Models can be used to represent complex systems and their many interactions.

I understand that scientists and engineers develop and use models of systems and subsystems because complex systems can be modeled on a small scale to predict how real-life systems will work. Testing a model can reduce the risk or cost of studying or testing a system in real life.

EXPLORATION 3 Small-scale and large-scale technologies can improve quality of life.

An example of a large-scale technology that affects my life is the system that generates and transmits electrical energy to buildings in my city. This allows me to use light bulbs, refrigerators, and computers.

EXPLORATION 4 An engineering design process describes steps that can be used to identify a problem and then propose, test, and optimize a solution to that problem.

I know testing a solution based on criteria and constraints is an important part of an engineering design process because testing tells how a solution performs against the criteria and constraints. A solution that meets the criteria and constraints will be more successful than one that does not.

A "Be Creative" page appears in every lesson for students to approach self-check in a more open-ended, imaginative, and expressive way. Students can write a poem, draw an image, or build a collage to connect with science topics creatively and personally.

LESSON 1 SELF-CHECK

Be Creative

Review the lesson's vocabulary in a creative way. You could write a story, song, or poem; draw a comic strip or graphic organizer; or use another way that helps you learn. Include the following vocabulary terms in your work.

Lesson Vocabulary
- components
- constraint
- criteria
- engineering
- input
- output
- system

Additional Vocabulary
- evaluate
- prioritize
- technology

Be Creative

Encourage students to choose how they complete this page. The ideas listed on the student page are only suggestions and should not limit students' choice of how they express themselves. If students are interested, have students share their work with the class or in small groups.

Be Creative Scoring Rubric

Points	Criteria
	Uses vocabulary terms appropriately
	Demonstrates understanding of lesson topics
	Uses a creative means of expression

Additionally, Culturally Responsive Education and Connect Your Learning features help students recognize the impact of science on their own lives. These features not only reinforce science learning but also foster a sense of belonging and of community pride, both avenues through which social and emotional development are supported.

Culturally Responsive Education

As an alternative way to finish the lesson, students could complete this activity instead of the Reflect and Summarize student activity. Students may underestimate how communities of people can affect decisions in large public works projects, such as planning where to put bus routes. This discussion can be used to help students understand how society influences engineering, and how engineering influences society.

Consider transportation systems near where you live. How does the location of things such as highways, bus stops, subway or train stations, and parking garages affect people in these areas? Discuss how community values and voice may affect decisions engineers make when planning one of these systems. If you were an engineer planning a large project such as where to put bus stops, what factors would you consider?

Students should use active listening techniques and positive wording to discuss differences in opinion.

CONNECT YOUR LEARNING

Think back to the Unit Phenomenon about helping boats travel between the Forth and Clyde canal and the Union canal. How can systems help analyze this problem?

Sample answer: Using systems can help simplify the problem by reducing the number of things that need to be considered at a time. Analyzing a subsystem reduces complexity compared to analyzing the full problem as a large system.

ADDRESSING EQUITY

Given the rapid expansion of scientific knowledge and technological developments impacting life in the 21st century, a primary aim of science education in the United States for decades has been to boost younger generations' scientific literacy and college and career readiness as a means of advancing economic development of individuals and of society (Bybee, 2010; Krajcik & Sutherland, 2010; NSTA, 2003; NRC, 1996). Yet, despite continually growing demands for a STEM-trained workforce (Langdon et al., 2011) as well as shrinking achievement gaps, historically underrepresented groups that include females, African Americans, Latinx people, Native Americans, English language learners, students in poverty, and those with disabilities remain marginalized in STEM education and professions (Anwar et al., 2019; Jackson et al., 2021; Kang et al., 2019; Januszyk et al., 2016; National Science Board, 2016). This "leaky pipeline" diverting entry of large swaths of the population into science-related fields has troubling implications for economic and technological advancement and exacerbates pervasive social inequities across the United States.; developing a more scientifically literate workforce requires confronting persistent gender and racial/ethnic divides in STEM education (Quinn & Cooc, 2015).

A central goal of the *Framework* and NGSS is ensuring equitable science education for students of all backgrounds—which calls for rigorous standards for all students as well as accounting for diversity and equity in teaching all students (Krist & Reiser, 2014; NGSS Lead States, 2013; NRC, 2012). "The *NGSS* offer both opportunities and challenges for educators in enabling all students to meet the more rigorous and comprehensive standards set forth by the *NGSS*" (Lee, Miller, & Janusyzk, 2014, p. xi).

The United States is at a point—historically, economically, and pedagogically—in which issues of equity have never been more pressing nor have calls for increased equity ever been stronger. It is imperative for educators to mitigate longstanding inequities that disadvantage some students. *HMH Into Science* seeks to advance equity and accessibility by providing science instruction that meets the needs and serves the interests of all students.

CONNECTING TO STUDENTS' INTERESTS AND EXPERIENCES

"A rich science education has the potential to capture students' sense of wonder about the world and to spark their desire to continue learning about science throughout their lives. Research suggests that personal interest, experience, and enthusiasm—critical to children's learning of science at school or in other settings—may also be linked to later educational and career choices. Thus, in order for students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences" (NRC, 2012, p. 28).

Connecting instruction to students' interests and experiences as well as to the diverse backgrounds that students bring to a classroom is essential to broadening participation in science. In a study of effects in schools that had been early implementers of NGSS, researchers found that NGSS instruction strongly engages a wide range of students, including English language learners, students with special needs, and lower-performing students. Some schools also reported increased parity in engagement and learning between females and males. When asked in a survey whether student engagement of low-performing students has changed following NGSS implementation, nearly half (46%) of teacher leaders and over a third of principals (35%) reported a "substantial" change, and only 2% of teachers and 6% of principals reported "no change." In interviews, teachers and administrators cited possible reasons for the increased engagement of diverse student groups that included higher levels of hands-on activity in NGSS classrooms as well as students' being encouraged to question and to vocalize their ideas. In addition, respondents claimed, "in NGSS lessons, academically challenging activities such as reading, learning vocabulary, and analyzing data come *after* students' interest has been engaged through a more accessible, hands-on investigation set in a real-world context" (Tyler et al., 2018, p. 6).

Such findings echo earlier research demonstrating that when students are interested in what they are learning, they will persist in spending the time and energy needed for learning to occur. In this way, engagement leads to motivation, which leads to learning. Effective teachers know that students must be engaged by content to be motivated to persist (Eccles et al., 1998; Guthrie & Humenick, 2004; Hidi & Boscolo, 2006). When students are actively engaged in the process of observing, reasoning, and making connections through experimentation and hands-on study, they acquire necessary skills and ways of thinking (Stewart et al., 2005). Deeper conceptual understanding and more-complex scientific ways of knowing and reasoning are directly supported by higher levels of engagement in the course of science instruction (Azevedo, 2015; Bae & DeBusk-Lane, 2019). As confirmed in a large meta-analysis, positive effects of increasing active learning and decreasing lectures in classroom settings are particularly impactful in STEM education (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014).

Engagement in school at all levels is critical to students' educational success—especially in middle school (Bae & DeBusk-Lane, 2019). Studies have established longstanding trends in declining academic engagement at the secondary level (Eccles & Wang, 2012; Marks, 2000; Wigfield, Eccles, Schiefele, Roeser, Davis-Kean, 2006). This issue particularly affects science education, in which drops in interest, motivation, and performance tend to be sharper compared to other subject areas during the pivotal middle school years (Morgan et al., 2016; Quinn & Cooc, 2015). In these years, students begin to formalize their attitudes toward academic activities and choices related to their future professional careers (Green et al., 2021; Singh et al., 2002; Tyson et al., 2007). Quality STEM learning experiences in Grades 6–8 that promote positive, productive dispositions toward STEM are important to all students' future success in related fields, particularly for historically disadvantaged students (Bae & DeBusk-Lane, 2019; Jackson et al., 2021; Kang et al., 2019; NSTA, 2016). "Because it is malleable to changes in the learning context, a better understanding of student engagement has tremendous potential for informing educational interventions aimed at increasing learning and persistence in science" (Bae & DeBusk-Lane, 2019, online).

"When instruction is anchored in the context of each learner's world, students are more likely to take ownership for their own learning" (McREL, 2010, p. 7). The *Framework* promotes the development of curricula around sets of questions to generate interest and communicate relevance to students through real-world problems as a basis for science learning. "Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. . . . The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights gained help them recognize that the work of scientists and engineers is a creative endeavor—one that has deeply affected the world they live in" (NRC, 2012, p. 42–43).

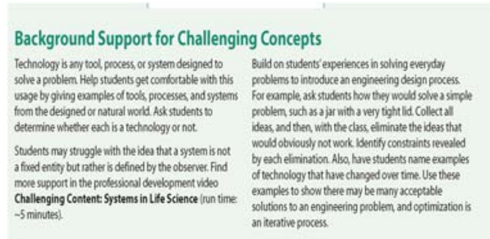
Sneider and Ravel (2021) found that benefits of P–12 engineering education include increased student persistence, motivation, self-confidence, and STEM identity; instruction exploring technological systems, particularly robotics, appears to generate students' engagement and interest in STEM as their linkages to societal issues, real-world problems, and other relevant connections to students' own lives have a motivational effect. Early engagement with engineering, as fostered by NGSS, is especially important for students who have not traditionally considered science as a possible career pathway: "From a pedagogical perspective, by designing engineering solutions to problems in local contexts, students deepen their science knowledge and recognize science as relevant to their lives and future" (Janusyk, et al., 2016, online). Further, incorporating creative outlets into the early stages of learning about robotics, new technologies, and other engineering systems is additionally catalyzing (Anwar et al., 2019), and exposure to engineering in local contexts (e.g., habitat restoration, watershed improvement) boost students' interest in studying STEM and pursuing related careers (Janusyk et al., 2016).

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science incorporates Houghton Mifflin Harcourt's broad commitment to a Learning by Design approach to instruction (https://www.hmhco.com/blog/learning-by-design). This means that the program is not intended to serve as a source of discrete content imparted formulaically. Rather, *HMH Into Science* is built to empower teachers to create meaningful, joyful, authentic, challenging, relevant experiences and environments for students that ignite curiosity and inquiry. *HMH Into Science* cultivates students' interests and fosters personal connections to everything they learn and do within the program experience, including investigative processes that are student driven and hands-on.

The anchor phenomenon at the center of each investigation engages students' interest as well as invites students to construct questions and explanations drawing on what they already know about the world around them. However, for any given anchor phenomenon, not all students may find it to be familiar from their own experience. For this reason, the program provides alternative anchor phenomena to ensure broad, equitable engagement. Additionally, *HMH Into Science* includes an ongoing Connect Your Learning feature that has students tap into their previous learning and build on background knowledge.

HMH Into Science Teacher Activity Guides for each unit also provide Background Support for Challenging Concepts to further help students access new content by building on the experiences and knowledge they uniquely bring to the classroom.



Background Support for Challenging Concepts

Technology is any tool, process, or system designed to solve a problem. Help students get comfortable with this usage by giving examples of tools, processes, and systems from the designed or natural world. Ask students to determine whether each is a technology or not.

Students may struggle with the idea that a system is not a fixed entity but rather is defined by the observer. Find more support in the professional development video **Challenging Content: Systems in Life Science** (run time: ~5 minutes).

Build on students' experiences in solving everyday problems to introduce an engineering design process. For example, ask students how they would solve a simple problem, such as a jar with a very tight lid. Collect all ideas, and then, with the class, eliminate the ideas that would obviously not work. Identify constraints revealed by each elimination. Also, have students name examples of technology that have changed over time. Use these examples to show there may be many acceptable solutions to an engineering problem, and optimization is an iterative process.

HMH Into Science Teacher Activity Guides also offer ongoing opportunities to increase relevance and engagement via suggestions for Making Connections between science learning students' local contexts and communities.

PROMOTING EQUITY

"Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science" (NRC, 2012, p. 28). The science classroom that attends to NGSS principles and practices stands to serve diverse students well, not just to further their science learning but to support their broader academic progress (Quinn, 2015). A study of effects in early NGSS-implementing schools indicates one targeted outcome has been greater and more inclusive engagement of a wide range of students, including English language learners, students with special needs, and lower-performing students as well as increased parity in engagement and learning between females and males (Tyler et al., 2018).

Within the United States, students traditionally marginalized by race, ethnicity, and gender endure a unique struggle with uncertainties of academic belonging due to negative messaging about their capability and value within academic settings. Historically, such messaging has been pervasive and entrenched within schools, in both overt and unintentional ways. And this messaging yields what is known as stereotype threat. For students of underrepresented backgrounds, stereotype threat adversely affects their self-perceptions, self-confidence, attitudes toward learning, and academic performance; forces students to reconcile their own aspirations and self-concepts against the threat of stereotypes; creates anxiety over confirming negative stereotypes about their intellectual abilities; and may cause students to underperform. In a vicious cycle, these stereotype threats then reinforce inequalities and achievement gaps (Farrington et al., 2012; Steele & Aronson, 1995; Walton & Cohen, 2011; Shapiro & Williams, 2012; Yeager et al., 2013). "Many of the critical challenges facing racial and ethnic minority students in the formation of strong, positive mindsets for academic achievement can be alleviated through the careful work of creating supportive contexts that provide consistent and unambiguous messages about minority students' belonging, capability, and value in classrooms and schools" (Farrington et al., 2012, p. 34).

Historically within Western education, most curricula have focused on European contributions to science, largely excluding other cultures' contributions to and diverse ways of participating in and knowing science—all while science has been presented as objective and established, rather than as an evolving set of ideas and practices in which innovation is carried out by the disadvantaged and oppressed and not just the privileged. A consequence has been STEM aversion for far too many students. To counter inequities within science education, all students—not only students of racial and ethnic minority backgrounds—must have access to diverse representations of models for success, ingenuity, and agency across scientific fields of study and knowledge as well as have their own experiences and perspectives incorporated and validated (Anwar et al., 2019; Gutiérrez et al., 2017; Jackson et al., 2021; Sneider & Ravel, 2021; Vakil & Ayers, 2019).

"There is increasing recognition that the diverse customs and orientations that members of different cultural communities bring both to formal and to informal science learning contexts are assets on which to build—both for the benefit of the student and ultimately of science itself" (NRC, 2012, p. 28). To make learning opportunities more equitable and support all students in having successful, positive experiences within STEM, educators must value and incorporate the experiences and perspectives that all students bring to school from their backgrounds; articulate students' cultural, environmental, and linguistic knowledge with disciplinary knowledge; and offer sufficient and effective resources to support students on an individual level (Anwar et al., 2019; Lee et al., 2014; Lee & Buxton, 2010).

Meaningful engagement in scientific practices requires a careful design of sustained inquiry around content-learning goals, and such inquiries should be enacted in ways that offer appropriate social supports (Ford, 2008). "Therefore, viewing science learning as *participation in a classroom community of practice* offers a useful analytical framework for understanding how teachers and students develop knowledge-building goals and learn to engage in meaningful scientific practices" (Krist & Reiser, 2014, p. 2).

Drawing from the research literature, Jackson and colleagues developed the following an Equity-Oriented STEM Literacy Framework (2021) to increase opportunity and access to high quality, integrated STEM learning experiences:

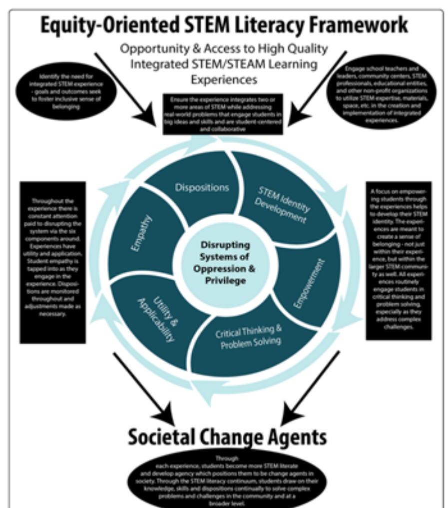


Fig. 2 Implementation of the Equity-Oriented STEM Literacy Framework

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science supports rigorous instruction for all students by encouraging them to collaborate, think critically, and explore science, all within the context of a coherent phenomenon storyline. *HMH Into Science* also promotes equity through inclusive representation that include profiles of historical and working scientists that reflect ethnic and gender diversity.

HMH Into Science provides engaging, equitable learning experiences through multifaceted instructional approaches and academic-support strategies that address the distinct needs, interests, aspirations, and cultural backgrounds of individual students and student populations. Program-design elements to help each learner meet the rigorous performance expectations set forth by the NGSS and recognize their rightful role within a community of learners and prospective careers include the following:

Compelling Content: Learning experiences that offer authentic interdisciplinary tasks provide relevance and promote curiosity for students. *HMH Into Science* allows teachers to transcend discrete standards and connect content and performance expectations via real-world problems or situations for students to solve.

Learning Goals and Success Criteria: Great lessons (a) begin with clear goals for what students need to know and be able to do and (b) convey criteria for success. *HMH Into Science* identifies explicit goals and success criteria for students in a manner that clarifies expectations and serves as a guide for self-assessment.

Collaborative Culture: Learning is social; the purposeful inclusion of collaboration throughout the learning process is highly engaging for students. Across the program, *HMH Into Science* provides collaborative opportunities for students to learn with flexible groups, partners, and online experts.

Student Empowerment: Giving students choice over how to show mastery or create a final product or performance significantly increases ownership in their learning. *HMH Into Science* encourages students to play the role of codesigner in their learning experiences, allowing their input in what they learn and how they want to engage with the content.

Authentic Tools and Resources: Providing a variety of tools and resources offers students choice and emphasizes process over product. Great learning experiences leverage such variety in both the learning process and in how students create products of their learning. *HMH Into Science*'s digital tools and strategies—such as blended learning, flipped classrooms, and production tools—alongside its print features offer rich experiences that are highly engaging and honor how students like to learn and create.

Intentional Instruction: Research has well established that evidence-based strategies suited to support goals for learning should be carefully selected in order maximize impact. *HMH Into Science* uses the Gradual Release of Responsibility model to provide structure for direct instruction, modeling (Show Them), guided practice (Help Them), and enabling independent learning (Let Them).

Focus on Literacy: Regardless of the content, reading, writing, and speaking should be incorporated into every learning experience. *HMH Into Science* exposes students to a variety of texts, both fiction and nonfiction, as well as online resources. The program also engages students in opportunities to write often as they encounter phenomena, construct meaning, and demonstrate learning. *HMH Into Science* also encourages students to engage in academic discussions, collaborative conversations, and healthy debate.

Feedback for Learning: Feedback is formative and provides students with the safety and security that allows them to take risks and try new things without the fear of failure. Throughout the learning experience, *HMH Into Science* has built-in feedback loops in the form of teacher-to-student, student-to-student, or self-assessment to give students guidance on their progress toward the learning goals.

To additionally support students and to promote broad engagement of families, *HMH Into Science* offers an array of digital resources. The online platform *Ed* provides family letters and videos along with other materials that can be printed and shared. *HMH Go* extends the classroom by giving students the ability to download their *HMH Into Science* digital resources for later offline use. *Family Room* creates a more manageable experience for caregivers as they assist with their student's learning.

MEETING THE NEEDS OF ALL LEARNERS

Research has consistently demonstrated that when provided with equitable educational opportunities and appropriately supported, students from diverse backgrounds, including those from historically marginalized groups are capable of constructing meaning, engaging in practices, and achieving in science (Lee et al., 2014; NRC, 2007 & 2012; NGSS Lead States, 2013).

Disparity in language development upon school entry is a primary factor in differing education outcomes for different groups of students (Fernald et al., 2013). The science classroom that supports diverse students well emphasizes language development broadly. For all students, but especially English learners, classrooms that provide equitable science instruction offer (a) sufficient, effective resources and ongoing opportunities to communicate observations and ideas in writing and discourse among peers and teachers; (b) scaffolding that allows proficient use of science text; (c) explicit teaching of key words and tools, thus allowing for scientific thinking to be clarified and scientific confidence to be gained (Quinn, 2015).

Research indicates that historically underserved students may benefit the most through engagement in SEPs anchored in exploration of phenomena from their own backgrounds and lived experiences as well as in their own wonderment and curiosity (Lee, 2020; Quinn, 2015; Tyler et al., 2018). "When phenomena and problems are placed in home and community contexts, diverse students build on their everyday experience and language to make connections among school science and home and community" (Janusyk et al., 2016, online). While they are being encouraged to explore and develop their own explanations of phenomena, it is important that at-risk students are still taught well-established core ideas of science. "This work helps students to process the science ideas and to make the conceptual shifts needed to truly understand and incorporate the science ideas into their way of looking at the world" (Quinn, 2015, p. 11).

Particularly among at-risk students and those from underrepresented backgrounds who may be disconnected from science learning, broader positive outcomes require differentiated approaches to boost engagement. Teachers can effectively support students' mastery orientation and self-efficacy by creating learning opportunities that immerse students in autonomous, practice-based science activities, such as sharing and testing scientific ideas, drawing from students' prior knowledge base and experiences, and developing explanations for phenomena in the natural world (Bae & DeBusk-Lane, 2019). To engage and accommodate individual students, "teachers need to understand how students think, what they are capable of doing, and what they could reasonably be expected to do under supportive instructional conditions, and how to make science more accessible and relevant to them" (NRC, 2007, p. 345).

The NGSS outline research-based strategies for increasing equity in science instruction and meeting the needs of student groups who are historically underrepresented within science. Information below comes from NGSS Appendix D, "All Standards, All Students" (NGSS Lead States, 2013):

Economically disadvantaged students:
Strategies to support economically disadvantaged students include (a) connecting science instruction to students' own physical, historical, and sociocultural dimensions and (b) facilitating students' applying their background knowledge and cultural practices to the construction of meaning. Project-based science learning is an effective form of "connected science."

Students from underrepresented racial and ethnic groups:
Students from various racial and ethnic groups benefit from strategies in the following categories: culturally relevant pedagogy; community involvement and social activism; multiple representation and multimodal experiences; and support systems that feature role models and mentors of similar racial or ethnic backgrounds.

Students learning English:
Both science and language instruction for students learning English are best supported by the following strategies, according to the research literature: literacy strategies proven effective for all students, language support strategies effective specifically for English learners, discourse strategies for English learners, home language support, and home culture connections. Lee and colleagues (2019) describe a conceptual framework that (a) highlights the mutually supportive nature of science and language instructional shifts for students learning English and (b) promotes the perspective that these students use language purposefully in the service of doing science in a classroom community of practice.

Students with disabilities:
Students with disabilities have Individualized Education Plans (IEPs) that mandate the accommodations and modifications that teachers must provide to support student learning in the regular education classroom. Accommodations are designed to facilitate students' with disabilities fulfilling the same performance expectations as their peers, whereas modifications generally change the curriculum or performance expectations for a specific student. Performance expectations within the NGSS were intentionally designed for flexible use to accommodate the developing knowledge and skills of specific students or groups of students. Two approaches in wide use by general education teachers in their classrooms include differentiated instruction and Universal Design for Learning.

Females:
Research suggests three main areas in which schools can positively impact girls' achievement, confidence, and interest in science and engineering. These include (a) utilizing instructional strategies to increase girls' science achievement and their intentions to continue studies in science; (b) promoting images of successful women in science as part of science curricula; and (c) implementing organizational structures within classrooms and schools that benefit girls in science, such as science clubs and mentoring programs.

Advanced learners:
Advanced learners require differentiation in the form of extension or acceleration activities. They need daily challenge, opportunities to work with peers, opportunities for independent learning, and varied instructional delivery (Rogers, 2007). Providing real-world, issue-based or problem-based learning activities will boost motivation and engagement of advanced learners (VanTassel-Baska & Brown, 2007). Per the NGSS, advanced learners and gifted-and-talented students may have such characteristics as intense interests, rapid learning, motivation and commitment, curiosity, and questioning skills. NGSS recommend that teachers additionally employ these differentiation strategies to promote science learning for advanced learners: fast pacing, level of challenge (including differentiated content), opportunities for self-direction, and strategic grouping.

HOW *HMH INTO SCIENCE* DELIVERS

HMH Into Science provides a student-centered environment that helps all learners achieve success in rigorous, relevant science instruction through hands-on, engaging, and equitable content and pedagogical approaches.

Differentiated instruction support is presented throughout the program to help educators better address the needs of each student who may be struggling with the curriculum as well as those who would benefit from the extra challenge of extension opportunities.


Differentiate Instruction
Vocabulary Support
Unit Vocabulary
Differentiate with Technology
Differentiated Instruction Support

HMH Into Science also offers differentiated assessment to accommodate all learners. Modified measures are targeted to help struggling readers and English language learners demonstrate their science mastery with less emphasis on reading ability. These items have a slightly lower difficulty and reading level but are visually identical to the on-level test and assess the same NGSS dimensions. The digital versions of these tests include audio for added reading support.

HMH Into Science also provides Pacing Guides to help teachers make the best instructional decisions given various time and scheduling constraints as well as to effectively accommodate their own students' wide-ranging needs. Specific pacing information for learning experiences is also found at point-of-use throughout the Teacher Activity Guide.

The NGSS place strong emphasis on teaching all standards to all students. One of the challenges of teaching using NGSS pedagogy is reteaching. Two of the three dimensions within NGSS are self-reteaching. Both the SEPs and the CCCs are revisited throughout the program. Multiple exposures to a concept in different contexts have been shown to be an effective form of reteaching CCCs and SEPs. Strategies for teaching these are included within the teaching materials. Online and print student materials present the same content in different ways. Online student activities provide additional interactions and voice-over to reinforce and reteach the content in ways that enable students with reading deficits to learn the core science concepts. Online activities also provide students with immediate feedback on many interactivities to reinforce learning.

Hands-on labs are particularly useful for students with language challenges or who lack interest in science content, because kinetic activities are not only more engaging but also less language intensive. The program features ongoing opportunities for hands-on labs. Indeed, much of the program is driven by hands-on learning that helps to strengthen the core activity upon which every lesson is based. This helps to support authentic scientific inquiry and to leverage psychomotor learning strategies.

HMH Into Science also includes adaptable features, such as the following:

- multiple options for student input (spoken, written, drawn) to flexibly accommodate individual skill levels or preferred modalities
- audio and closed-captioning accompanying all learning experiences
- Web Content Accessibility Guidelines 2.0 compliance that allows the digital edition to work well for all screen readers and similar adaptive devices

To support students from diverse language backgrounds in learning science content, the interactive Multilingual Glossary provides translations of common science terms and definitions in Spanish, Vietnamese, Filipino/Tagalog, Simplified Chinese, Arabic, Hmong, Korean, Punjabi, Russian, and Brazilian Portuguese. This resource also helps students learn how to spell and define vocabulary terms in English and Spanish. Additionally, handbooks to support English language arts, math, SEPs, CCCs, and lab safety can all be found on *Ed*.


ENGLISH GLOSSARY


Safety in the Lab

HMH Into Science enables teachers, via professional development and practice, to best meet the needs of all learners. "All grade levels' Teacher Resources feature a series of author articles. In one of these articles, program author Bernadine Okoro provides the following guidance:


Ensuring Educational Equity For Students
Supporting All Learners
Students Below Grade Level
Students Living in Poverty

BLENDED PROFESSIONAL LEARNING AND SERVICES

To support the delivery of effective instruction, *HMH Into Science* features research-based approaches to professional learning that support teachers in becoming developers of high-impact learning experiences for their students. Comprehensive professional learning solutions are data and evidence driven, mapped to instructional goals, and centered on students—and they build educators' collective capacity. HMH allows teachers to achieve agency in their professional growth through effective instructional strategies, embedded teacher support, and ongoing professional learning relevant to everyday teaching.

CONTINUUM OF CONNECTED PROFESSIONAL LEARNING

Effective professional learning, whether in-person, online, or blended, takes place as a "series of connected, coordinated components on a continuum" (Rock, 2019). This continuum includes alignment between the study of theory and practice, observation of theory and practice, individual coaching, and further practice and refinement through collaboration. Each of these components is essential to support and build on the content and pedagogy that is learned, observed, and practiced in each of the other components.

Long-term connected professional learning includes cohesive features—online coaching, remote peer observations, online collaboration, and facilitated online communities—all with a focus on how to ensure social and emotional well-being and meaningful student learning in digital environments. Connecting workshops to follow up learning and to support from peers and from coaches can help teachers retain new knowledge, practice new skills, and share innovative, effective approaches. A connection between workshops, coaching, and collaboration is essential for professional learning to make a difference in student achievement (Aguilar, 2019).

Research increasingly finds that teachers' professional learning is essential to school reform and a vital link between standards movements and student achievement (Borman & Feger, 2006; Garet et al., 2001; Gulamhussein, 2013; Sweeney 2011; Wei et al., 2009; Yoon et al., 2007). According to Wei et al. (2009),

> As students are expected to learn more complex and analytical skills in preparation for further education and work in the 21st century, teachers must learn to teach in ways that develop higher order thinking and performance. . . . Efforts to improve student achievement can succeed only by building the capacity of teachers to improve their instructional practice and the capacity of school systems to advance teacher learning. (p. 1)

Enabling educational systems to achieve on a wide scale the kind of teaching that has a substantial impact on student learning requires much more intensive and effective professional learning than has traditionally been available. If we want all young people to possess the higher-order thinking skills they need to succeed in the 21st century, we need educators who possess higher-order teaching skills and deep content knowledge (Gov. James B. Hunt, Jr. in Wei et al.'s *Professional Learning in the Learning Profession: Status Report*, 2009, p. 2).

Current reform efforts across disciplines require significant shifts in teachers' roles from traditional, rote, fact-based approaches to fostering students' deeper engagement, critical thinking, and problem solving. For schools to support these standards and instructional practices, effective professional learning during the implementation stage (when teachers are learning and committing to an instructional approach) is critical (Gulamhussein, 2013). Technology transforms the teacher's role. Yet this does not mean that evidence-based teaching practices should be discarded. In fact, effective instruction results when teachers purposefully combine these tools with proven instructional approaches (Kieschnick, 2017).

Teachers' initial exposure to a concept should engage them through varied approaches and active learning strategies to make sense of the new practice (Bill & Melinda Gates Foundation, 2014; Garet et al., 2001; Gulamhussein, 2013). An effective professional learning program should focus on the targeted content, strategies, and practices (Bill & Melinda Gates Foundation; 2014; Saxe et al., 2001; Wei, 2009) and should be grounded in the teacher's grade level or discipline (Gulamhussein, 2013).

Research has documented that educational reforms are not self-implementing or predictable in terms of how they may (or may not) take hold at the classroom level; the vital link necessary for targeted change is local professional learning by teachers (Borman & Feger, 2006).

Effective professional learning is embedded and ongoing as part of a wider reform effort, rather than an isolated activity or initiative (Garet et al., 2001; Wei, 2009). "The duration of professional development must be significant and ongoing to allow time for teachers to learn a new strategy and grapple with the implementation problem" (Gulamhussein, 2013, p. 3).

HOW *HMH INTO SCIENCE* DELIVERS

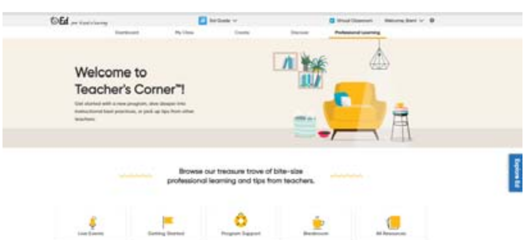
HMH Into Science includes a comprehensive professional development model to support teachers as they guide all students' learning. HMH's approach to professional learning includes *Implementation Success, Coaching, Live Online Courses,* and *Leadership Advisory Services*.

Implementation Success for *HMH Into Science* helps all teachers get started with their new science program, providing the foundational program knowledge teachers need to be successful in their first 30 days of instruction. As a follow-up to the getting-started session, *HMH Into Science Implementation Success* also features topic-specific professional learning to extend and deepen program understanding. Topics include

- Make Science Accessible for All Learners
- Use Data to Monitor Progress and Inform Science Instruction
- Plan Effective Science Learning Experiences
- Integrate Meaningful STEM Experiences
- Maximizing Learning with Digital Resources
- Support English Learners in Science

To ensure teacher success with *HMH Into Science*, we offer personalized Teacher Success Pathways easily accessible on *Ed,* the HMH learning platform. Educators have access to relevant, purposeful, and immediately actionable professional learning on their schedule.

Support continues throughout the year with on-demand professional learning in Teacher's Corner, access to curated professional learning content to support teacher's program use, organize their classrooms, and learn best practices with the teaching community. Dig deep into the *HMH Into Science* program's components or explore instructional strategies aligned to areas such as STEM, SEL, or culturally responsive teaching.



HMH Coaching for *HMH Into Science* offers individuals or teams of teachers sustainable, data-driven, and personalized support aligned to each teacher's learning goals. Our research-based blended coaching model is student focused and proven to help teachers improve their practice and raise student achievement.

HMH Coaching is customized to educators' busy schedules as well as to their learning needs. Our coaches work with teachers virtually via live online sessions or in a blended combination of in-person and online. The HMH Coaching Studio makes it easy for teachers and coaches to stay connected, share resources, upload and reflect on classroom videos, and make continuing progress on learning goals. Through the HMH Coaching Studio, teachers have access to

- *Goal Tracker*—allows teachers to create and track growth goals personalized to them
- *Model Lesson Library*—hundreds of HMH classroom and expert videos of best practices
- *Collaboration Hub*—discussion forums, resource sharing, and video-based reflection to drive collaboration with coach and peers
- *Video-Powered Coaching*—allows teachers to upload video of their instruction for reflection or to share with their coach and peers

HMH Leadership Advisory services provide a system-wide approach to implementation that can maximize the success of *HMH Into Science*. Through a focus on culture, organization, and instructional leadership actions, *HMH Leadership Advisory* services equip school and district leaders with access to strategies, guidance, and resources needed to implement HMH programs to align with and achieve district strategic goals.

HMH Professional Learning is recognized as a provider of effective and relevant professional learning by the *Professional Learning Partners Guide. HMH Professional Learning* received a "high-quality" rating in three key areas: Launching Instructional Materials, Ongoing Professional Learning for Teachers, and Ongoing Professional Learning for Leaders. To learn more, go to https://plpartnerguide.org/partner/houghton-mifflin-harcourt/.

PLPG CERTIFIED PROVIDER
PROFESSIONAL LEARNING PARTNER GUIDE

JOB-EMBEDDED COACHING TO STRENGTHEN TEACHING AND LEARNING

Research has demonstrated that sustained, job-embedded coaching is the most effective form of professional learning, whether it is delivered in person or in a virtual setting. Coaching delivered in person has been most effective when coaches are highly experienced and focus their work with teachers on a clearly specified instructional model or program. Other opportunities for teachers to develop their content knowledge of the targeted instructional model (e.g., in courses, workshops, or coach-led learning groups) are also an important component of successful coaching programs. Online coaching shows promise for being at least as effective as in-person coaching for improving outcomes, though the research base comparing delivery systems is thin. The balance of evidence to date, however, suggests that the medium through which coaching is delivered is less important than the quality and substance of the learning opportunities provided to teachers (Matsumura et al., 2019).

A recent meta-analysis of coaching programs found effect sizes of 0.49 *SD* on instructional practices and 0.18 *SD* on student achievement (Kraft et al., 2018). Encouragingly, teachers who received virtual coaching performed similarly to teachers who received in-person coaching for improving both instructional practices and student achievement. The authors identified several aspects of coaching in a virtual setting as potential strengths: increasing the number of teachers with whom a high-quality coach can work, reducing educators' concern about being evaluated by their coach, and lowering costs while increasing scalability (Kraft et al., 2018).

The International Society for Technology in Education (ISTE) embraces a professional development model that includes effective coaching, collaborative communities, and a technology-rich environment. Effective coaching is contextual, relevant, and ongoing. Collaborative communities can be school-based or online professional learning communities that allow teachers to learn from one another through observation, imitation, and modeling. ISTE recommends that school districts chose a coaching model that best fits the needs of their teachers, whether it is cognitive coaching, instructional coaching, or peer coaching (Beglau et al., 2011).

Effective professional learning programs provide continued follow-up and support from coaches (Sweeney, 2011). Knight (2011) stresses that once training initiatives are kick-started to raise awareness of targeted teaching practices, follow-up and coaching are essential: "Lasting change does not occur without focus, support, and systemwide accountability. . . . Support is necessary for transferring talk into action" (p. 10).

Instructional coaching entailing the modeling of specific sought-after practices has been shown to help teachers embrace and implement best practices and educational policy (Coburn & Woulfin, 2012; Gulamhussein, 2013; Heineke & Polnick, 2013; Knight, 2011; Taylor & Chanter, 2016; Wei et al., 2009).

Effective modeling of targeted instructional practices is purposeful and deliberate, incorporates academic language, and is based on research (Taylor & Chanter, 2016). Gulamhussein (2013) reports that

> while many forms of active learning help teachers decipher concepts, theories, and research-based practices in teaching, modeling—when an expert demonstrates the new practice—has been shown to be particularly successful in helping teachers understand and apply a concept and remain open to adopting it. (p. 17)

"Like athletes, teachers will put newly learned skills to use—if they are coached" (Joyce & Showers, 1982, p. 5). According to a large-scale survey commissioned by the Bill and Melinda Gates Foundation (2014), teachers value the potential of professional development to improve their planning and instruction and seek opportunities for effective means of such learning."

HOW *HMH INTO SCIENCE* DELIVERS

HMH Coaching for *HMH Into Science* offers individuals or teams of teachers sustainable, data-driven, and personalized support aligned to each teacher's learning goals. Our research-based blended coaching model is partner based, student centered, goal driven, and proven to help teachers improve their practice and raise student achievement.

Partner Based
For coaching to be effective, we must quickly establish a professional and trusting relationship with the educators we support. "Partnership, at its core, is a deep belief that we are no more important than those with whom we work and that we should do everything we can to respect that equality. This approach is built around the core principles of equality, choice, voice, dialogue, reflection, praxis, and reciprocity" (Jim Knight, 2007). Coming into school districts as outside consultants can make it more challenging to establish partnership relationships. We establish a coaching partnership by communicating our purpose and goals, delivering coaching in a consistent structure, and empowering the educators we coach to be real partners in the conversation during every step of the process.

Student Centered
The most effective results occur when we focus coaching conversations on improving student learning rather than on teaching practices. In student-centered coaching, we begin conversations by focusing on what students should do and then consider instructional practices that can achieve those targets. "Student-centered coaching is about providing opportunities for a coach and teachers to work in partnership, to (1) set targets for students that are rooted in the standards and (2) work collaboratively to ensure that the targets are met" (Diane Sweeney, 2014). Leading with student-learning targets puts teachers at ease and allows for richer instructional conversations.

Goal Driven
The impact of coaching can be measured only if goals are clearly defined and action steps are outlined at the outset of the coaching relationship. HMH's five-step coaching process, shown below, is grounded in a continuous-improvement model. The model recognizes that improvement is a process that allows for incremental and ongoing analysis, reflection, and revision.

Whether side by side or remotely, the coach and the teacher work together to

- Analyze student data—such as formative assessments, student work, and testing data—to establish goals for the coaching process
- Set student learning targets with measurable goals based on the student data to increase student understanding and learning behaviors
- Learn new instructional skills directly related to the established student learning targets to have the most significant impact
- Apply the instructional skills in the classroom with students
- Reflect and Review Progress by examining the measurable results demonstrated by student learning behaviors and student data from the classroom

We believe planning, analysis of student work, and progress monitoring are integral parts of the coaching cycle.

Online and Blended Coaching
We recognize that professional growth does not occur through isolated engagements but through a sustained learning process in which the personal needs of each participant are elevated and supported strategically and systematically. Online and blended coaching provide a sustained, personalized, flexible, and collaborative professional learning experience. HMH Instructional Coaches work shoulder to shoulder with teachers in a remote environment through each step in our five-part coaching model, adjusting seamlessly from the in-person to the online medium. During live, online sessions, coaches work with teachers to analyze student data, set student learning targets, learn new skills, apply them, and use data to continue collaboration throughout the year. Teachers use Coaching Studio resources between sessions.

HMH Coaching Studio
HMH online and blended coaching grant teachers the opportunity to leverage HMH's web-based coaching platform, the Coaching Studio, to ensure that learning is a sustained process. The Coaching Studio sustains teachers' connections to their coaches and colleagues as they implement new practices and strive toward success. Through the Coaching Studio, teachers and leaders are empowered to make continued progress on their goals, reflect on their learning, and set goals for their next coaching session.

HMH Coaching Studio is a 2020 EdTech Awards Cool Tool.

PERSONALIZED AND ACTIONABLE PROFESSIONAL LEARNING

Personalized professional development allows teachers to pursue learning to support their instructional needs in their own place and at their own pace. Teachers can take courses via online professional learning portals, opportunities offered by the school, or off-campus settings. In this process, teachers learn new competencies, demonstrate what they have learned in their classrooms, and submit evidence of mastery. As teachers build their knowledge and skills, they earn badges to demonstrate their expertise (Clayton et al., 2014).

Many school districts and providers of teachers' professional development are moving toward a more personalized model of professional development, taking a cue from the movement toward personalized learning for students. This approach often focuses on short modules, which teachers can choose and then complete on their own time. The modules can incorporate aspects of gamification, micro-credentialing, and online professional development communities. By allowing teachers to choose their own professional development courses and activities, the professional development will be better matched to their needs. Teachers will be able to set goals, find resources to help them meet those goals, track their progress, and get feedback from supervisors and colleagues (Gamrat et al., 2014; Meeuwse & Mason, 2018).

Effective training efforts should be developed according to evidence-based strategies for adult learning and communication, including engaging teachers in varied approaches that allow for their active participation (Bill & Melinda Gates Foundation, 2014; Garet et al., 2001; Gulamhussein, 2013; Guskey, 2002; Taylor & Chanter, 2016). As intellectuals, they are empowered to reflect on theory, research, and their practice to innovate and implement new teaching strategies and approaches. This process of reflection can lead to teachers' turning to their colleagues for advice and clarification—a process sometimes called collective sensemaking; research has shown that the collective sensemaking that occurs in professional learning communities can be a powerful motivator for school improvement (Coburn, 2005).

As Bryk and colleagues (2015) noted in a study of improvement efforts that included professional learning, positive changes happen in the presence of teachers' "good will and engagement," which is often rooted in teachers' having choice and autonomy in their own learning. These qualities are essential whether teachers meet for large-group professional learning, attend professional learning communities within their schools, or work on their own to search out experts to guide them through self-study with print or online resources.

Teachers who seek to improve their practice and their students' achievement can also turn to resources to help them continue successfully on their path toward professional mastery and control the place, pace, and path of their professional learning. Individually and collaboratively, they engage in a process sometimes called self-coaching (Wood et al., 2014). There are five steps to self-coaching that align with high-quality teaching:

1. Collect data to help answer questions about instructional improvement. Formative and benchmark data are important, but so is information about students' interests, styles of learning, and work habits.
2. Reflect on the data as a whole and on the data that results from looking back on each day's instruction and each week's instruction.
3. Act on the reflections by trying things out and sharing the results of teachers' actions in a collaborative and mutually supportive group.
4. Evaluate teacher practices, especially through video self-reflection, and ask questions about effectiveness of instruction and students' receptivity to the instruction.
5. Extend actions. For example, a successful approach to teaching students to understand complex narrative texts can be applied to instruction on reading, social studies, science, or other informational texts.

HOW *HMH INTO SCIENCE* DELIVERS

Educators have access to sustained professional development support for *HMH Into Science*. A subscription includes continuous implementation support all year long. To ensure teachers are successful and confident with their new HMH program from the outset, we provide a system of support designed to concentrate on what's most important for a teacher's first 30 days, which includes district-scheduled program trainings and Teacher Success Pathways on *Ed*, the HMH learning platform.

Benefits:

- Solution-specific teaching resources are available on their schedule, both live and on-demand.
- Teachers have multiple opportunities to attend the sessions in their pathway and unlimited access to their resource materials throughout the year, no matter when in the year they are hired.
- Printable parent and caregiver letters—in both English and Spanish—help with at-home support and more!

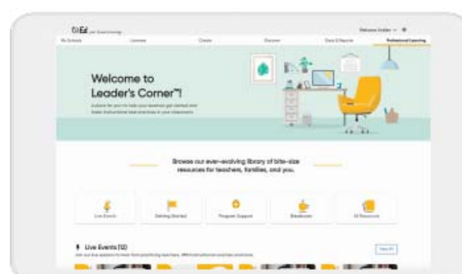
What types of resources are included?

- Teacher Success Pathways are personalized to match each teacher's programs and grades and include topics that address different elements of teaching, such as planning and prioritizing instruction, assessing and differentiating, and personalizing instruction.
- Yearlong access to Teacher's Corner™ puts real-world classroom videos and best practices at your fingertips on your schedule. Plus, free Live Events allow you to build a community around solutions to today's instructional challenges.

Ongoing professional learning and support for *HMH Into Science* isn't limited to teachers—leaders can also view on-demand resources, such as classroom videos and live events via *Leader's Corner*.

Leader's Corner Resources Support:

- Live Events
- Getting Started
- Program Support
- Breakroom
- And much more!



SUMMARY

In this paper, we have demonstrated how *HMH Into Science* aligns with research-based principles and practices for high-quality, highly effective science instruction. With its flexible design—including expanded access to rich and varied digital resources, support of productive perseverance and a growth mindset, and engaging and rigorous texts throughout—*HMH Into Science* provides a cohesive, innovative solution that builds intellectual stamina and tenacity while developing scientific thinkers, problem solvers, and communicators.

HMH Into Science features student-centered learning that encompasses and integrates inquiry and conceptual understanding, tasks that require high cognitive demand, argumentation, and more. The solution is also data driven, providing a comprehensive, balanced assessment system to ensure teachers help students meet targeted learning goals. Finally, the solution is supported by ongoing professional learning for teachers, including modeling and coaching to maximize educator agency and accommodate individual students.

HMH Into Science addresses the needs of today's classrooms and the requirements of tomorrow's world to better prepare students for college, career, and citizenship.

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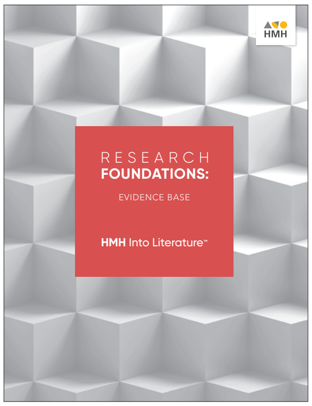

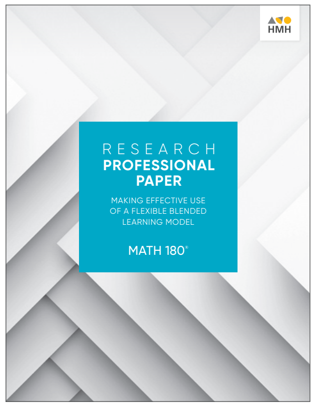

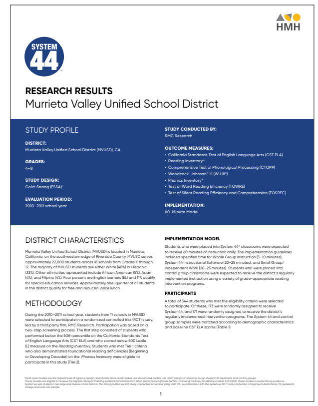

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