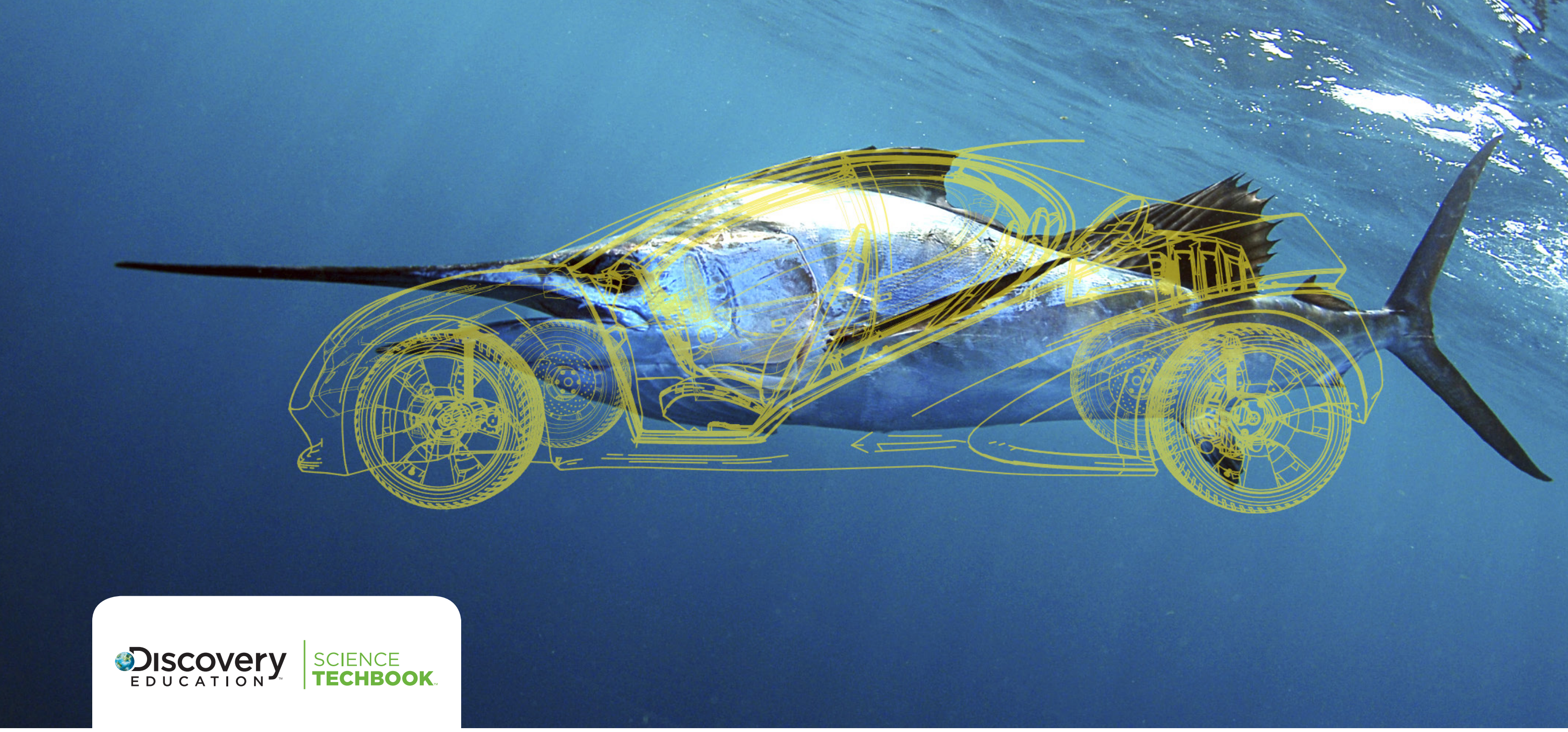


PROVIDING *NEXT GENERATION* K-12 SCIENCE INSTRUCTION

Using Science Techbook to Support NGSS

Within science education there is a consensus that science literacy for all is the goal for K-12 education in science.

First published in 1986, *Science for All Americans*[1] presents a compelling case for the importance of science literacy for all students. This seminal work makes it clear that all students, not just students who will go on to science careers, need to have a deep and clear understanding of major ideas in science, technology, engineering, and mathematics. In order to be fully functioning citizens in a world where complex issues in medicine, environmental science, energy policy, and other topics in science shape people's day-to-day existence, it is imperative that students graduate from high school with a deep and clear understanding of foundational topics in science. It is also important for graduates to understand how scientists and engineers approach their work and what kinds of questions they can and cannot help society answer. Within science education there is a consensus that science literacy for all is the goal for K-12 education in science.

Released in July 2011, *A Framework for K-12 Science Education*[2] *(Framework)* opens with the following statements:

> *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.*

Despite a consensus on the goal, 25 years later, science educators were still struggling to put in place the supports needed to ensure exemplary science education for all K-12 students. The *Framework* uses a growing body of research on the effective teaching and learning of science to describe a vision for the next generation of science instruction. The authors of the *Framework* envision 21st century science instruction as being built around three major dimensions.

[1] Rutherford, F., & Ahlgren, A. (1990). *Science for all Americans.* New York: Oxford University Press

[2] National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academy Press.

Science instruction must move away from a model where students listen to a college-type lecture and then complete a laboratory experience that confirms what the teacher presented in the lecture.

These dimensions are:

- Scientific and engineering practices
- Crosscutting concepts that unify the study of science and engineering through their common application across fields
- Core idea in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science.

Students should actively learn science by participating in learning experiences that require them to use the science and engineering practices and apply the crosscutting concepts to deepen their understanding of the core ideas within the disciplines of science. One way to think about this vision for 21st century science instruction is to think about the kinds of tasks that scientists, engineers, and others who work in high tech fields do every day. The authors of the Framework recommend that science instruction be more like challenging and interesting STEM (Science, Technology, Engineering, and Mathematics) work experiences. Science instruction must move away from a model where students listen to a college-type lecture and then complete a laboratory experience that confirms what the teacher presented in the lecture.

In support of this change, under the guidance of Achieve, an organization that also played a leading role in the development and support of the Common Core State Standards (CCSS), and in collaboration with 26 lead partner states, educators, scientists and other stakeholders in science, science education, higher education, and industry worked together to translate the vision of the *Framework* into standards that lay out what children should know and be able to do at each grade level in K-12. The standards are referred to as Next Generation Science Standards (NGSS).[3] Full implementation of the NGSS will require new instructional materials designed specifically to support implementation of the new vision.

As new materials are developed by publishers, state and district educators will review the materials to determine the extent to which they actualize the vision of NGSS. Achieve and the NGSS has created the Educators Evaluating the Quality of Instructional Products (EQuIP)[4] rubric for science to assist educators with the review of science instructional materials. The purpose of this paper is to elaborate on the vision for next generation science and then use important criteria associated with the EQuIP rubric to demonstrate how Discovery Education's Science Techbook supports teachers in delivering exemplary, research-based science instruction that brings the vision of the *Framework* and of NGSS to life for K-12 students.

What is next generation science instruction and how does Discovery Education Science Techbook support teacher implementation of an exemplary science program?

This paper will look at nine criteria for quality science instructional materials and discuss how Science Techbook addresses each one. The nine criteria relate to the following topics:

- Three dimensional learning
- Coherence
- Meaningful connections to students' lives
- Integration of scientific inquiry and engineering design
- Prior knowledge and learning progression
- Integration of CCSS in mathematics and English Language Arts (ELA)/literacy
- Integration of digital resources
- Student assessment
- Professional learning for teachers

1. Three-Dimensional Learning: *Next generation* K-12 science instruction supports students in three-dimensional learning.

Over the last three decades, educators, scientists, and researchers have learned a lot about best practices in teaching science so that all children have the opportunity to learn the knowledge

[3] Next Generation Science Standards For States, By States. (Achieve). Retrieved November 18, 2015, from http://www.nextgenscience.org/development-overview

[4] Resources I Next Generation Science Standards. (n.d.). Retrieved November 9, 2015, from http://www.nextgenscience.org/resources

The courses in Science Techbook were designed from the ground up to address the requirements of NGSS.

and skills needed to achieve science literacy. Much of this research was summarized and used to develop the *Framework*, which then informed the development of the NGSS. A major shift of NGSS is the interweaving of science and engineering practices, disciplinary core ideas, and crosscutting concepts. The standards require students to engage actively in science and engineering practices that are connected to crosscutting concepts in science in order to deepen student understanding of the core ideas of the major subdisciplines of science. At least one of eight practices is interwoven with at least one of seven crosscutting concepts in science to deepen student understanding of major ideas in the physical sciences, life sciences, earth and space sciences, and in engineering, technology, and applications of science. Developers of the NGSS standards were charged with developing standards that could only be fully achieved when all three dimensions are integrated into curriculum, instruction, and assessment. To fulfill the charge, each standard in the NGSS is stated as a performance expectation and each performance expectation identifies the science and engineering practices, disciplinary core ideas, and crosscutting concepts that were used in its development. Most recently, the NGSS published evidence statements that clarify knowledge and behaviors that students should exhibit for each performance expectation.[5]

How Science Techbook Supports Three-Dimensional Learning

The courses in Science Techbook were designed from the ground up to address the requirements of NGSS. Science Techbook uses the well-researched 5E instructional model[6] and includes a 5E model lesson for every concept. For example, the fifth grade life science unit titled "Energy for Humans and Other Living Things" includes the following four concepts with a model lesson for each concept:

- Food and Oxygen
- Basic Needs of Plants
- Parts of Ecosystems
- Energy in Systems

Each model lesson includes a standards overview that explicitly identifies the performance expectation from NGSS and then identifies the disciplinary core idea(s), crosscutting concept(s), and science and engineering practice(s) that are woven together in the lesson. The example below is from the standards overview for the model lesson on the basic needs of plants.

Performance Expectation: 5-LS1-1 – Support an argument that plants get the materials they need for growth chiefly from air and water.

Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
LS1.C Plants acquire their material for growth chiefly from air and water.	Energy and Matter: Matter is transported into, out of, and within systems.	Engaging in Argument from Evidence: Support an argument with evidence, data, or a model.

[5] Evidence Statements; Next Generation Science Standards For States, By States. Retrieved November 18, 2015, from http://www.nextgenscience.org/k-5-evidence-statements

[6] Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Powell, J., Westbrook, A., & Landes, N. (2006, June 12). The BSCS 5E Instructional Model: Origins and Effectiveness. Retrieved November 9, 2015, from http://bscs.org/sites/default/files/_media/about/downloads/BSCS_5E_Full_Report.pdf

Science Techbook addresses no more and no less than the content specified within NGSS while expanding the time and depth devoted to the core concepts.

This model lesson includes 12 sessions that are approximately 45 minutes long. In these sessions, students engage in several hands-on activities and have the opportunity to obtain and evaluate a variety of online digital resources. Throughout the experiences, students are expected to gather evidence to support their argument around a central driving "Can You Explain" question related to how plants get the materials they need for growth. Students will build their proficiency with multiple science and engineering practices, making connections to crosscutting concepts such as matter, structure and function. These experiences are woven together to deepen student understanding of the disciplinary core idea (plants acquire their material for growth chiefly from air and water). To support teacher planning, the model lesson includes a section entitled "Three-Dimensional Learning in Focus" to explain how the lesson authors envision students using the practices and crosscutting concepts to develop and deepen understanding of the science concept, which is the disciplinary core idea.

2. Coherence: Lessons fit together coherently and develop appropriate intra- and inter-disciplinary connections.

In designing NGSS, developers consciously worked to avoid developing a long list of detailed and disconnected facts for students to memorize. A major criticism of previous generations of K-12 science curricula has been the tendency to be "a mile wide and an inch deep."[7] In contrast, NGSS identifies a limited number of foundational concepts from the subdisciplines of science. Students are expected to develop their understanding of these concepts over a period of years. Therefore, NGSS developers have identified learning progressions that help educators know what should be taught in various grades. When the framework is implemented properly, teachers guide students to more scientifically based views of the world and they deepen student understanding of how scientists and engineers do their work.

Developers chose concepts that are truly foundational to scientists' current understanding of how the world works. Therefore, there are multiple opportunities to illustrate the connections among life science, physical science, earth and space science, and engineering, technology, and applications of science. Finally, the emphasis on fewer topics makes it possible for students to take the time needed to engage in scientific inquiry and engineering design. NGSS developers designed the standards to develop science literacy in all students and to provide the foundational knowledge needed for students who wish to pursue careers in science, engineering, and other technical fields.

How Science Techbook Addresses Coherence

Science Techbook provides for coherence by

- Limiting the topics covered to the topics identified in NGSS
- Arranging experiences so that student understanding grows over the course of the unit
- Connecting concepts over the course of the year and from one year to the next

Because the courses in Science Techbook were designed to address the requirements of NGSS, they include the core ideas, science and engineering practices, and crosscutting concepts that are identified in NGSS for a given grade. Science Techbook addresses no more and no less than the content specified within NGSS while expanding the time and depth devoted to the core concepts. For example, the kindergarten course in Science Techbook includes three units: Energy and Motion, Living Things, and The World Around Us.

[7] Schmidt, W., McKnight, C., & Raizen, S. (2002). Executive Summary. In *A splintered vision an investigation of U.S. science and mathematics education*. New York, NY: Kluwer Academic

...lesson length allows for a deeper and more explorative experience around the core concepts.

Science Techbook has 5E model lessons for the following concepts in those units:

Energy and Motion	Living Things	The World Around Us
Moving Things	Basic Needs	Sky and Weather
Force and Motion	Animals and People	Environmental Resources
Heat		Habitats
		Environmental Problems and Solutions
		Building a Shelter

The three Science Techbook units include the following topics from NGSS:

Energy and Motion	Living Things	The World Around Us
K-PS2 Motion and Stability: Forces and Interactions	K-LS1 From Molecules to Organisms: Structures and Processes	K-ESS2 Earth Systems
K-PS3 Energy		K-ESS3 Earth and Human Activity
		K-2-ETS1 Engineering Design

The standards overview for the model lesson on Moving Things includes the same performance expectations, science and engineering practices, disciplinary core ideas, crosscutting concepts, and Common Core Standards Connections as those listed in NGSS for the kindergarten standard K-PS2 Motion and Stability: Forces and Interactions. It is clear that the developers of Science Techbook limited the standards addressed to the standards identified for kindergarten in NGSS. All kindergarten standards from NGSS are included and additional standards and additional topics have not been added. However, lesson length and the multitude of resources within the concept allow for a deeper and more explorative experience around the core concepts.

Science Techbook provides for coherence by arranging topics so that student understanding grows over the course of a lesson and by connecting ideas from one lesson to another. Each 5E model lesson is designed for multiple sessions. For example, the model lesson on Moving Things is designed for ten 30-minute sessions. Students begin with an experience that requires them to get up and move. They then work as a class to make a list of words that describe how they moved. Students then participate in several hands-on investigations in which they study the movement of balls, toy cars, and blocks. Throughout these experiences they focus on gathering evidence to answer questions such as "How do things start moving?" Students are given the time and the experiences needed to build conceptual understanding. In this series of lessons, students also watch video segments of animals moving. Later in the course students will talk about why animals need to eat. Teachers will have the opportunity to connect the concept of animals needing food for energy to the experience students had in this lesson of watching animal movement. Additionally, throughout the unit, teachers are using the lessons in science to develop literacy and problem-solving skills that students are learning in language arts and mathematics. Concepts introduced in kindergarten are then reinforced and built upon as students move on to later grades.

Because science teachers are encouraged to teach for conceptual change, they are also encouraged to use experiences that come from the everyday lives of their students.

3. **Meaningful Connections to Students' Lives: *Next generation* K-12 science instruction engages students in explaining phenomena that relate to students' lives and designing solutions to problems with which students have experience.**

   Research strongly supports the belief that children develop their own conceptions of how the world works long before they participate in formal instruction in science at school.[8] For most children, developing science literacy involves replacing childish preconceptions of how the world works with more scientifically accurate views of natural phenomena. "Everyday experience provides a rich base of knowledge and experience to support conceptual changes in science."[9] Because science teachers are encouraged to teach for conceptual change, they are also encouraged to use experiences that come from the everyday lives of their students. An added benefit of this approach is that using experiences that students can relate to their everyday lives has also been shown to increase student engagement with learning.[10]

How Science Techbook Makes Meaningful Connections to Students' Lives

Science Techbook provides teachers with clear and specific examples that can be used to connect with students' everyday lives. Every model lesson includes a tab entitled "Teacher Preparation." This page of the Techbook includes the following components:

- Prior Knowledge and Learning Progressions
- Common Misconceptions
- Connections to Students' Lives

In Connections to Students' Lives, the authors of Science Techbook give teachers ideas for relating the science to the everyday experience of students. For example, the high school chemistry course includes a unit entitled "Properties and States of Matter." One concept included in this unit is classification of matter. The model lesson for this concept suggests relating this topic to students' lives by having students think about what they might experience on a foggy morning. This discussion includes thinking about how the fog tends to clear up as the temperature rises. The discussion leads to prompting students to think about one method of classifying matter. Matter can be classified into four states: solids, liquids gases, and plasma. Students are then prompted to think about another way of classifying matter, namely as pure substances or mixtures. Students are then prompted to think about a variety of substances found in their homes. They are encouraged to think about the food they eat, the clothes they wear, shampoo and soaps they use, and cleaning supplies found in the home. This component ends with a brief description of what students will do as part of the lesson and how this connects to jobs and careers.

In addition to the section labeled Connection to Students' Lives, every 5E lesson includes "Engage" as the first component of the lesson. In the "Engage" section of the lesson on Classification of Matter, students read a text that introduces students to the phenomena of glaciers. This extreme example is then used to bring the idea of water to more familiar phenomena, such as boiling water to make noodles. Students are then given a series of formative assessment items to indicate which core ideas they already possess related to elements, mixtures, compounds, and substances, before they dive into the disciplinary core idea of the behavior between atoms.

[8] Kyle, W., & Shymansky, J. (1989). Enhancing Learning Through Conceptual Change Teaching. *Research Matters to the Science Teacher*, 8902. Retrieved November 10, 2015, from https://www.narst.org/publications/research/concept.cfm

[9] National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academy Press. (p. 284)

[10] Taylor, L. & Parsons, J. (2011). Improving Student Engagement. *Current Issues in Education*, 14(1). Retrieved November 10, 2015, from http://cie.asu.edu/

Good teachers generally begin instruction with an understanding of what students already know and can do.

4. **Use of Students' Prior Knowledge and Learning Progressions: *Next generation* K-12 science instruction develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students' prior knowledge.**

   Good teachers generally begin instruction with an understanding of what students already know and can do. However, this is especially important when teaching for conceptual change. For many years, researchers studying student learning of science have documented the difficulty of getting students to replace their naïve preconceptions with more scientifically accurate understandings of natural phenomena.[11] However, in keeping with the goal of science literacy for all, the vision of NGSS is that students over time build "progressively more sophisticated explanations of natural phenomena."[12]

How Science Techbook Helps Teachers Build on Students' Prior Knowledge

Every 5E model lesson in Science Techbook includes resources to help teachers understand the science concept for which the lesson was developed and understand the prior knowledge that students may bring to the lesson. In addition to Connections to Students' Lives, the Teacher Preparation component of the lesson always includes:

- Prior Knowledge and Learning Progressions
- Common Misconceptions

For example Middle School Earth and Space Science includes a unit entitled "The Earth-Sun-Moon System." This unit includes three concepts with 5E model lessons for each concept:

- Rotation, Orbits, and the Seasons
- Phases
- Eclipses

The model lesson for Rotation, Orbit, and the Seasons includes teacher preparation that provides background information on why we experience days, seasons, and years. It also provides the following chart that helps teachers understand what students should have learned about this topic in elementary school, what they are expected to know and be able to do related to this topic by the end of middle school, and what they will learn about this topic in high school.

The teacher preparation also includes a list of common misconceptions that middle school students may have about rotation, orbits, and the seasons.

The lesson, designed to be implemented in eight class periods, begins by having students share what they already know about rotating and revolving in an orbit. They then discuss how these terms apply to Earth. Students are also asked to support their own explanation for why they think we have seasons. Teachers are encouraged to make note of misconceptions, but not to correct them at this point in the lesson. Students then use video segments and hands-on activities to gather evidence about why Earth has seasons.

Prior Knowledge and Learning Progressions

Content Assessed at Grade Levels

	DCI/PE	ES	MS	HS
ESS	PE	5-ESS1-2	MS-ESS1-1	HS-ESS1-4 HS-ESS2-4
	DCI	5.ESS1.B	ESS1.A ESS1.B	HS-ESS1.B
PS	PE	3-PS2-1 3-PS2-2 5-PS2-1		HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-PS2-4 HS-PS2-5 HS-PS2-6
	DCI	3.PS2.A 5.PS2.B		HS.PS2.A HS.PS2.B

[11] Ruhf, R. J. (2003). A General Overview of Conceptual Change Research. Unpublished paper. Retrieved November 11, 2015, from www.x98ruhf.net/conceptual_change.pdf

[12] National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academy Press. (p. 25)



A major shift of NGSS is the full integration of engineering and technology into science instruction.

In the Explain component of the lesson, students revisit their initial ideas and assess how their initial thinking compares to the scientifically accepted explanation of seasons. The final components of the lesson have students read a passage to learn about seasons on other planets in the solar system and develop a scientific explanation, supported with evidence, to share what they have learned about seasons.

This 5E lesson, like many in Science Techbook, was designed to build on students' prior knowledge and to cause students to rethink any misconceptions.

5. **Integration of Scientific Inquiry and Engineering Design: *Next generation K-12 science instruction uses scientific inquiry AND engineering design as significant elements of the science program.***

   A major shift of NGSS is the full integration of engineering and technology into science instruction. Previous science standards[13] included standards for Science and Technology within each grade band. Within NGSS, however, engineering design has been raised to the same level as scientific inquiry to provide students with an additional context to approaching a problem or investigation. Therefore, engineering design should be interwoven appropriately throughout science courses. In addition, core ideas of engineering and technology are given the same importance as the core ideas of other subdisciplines of science.

   Within NGSS Appendix A[14], the authors of the standards provide two reasons for this shift. First, it is hoped that students will be inspired to pursue careers in science and engineering. Second, by using engineering design practices, students have an opportunity to apply what they are learning and thus deepen their understanding of many of the concepts of science.

How Science Techbook Integrates Scientific Inquiry and Engineering Design

The Standards Overview for all of the 5E lessons in Science Techbook includes the science and engineering practices from NGSS that are interwoven into the lesson. For example, the 5E lesson on Earthquakes found in the Grade 4 Science Techbook has students use engineering design to deepen their understanding of a science concept. After completing a variety of activities related to understanding patterns associated with earthquakes, students are given the task of creating a new style of house that will resist the shaking of a moderate to strong earthquake. Students use the engineering design practices of creating a plan for their structure, conducting initial tests, and then building, testing, and refining their structure.

6. **Integration of CCSS in Mathematics and ELA/Literacy: *Next generation K-12 science instruction deliberately connects science, mathematics, and ELA/literacy.***

   Most science teachers recognize that they have a responsibility to develop students' literacy and mathematical reasoning skills as a component of what they do in science classes. The developers of NGSS understood this responsibility and built the connections to the mathematics and literacy

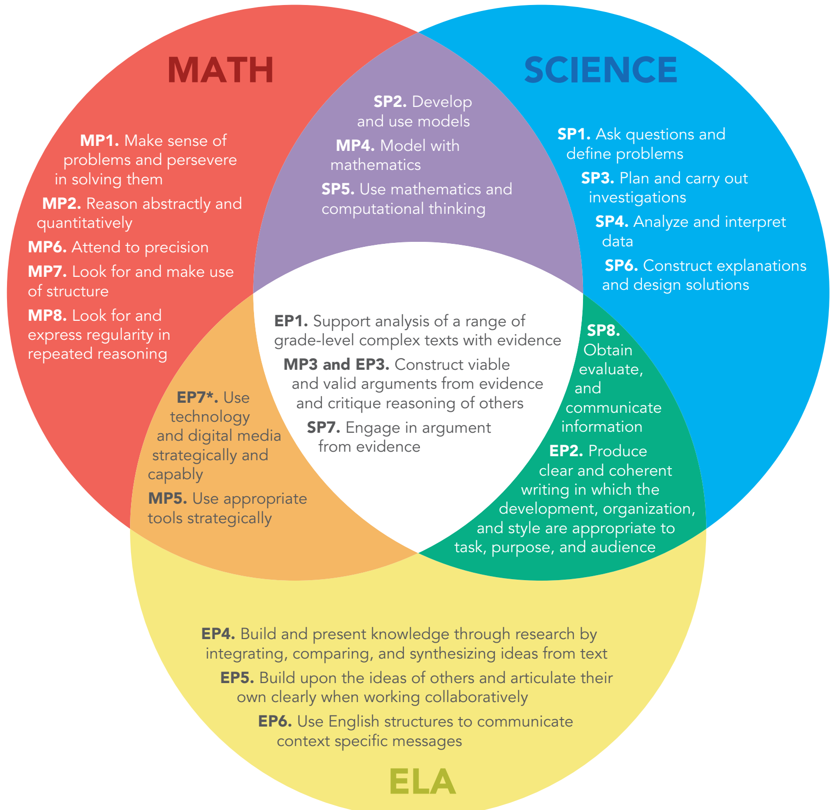
[13] National Research Council. (1996). *National Science Education Standards observe, interact, change, learn.* Washington, D.C.: National Academy Press.

[14] The Next Generation Science Standards. (n.d.). Retrieved November 11, 2015 from www.nextgenscience.org/sites/ngss/files/Appendix A - 4.11.13 Conceptual Shifts in the Next Generation Science Standards.pdf

When teachers emphasize what it means to read, write, and think like a scientist or an engineer, they make these careers more accessible for a broad range of students.

standards into NGSS. Educators have also noted the overlap that exists among the mathematical practices, the capacities of a literate individual, and the science and engineering practices.

The diagram[15] below illustrates this overlap.



The National Research Council report *Taking Science to School*[16] identified four strands of proficiency that students develop as they learn science. Students who are proficient in science:

- Know, use, and interpret scientific explanations of the natural world
- Generate and evaluate scientific evidence and explanations
- Understand the nature and development of scientific knowledge
- Participate productively in scientific practices and discourse

When teachers highlight explicitly how scientists and engineers use mathematics and language skills within their work, they are developing the abilities that students will need to participate productively in scientific practices and discourse. Students need multiple opportunities over years of schooling to develop the sophisticated skills associated with making a scientific argument. They need extensive practice with developing and analyzing charts, tables, and graphs to understand fully how scientists and engineers think about and use quantitative data in their work. When teachers emphasize what it means to read, write, and think like a scientist or an engineer, they make these careers more accessible for a broad range of students. They also empower all students to participate as knowledgeable citizens in a society that is increasingly being shaped by advances in science and technology.

[15] Cheuk,T. (2013). Relationships and convergences among the mathematics, science, and ELA practices. Refined version of diagram created by the Understanding Language Initiative for ELP Standards. Palo Alto, CA: Stanford University. Retrieved November 11, 2015 from http://ell.stanford.edu/content/science

[16] Duschl, R., Schweingruber, H., & Shouse, A. (Eds.). (2007). Taking science to school: Learning and teaching science in grades K-8. Washington, D.C.: National Academies Press. Retrieved November 11, 2015 from http://www.nap.edu

By providing students with support and repeated practice in developing scientific explanations, Science Techbook strengthens students' ability to participate productively in scientific practices and discourse.

How Science Techbook Makes Connections to Common Core Standards in Mathematics and English Language Arts/Literacy

Every 5E model lesson in Science Techbook includes a Standards Overview. The Standards Overview not only includes the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices from NGSS, but it also includes connections to Common Core State Standards. For example, the Middle School Physical Science course includes a unit entitled "Force and Motion." This unit includes lessons on the following concepts:

- Gravity
- Friction
- Straight Line Motion
- Interaction of Force and Mass

Each lesson in this unit includes connections to CCSS. For example, the lesson on friction includes the following ELA/Literacy standards:

- Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually
- Cite specific textual evidence to support analysis of science and technical texts
- Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions
- Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes
- Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation
- Write arguments focused on discipline content

Throughout the lesson, students collect evidence from video clips and hands-on investigation. Students use the evidence they have collected to construct a scientific explanation. This is a tool that is introduced in elementary science courses and is used consistently in Science Techbook lessons. The tool was developed using a framework for constructing scientific explanations proposed by McNeill and Krajcik.[17]
Students are taught that a scientific explanation includes three parts:

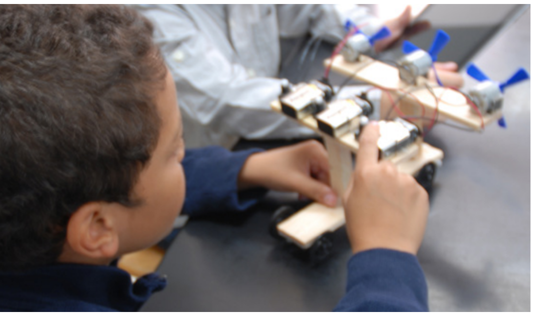
- A claim that answers the question being studied
- Evidence to support the claim
- Scienti ic reasoning that explains how the evidence supports the claim

Writing scientific explanations also addresses the common core ELA writing standard that requires students to use evidence and reasons to support claims. By providing students with support and repeated practice in developing scientific explanations, Science Techbook strengthens students' ability to participate productively in scientific practices and discourse. Students also develop logical reasoning skills that are beneficial across the curriculum and useful in everyday life.

Mathematics practices are also woven into the core of Science Techbook. For example, in the concept, Solutions, Grade 5, students use a virtual lab, Dessert Solutions, to explore the relationship among measures of materials that will form a gelatin. They collect data in a table and use a graphing tool to identify the pattern that will form a firm gelatin, then model that with mathematics. This activity addresses the following mathematical practices:

- Make sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Model with mathematics
- Look for and make use of structure (patterns and structures in mathematics)

[17] McNeill, K., & Krajcik, J. (2012). *Supporting grade 5-8 students in constructing explanations in science: The claim, evidence, and reasoning framework for talk and writing.* Boston: Pearson.



Students using Science Techbook have the opportunity to work independently, to work with others in small groups, and to work as members of a larger community.

7. Integration of Digital Resources: *Next generation* K-12 science instruction uses digital resources to improve teaching and learning.

The National Center for Research in Advanced Information and Digital Technologies was established to improve the opportunity to learn for all Americans through technology and research. They have identified a number of ways that digital resources can support the use of key research-backed principles that have a positive correlation with improved student learning. In the hands of well-trained and knowledgeable teachers, digital tools have the potential to support the following:

- Personalized, differentiated, and self-paced learning
- A positive emotional climate, and social and emotional learning
- Authentic, real-world learning
- Collaborative learning
- Data gathering, analysis, and timely feedback[18]

How Science Techbook Uses Digital Resources

Personalized, differentiated, and self-paced learning: Science Techbook is more than a collection of digital learning objects. The model lessons specify how and when such resources are appropriate to the instructional progression and the digital resources are woven into the Core Interactive Text that students read as a direct support to conceptualization. Science Techbook also has tools that allow teachers to assign learning activities and resources to specific students. As appropriate, students in the same class can be working on the same or different assignments or working with text at different Lexileâ levels. This allows teachers to customize instruction to the speci ic learning needs of each student. Universal Design for Learning features are built into the system, as are specific suggestions for meeting the needs of English Language Learners, struggling learners, and advanced learners. Students can highlight text and have the computer read it to them. Students can read Core Interactive Text in English and Spanish. In the high school courses, reading passages are available at two reading levels in order to make the information accessible to a wider range of students. Teachers have the option of having students complete many assignments electronically or they can print out hard copies of assignments and have students answer on paper, as well as the ability to share resources through social media.

A positive emotional climate, and social and emotional learning: Students using Science Techbook have the opportunity to work independently, to work with others in small groups, and to work as members of a larger community. Teachers using the product learn to manage all of these approaches and they learn to develop in their students the social and emotional learning skills needed for success in a variety of learning environments.

Authentic, real-world learning: In addition to working with engaging problems grounded in the real world, students and teachers using Science Techbook are members of the Discovery Education Network. They receive advance notice of virtual field trips and opportunities to communicate with scientists in the field.

[18] Francisco, A. (n.d.). Technology's Role in Putting Learning Science Research To Work. Retrieved November 12, 2015, from http://www.digitalpromise.org/blog/entry/technologys-role-in-putting-learning-science-research-to-work

Students using Science Techbook have the opportunity to collaborate with classmates in their own classroom as part of the hands-on and digital activities.

They also have access to a treasure trove of archived footage of scientists, engineers, and other STEM professionals at work in the real world. Students can connect in real-time with researchers studying polar bears in the Tundra, farmers using modern farming techniques to grow fruits and vegetables for sale in local supermarkets, or get a behind-the-scenes look at geologists working in a copper mine. They routinely see that science is happening all around them, and they get a better idea of the work that STEM professionals actually do.

Collaborative learning: Students using Science Techbook have the opportunity to collaborate with classmates in their own classroom as part of the hands-on and digital activities. Teachers are encouraged to have students share their Scientific Explanations and to present and discuss scientific arguments, in addition to conducting analysis of group data sets related to the hands-on investigations. Through virtual field trips and Discovery Education national projects, students also have opportunities to collaborate with professionals in the field and to perform simple tasks that contribute to ongoing science research.

Data gathering, analysis, and timely feedback: Students can complete assignments and assessments that are in Science Techbook. Teachers can also utilize the Scientific Explanation, which can be submitted online or in print, to gauge student understanding. Having students work in the system also makes it easier for teachers to provide specific and timely feedback using the tools provided by Science Techbook.

8. **Student Assessment: *Next generation* K-12 science instruction requires ongoing assessment to support the development of rich and deep student understanding of all three dimensions of science.**

   Within classrooms implementing NGSS, three-dimensional assessments expect students to apply the disciplinary core idea along with the other two dimensions of the performance expectation statements.

   Assessment items must provide opportunities for students to show evidence of their three-dimensional learning. In addition, teachers and students want and need high-quality pre assessments, ongoing formative assessments, summative assessments, and opportunities for students to self assess.

How Science Techbook Supports Effective Student Assessment

Science Techbook provides teachers with pre assessments, formative assessments, summative assessments, and student self-assessments and these assessments address the scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Assessment types include selected response and constructed response items, and student record sheets for hands-on and virtual investigations and labs. Each of these are available both on-line for submission to the teacher as well as in print versions and each constructed response type comes with a scoring rubric that is visible to the student and the teacher. Teachers can score rubric-scored responses online or on paper. In addition, each concept contains an online student self assessment that students can use to assess their own learning. Science Techbook has a variety of resources that can be used for assessment and teachers have the ability to use these items however they wish. That being said, this paper will describe resources that are especially well suited for each of the four purposes.

Pre assessment: The primary purpose of pre assessment is to help teachers know what students already know so that instruction builds on student prior knowledge. Science Techbook does contain tools to enable teachers to develop and administer written pretests and quizzes that can be used to pre assess students. In addition, the engage component of the 5E lesson model is designed to "access the learners' prior knowledge and help them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity makes connections between past and present learning experiences, exposes prior conceptions, and organizes students'

It is important to note that Science Techbook contains items that assess not only disciplinary core ideas, but also science and engineering practices and crosscutting concepts.

thinking toward the learning outcomes of current activities."[20]

An earlier section of this paper described how Science Techbook recommends a teacher assess students' prior knowledge of why Earth has seasons. To cite another example, the high school biology model lesson on Cell Structure and Function recommends that teachers begin with a discussion of what students already know about cells. They are asked to describe what cells are and what they look like; to give examples of different cells that they have observed; and to relate ideas about different kinds of cells to characteristics of living things. Teachers can use this information to place students in learning groups and to support decisions about which learning experiences to assign to each student.

Formative assessment: The scientific explanation is a major tool that teachers use to assess how students are building on their existing knowledge and skills and developing a deeper understanding of all aspects of science. As mentioned earlier, the scientific explanation includes:

- A claim that answers the question being studied
- Evidence to support the claim
- Scientific reasoning that explains how the evidence supports the claim

A simplified version of the framework is introduced to students in the kindergarten course and is used in the explain component of every 5E lesson.
The template provided for the scientific explanation becomes more sophisticated as students move through the grades. Teachers also expect students' explanation of the scientific reasoning used to explain how the evidence supports the claim to become more sophisticated as students progress in their science education.

Summative assessment: Teachers can score the completed scientific explanation and use it as a summative assessment. Teachers can also have students design presentations to showcase what they know about a given topic. Science Techbook includes a tool called "board builder" that students can use to prepare presentations and displays. The student can then share the board with the teacher and the teacher can decide whether or not to make the student's board visible to other students. Science Techbook also includes Assessment Manager. This tool allows teachers to pull standards-aligned questions from the Discovery Education bank of questions and also to add the teacher's own questions to an assessment. Students can then complete the assessment online or the teacher can print the assessment for students to complete on paper. At the primary level (K-2) items are printable and follow a format that is more conducive to young learners. Finally, an online and printable unit assessment is pre-developed for each unit. For all online assessments with selected response, teachers can get reports from Assessment Manager. For all written responses, teachers have access to a dashboard that displays the responses and allows them to score or respond to them online. Students also have a student dashboard that displays only their responses and the teacher feedback.

Student self assessment: Science Techbook includes answer keys and rubrics for scoring learning activities and assessments. Providing access to a scoring rubric in advance of the assessment helps to guide students to meet the expectations of the assessment.[21] For this reason, the scoring tools in many resources are made visible to students, allowing students to self assess how they are learning. In addition, Science Techbook comes with access to interactives that respond to student input in ways that students can use to build their knowledge of speci ic topics in science and that students can use to assess how their knowledge of science topics is growing and developing.

It is important to note that Science Techbook contains items that assess not only disciplinary core ideas, but also science and engineering practices and crosscutting concepts. Discovery Education is continually adding to the resources available for assessment and is closely following national efforts to develop assessments that align with NGSS.

[20] Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Powell, J., Westbrook, A., & Landes, N. (2006, June 12). The BSCS 5E Instructional Model: Origins and Effectiveness. Retrieved November 9, 2015, from http://bscs.org/sites/default/files/_media/about/downloads/BSCS_5E_Full_Report.pdf (p. 2)

[21] Stiggins, R. (1997) *Student-Centered Classroom Assessment.* Prentice Hall, Upper Saddle River, NJ, pp. 38-39.

Discovery Education feels so strongly about the need for professional development that it is included in the purchase of the Techbook.

9. Professional Learning for Teachers: Professional learning is key for teachers to develop the knowledge and skills needed to support students in three-dimensional learning.

Developers of the standards ack that effective implementation of the new standards is dependent on effective professional learning for teachers. These professional learning experiences will need to focus on the standards, but be tightly linked to the curricular resources that the teacher is using.

How Discovery Education Supports Teachers in Making the Transition to NGSS

Discovery Education partners with school districts to customize professional learning so that teachers have multiple opportunities to experience three-dimensional learning and to talk about what they will need to do to support students in learning across the three dimensions of the NGSS. Professional learning is designed to support a systemic change model and to build on teachers' prior knowledge as it relates to both the pedagogy and the science content required for effective implementation of NGSS. Such a design is in keeping with best practices in science professional learning as described in projects such as the National Science Foundation Local Systemic Change Initiatives.[23]

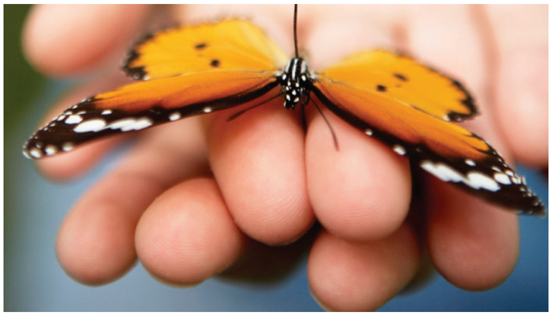
Discovery Education recognizes that for some teachers changing their practice to make greater use of digital resources is a major change in addition to the changes required by NGSS. Therefore, professional development is designed to assess teachers' digital integration skills using the Technology Integration Matrix (TIM) developed by the Florida Center for Instructional Technology.

The Discovery Education implementation team works with each school district to plan professional development that meets the specific needs and schedule of the district. Modules include an introduction to Science Techbook for Use with NGSS, Centers-based Teaching and Learning, Maximizing Student Engagement, Driving Student Achievement and Assessment, Read, Write, and Think Like a Scientist, Addressing Science and Engineering Practices with Science Techbook, and modules on flipped instruction using this digital resource.

[22] National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academy Press. (p. 260)

[23] Banilower, E. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006). *Lessons from a decade of mathematics and science reform: A capstone report for the local systemic change through teacher enhancement initiative.* Chapel Hill, NC: Horizon Research, Inc. Retrieved November 13, 2015, from http://www.horizon-research.com/the-lsc-capstone-report-lessons-from-a-decade-of-mathematics-and-science-reform/

[24] Allsopp, M. M., Hohlfeld, T., & Kemker, K. (2007). *The Technology Integration Matrix: The development and field-test of an Internet based multi-media assessment tool for the implementation of instructional technology in the classroom.* Paper session presented at the annual meeting of the Florida Educational Research Association. Retrieved November 13, 2015, from http://fcit.usf.edu/matrix/resources.php


Science Techbook was developed with a commitment to real-world problem solving and three-dimensional learning for student.

Conclusion

Discovery Education's Science Techbook is a next generation curriculum resource designed to support NGSS. It was designed from the start to address the requirements of the standards and as a digital resource it is undergoing continual content and functionality refinement as educators across the nation refine their understanding of the standards. As part of Discovery Education's commitment to improving education, these refinements, even the addition of tools and increased functionality, are provided to subscribers at no additional cost during the life of an adoption. Science Techbook was developed with a commitment to real-world problem solving and three-dimensional learning for student. Throughout each course, students have multiple opportunities to interact with challenging and interesting STEM experiences and to develop and deepen their knowledge of what it means to think about the world from the perspectives of scientists, engineers, and other STEM professionals.

About the Author

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Prior to her retirement, Evans served as Executive Director of Curricular Programs for Howard County Public Schools in Maryland. She also held positions as science coordinator and secondary curriculum director in that school district, as well as science curriculum specialist and high school science teacher in Baltimore City Public Schools. Evans earned a B.S. in Zoology from Michigan State University, a M.S. in curriculum from Loyola College, and a Ph.D in Educational Administration from University of Maryland.