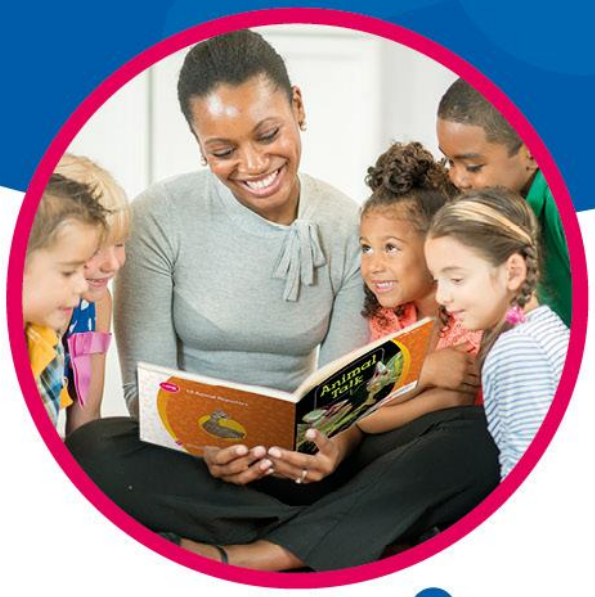
imagine learning | twig SCIENCE

Instructional Design

Grades K–5







What Is Twig Science?

Twig Science is a comprehensive, phenomena-driven K–5 science program designed to engage all students in a multimodal journey to master each of the Next Generation Science Standards (NGSS) Performance Expectations. Twig Science is built around the three dimensions of the National Research Council's *A Framework for K–12 Science Education* and the NGSS. Throughout the program, real-world, relatable phenomena that are topically aligned to Disciplinary Core Ideas (DCIs) inspire students to wonder, ask, and pursue the answers to questions. Students employ eight authentic Science and Engineering Practices (SEPs) and apply Crosscutting Concepts (CCCs) as a lens as they engage in sense-making around the DCIs and, ultimately, explain phenomena. Twig Science fosters student inquiry, critical thinking, and problem-solving skills that prepare twenty-first century students for college and career pathways.

Developed by Experts

Twig Science was developed through collaboration between science and education experts from around the world, driven by a collective commitment to making science accessible to all. All student and teacher materials were reviewed for scientific accuracy by scientists and engineers from Imperial College London, one of the world's leading STEM universities. Our partnership with Imperial helped ensure Twig Science includes all of the latest advancements in STEM. We also partnered with Stanford University's Center for Assessment, Learning, and Equity (SCALE), to embed evidence-based language routines and performance task assessments that support equitable access to and demonstration of mastery in science for all students.

A diverse team of learning architects with backgrounds and expertise in elementary education, science, English language development, and curriculum development designed the instructional and student materials. Student engagement specialists from the TV and video game industries collaborated with learning architects to design relevant, meaningful media and interactives. The curriculum was field-tested in classrooms throughout the US, and the resulting teacher feedback was invaluable during program iteration.

Student Centered

Phenomena Driven

The key to Twig Science's instructional design is its student-centered approach. Every module presents an Anchor Phenomenon (AP) that sets the purpose for students' learning journeys. At the beginning of each module, students observe and explore the AP and ask

questions about what they notice and observe. These questions are then used to drive investigation and sense-making at touchpoints throughout the module. Phenomena selected are multidimensional in nature, often connecting core science ideas (DCIs) and CCCs drawn from the assessed Performance Expectations for the module. The use of phenomena throughout the program provides an authentic reason for students to explore ideas and construct their own knowledge. Instead of just “learning about" science, Twig Science phenomena inspire authentic curiosity and drive students to “figure out” why, or how, things happen and then to explain their findings.

Engaging STEM Storylines

In each module, students dive into an engaging STEM storyline and take on a role—such as meteorologist, hydrologist, reporter, or even time-traveling tour guide—as they work to investigate and explain the module phenomenon. The STEM storyline is designed to capture students’ imaginations, working in tandem with students’ own curiosity about module phenomena to motivate the coherent student-driven learning journey[1]. Each STEM storyline ties topically to dimensions of focal module Performance Expectations, and the student roles provide opportunities for students to develop and hone their facility with focal SEPs.



College and Career Readiness

Twig Science supports students in achieving grade-level mastery of the science, engineering, and technology concepts that serve as the foundation for future careers in these fields[2]. Throughout the program, students think and act like scientists and engineers

[1] Reiser, B. J., Novak, M., McGill, T. A. W., & Penuel, W. R. (2021). Storyline Units: An Instructional Model to Support Coherence from the Students’ Perspective. Journal of Science Teacher Education, 32(7), 805–829. https://doi.org/10.1080/1046560X.2021.1884784

[2] National Research Council. 2012. A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.

as they explore, employ, and demonstrate their growing facility with the SEPs. In addition, Twig Science leverages and fosters the development of soft skills such as collaboration, teamwork, critical thinking, and problem solving that are essential in any workplace or academic setting.

In addition, each module is accompanied by a leveled reader that introduces a STEM career that is topically relevant to the module Performance Expectations. Students who gain an interest in the science ideas they gather through a module can learn about a real-life application for those concepts in the field.

Diversity, Equity, and Access

In alignment with the vision set forth in *A Framework for K–12 Science Education*, Twig Science is designed to provide equitable opportunities for all students to learn and succeed in science. Each lesson includes differentiation for English Language Learners (ELs), students with special needs, students from diverse cultural backgrounds, and above-level learners at the point of use[3]. Special Needs scaffolding provides practical advice on how to support students with a wide array of special needs. Cultural Connections invite students to connect their own diverse experiences and prior knowledge to the content, sparking rich and inclusive discussions. Differentiation for ELs includes research-based strategies to support them, consistent with the WIDA English Language Development (ELD) Standards Framework. In addition, research-based language routines, developed by Stanford University's SCALE team, are woven throughout each module and used to support sense-making and language development concurrently, as the two are inextricably linked. The embedded routines support all students in their acquisition of and facility with domain-specific language while giving students agency around their own learning, opportunities to make meaning together, and metacognitive awareness[4].

All student-facing materials are also available in Spanish and with read-aloud technology. In addition, Twig Science Tools provides the teacher with a repository of engaging resources in both English and Spanish for students who could benefit from additional support. Further supporting ELs and students with diverse learning needs, each module includes numerous opportunities for students to construct and communicate ideas through different

[3] National Research Council. 2012. A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.
[4] Zwiers, J., Dieckmann, J., Rutherford-Quach, S., Daro, V., Skarin, R., Weiss, S., & Malamut, J. (2017). Principles for the Design of Mathematics Curricula: Promoting Language and Content Development. Retrieved from Stanford University, UL/SCALE website: http://ell.stanford.edu/content/mathematics-resources-additional-resources

modalities[5,6]. Throughout the program, students sense-make and demonstrate learning through visual, auditory, reading, writing, and kinesthetic modes.

The Twig Science suite of materials—including those in print, visuals, videos, and supplemental materials—is reflective of all students through the representation of different genders, various races and ethnicities, and different cultures.



Program Design

The NGSS Performance Expectations for each grade level are bundled into interdisciplinary modules in the Twig Science program. Each module is designed to provide a coherent learning journey driven by students' own curiosity about what they observe and their authentic need to understand and be able to explain it. Each module was built around specific, concrete learning goals and reverse engineered to ensure that curriculum, instruction, and assessment all work together to support student progress and sense-making. Modules are scaffolded so that science concepts and practices increase in complexity and sophistication as students, starting with prior knowledge, build and revise their own ideas based on the evidence they gather through those practices. Immersed in a

[5] Grapin, S. 2019. "Multimodality in the New Content Standards Era: Implications for English Learners." TESOL Quarterly 53(1): 30–55.
[6] Kim, S. (2021). Transmodalising pedagogy: Developing STEM disciplinary literacy for young emergent bilingual learners. Bilingual Research Journal, 44, 281–297.

topically connected STEM storyline and owning their multidimensional sense-making, students' own experience in each module is one of seamlessly designed coherence[7].

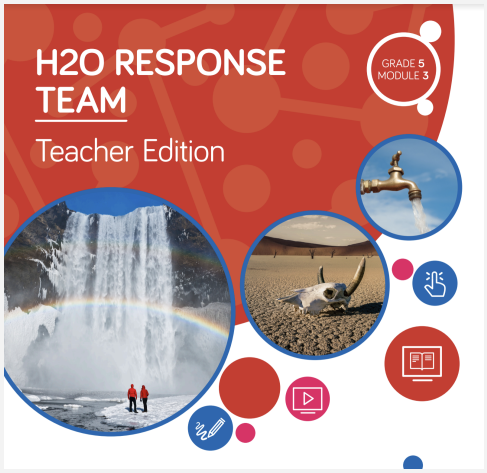
At the beginning of each module, students observe and explore the AP. They ask questions about what they observe, which are recorded by the teacher for ongoing reference. Students' questions are then used to drive investigation and sense-making at touchpoints throughout the module. In addition, student wonder questions are tied to the module Driving Questions, which are three-dimensional multi lesson instructional segments built around a central investigable question. Throughout each Driving Question, students engage in planning and carrying out hands-on investigations and modeling, evidence-gathering through media such as videos or digital interactives, scientific discourse and writing, and information-gathering through text. Through these three-dimensional multimodal experiences, students gather evidence that allows them to construct knowledge to help them to answer Driving Questions and to explain the AP. Students revisit the AP throughout each module to reflect on their own sense-making, identifying what they now know and what they still need to figure out in order to answer their questions. These metacognitive activities drive further investigation as students take control of their own learning[8].

As they step through each lesson of a Driving Question, students experience a coherent journey toward mastery of the grade level elements of the three dimensions of the module Performance Expectations. Each lesson is designed to address specific objectives for each of the module's assessed SEPs, DCIs, and CCCs. Additional supporting elements of each dimension are also integrated to reinforce cross-modular connections. 3-D Learning Objectives are clearly identified in the Teacher Edition at the start of each lesson, as are the DCIs, SEPs, and CCCs addressed. In the student workbook, known as the Twig Book, the "I can…" statements for each Driving Question explain the three dimensions in student-friendly language, giving students visibility and ownership of their learning journeys.

[7] Reiser, B. J., Novak, M., McGill, T. A. W., & Penuel, W. R. (2021). Storyline Units: An Instructional Model to Support Coherence from the Students' Perspective. Journal of Science Teacher Education, 32(7), 805-829. https://doi.org/10.1080/1046560X.2021.1884784

[8] Bybee, Rodger W., et al. "The BSCS 5E instructional model: Origins and effectiveness." Colorado Springs, Co: BSCS 5 (2006): 88-98.

Spotlight: H2O Response Team



Driving Question 1

In the Grade 5 H2O Response Team module, students work as hydrologists to investigate and explain the anchor phenomenon and accompanying question “The Pacific Ocean is providing San Diego County with an increasing amount of fresh water. Why do some places lack fresh water and what can we do to protect it?”. Developing an understanding around the significance of water as a resource, students synthesize ideas from informational text, the Information Gap routine, and videos in order to discover the role that water plays for different parts of the biosphere. Through a data analysis activity, students then engage with the AP. They generate questions about the phenomenon which are recorded by the teacher and revisited throughout the module. To begin to figure out an explanation for why some places lack fresh water, students first investigate how much fresh water there is on Earth.

To gather evidence to allow them to answer the Driving Question “How much fresh water is on Earth?”, students gather data using a model, then graph the relative percentages of water in varying reservoirs on Earth. They analyze data on the volume of water in various reserves and reflect on the portion of that water that is fresh, then complete a formative assessment in which they develop a model to communicate the proportions of salt and fresh water on Earth.

Students then revisit the AP, applying the practices and concepts they have developed as they construct and interpret graphs to communicate the percentage of the San Diego water supply coming from each source at different points in time. The class then engages in a metacognitive discussion in which they reflect on which of their initial questions about the AP have been answered and what they still need to figure out in order to explain it. By the end of the module, after investigating four more Driving Questions, students will have gathered the evidence they need in order to explain the Anchor Phenomenon.

The H2O Response Team module is built around the core assessed PEs 5-ESS2-1, 5-ESS2-2, 5-ESS3-1, 3–5-ETS1-1, 3–5-ETS1-2, and 3–5-ETS1-3.

5Es Instructional Model

Every module Driving Question follows the 5Es instructional model. Students construct, demonstrate, and reflect on their understanding of the three dimensions of the module Performance Expectations. Each phase of the 5Es instructional model is the basis for one or more lessons in each Driving Question. Through the 5Es instructional model, students:

- **Engage** with a phenomenon, connecting it to prior knowledge
- **Explore** core science ideas (DCIs), gathering evidence through authentic practices of science and engineering (SEPs), while applying new elements of familiar interdisciplinary crosscutting concepts (CCCs) as a lens for sense-making
- **Explain** their new ideas about the DCIs by developing and using models, constructing explanations, constructing scientific arguments, and other SEPs, using CCCs as a lens
- **Elaborate** on their new understandings by applying their three-dimensional learning in a new context
- **Evaluate** their mastery of the three dimensions of a Performance Expectation through a performance task, using a rubric.

The 5Es instructional model is associated with greater mastery of subject matter. It increases student interest in science and may aid in the development of more sophisticated scientific reasoning[9].

Assessment

Twig Science provides a suite of assessments designed to provide actionable information about students' alternate conceptions and prior knowledge, and their growing understanding and mastery of the NGSS Performance Expectations. Aligning to the vision set forth by the National Research Council in *A Framework for K–12 Science Education*, Twig Science assessments are multimodal, three-dimensional, and grounded in phenomena. The assessments are designed to provide appropriate touchpoints throughout students' coherent learning journeys to gauge their multidimensional reasoning.

The Pre-Explorations (pre-assessments) in each module are designed to help teachers gauge and track students' alternate conceptions and prior knowledge related to the module

[9]Bybee, Rodger W., et al. "The BSCS 5E instructional model: Origins and effectiveness." Colorado Springs, Co: BSCS 5 (2006): 88–98.

standards. Teachers receive guidance on how to tailor instruction based on student outcomes from the Pre-Exploration to ensure that alternate conceptions are engaged and replaced with new concepts[10].

Formative assessments are embedded throughout each module and provide frequent opportunities for teachers to gauge students' progress toward mastery of the elements of the three dimensions of the NGSS Performance Expectations, as well as their release of alternate conceptions. Progress Trackers are provided for use throughout each module to note how students develop in their multidimensional sense-making around the assessed standards and the point at which they release alternate conceptions. Intervention strategies are provided at point-of-use to guide teachers in supporting struggling students. Reflective formative assessments, also incorporated throughout, allow students to engage in metacognition as they reflect on their sense-making journey.

Twig Science's embedded performance tasks and Benchmark Assessments were developed in partnership with the Stanford Center for Assessment Learning and Equity (SCALE) and are underpinned by research carried out by the Stanford NGSS Assessment Project (SNAP). These assessments are designed to provide clear performance outcomes and tasks, to elicit rich language, to engage students through decision-making, accessibility, and relevance, and to align to the curriculum and instruction[11].

Performance tasks are built around the NGSS, and allow students to employ different modalities to demonstrate mastery of the assessed elements of the Performance Expectations through a portfolio that spans a variety of media. This approach allows students to show deeper levels of scientific reasoning and to draw on more skills as they communicate new ideas through posters, physical and virtual models, oral presentations, written explanations and arguments, and audio podcasts[12]. Rubrics are provided as guidance to students before the task, and to teachers, with added look-fors to aid in the evaluation of student work. Embedded performance tasks align to the module narrative and are designed to assess how students employ the SEPs to demonstrate their understanding of the DCIs, using the CCCs as a framework.

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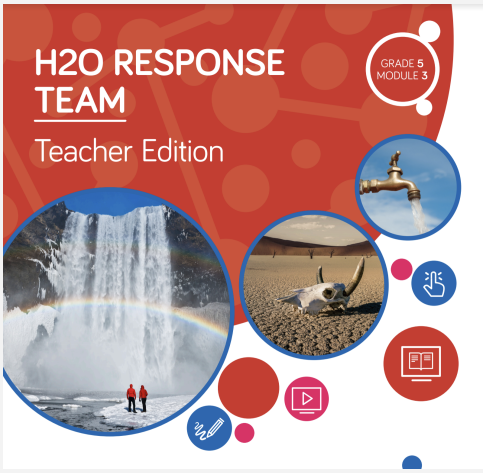
[10] Bransford, John D., Ann L. Brown, and Rodney R. Cocking. How people learn. Vol. 11. Washington, DC: National academy press, 2000

[11] *Performance Assessment Quality Criteria* by Stanford Center for Assessment, Learning, & Equity (SCALE). 2017.

[12] "An analysis of existing science assessments and the implications for developing assessment tasks for the NGSS" Prepared by the Stanford NGSS Assessment Project Team (SNAP) January, 2016. Jill Wertheim, Jonathan Osborne, Helen Quinn, Ray Pecheone, Susan Schultz, Nicole Holthuis, and Paolo Martin

The Benchmark Assessments provide a reliable and fair three-dimensional summative measure of student achievement at the end of each module. The Benchmark Assessments allow teachers to evaluate how students use the SEPs, CCCs, and DCIs in their sense-making around a new phenomenon, and students are challenged to show how they construct understanding in a novel context[13]. Benchmark Assessments are designed to elicit the highest understanding of each learning goal and therefore provide opportunities for students to demonstrate full mastery of the Performance Expectations.

Spotlight: H2O Response Team



Driving Question 3
Students investigate how the Mojave desert could be so dry when there is plenty of water in other parts of California. Through soil testing, rainfall data analysis, photo observation, hands-on 3-D investigative modeling, and informational text, students investigate and construct ideas around the sphere interactions that cause the Mojave desert to be so dry. In the summative assessment, students share their findings as they construct a 3-D scientific explanation supported by the evidence they have gathered. The teacher scores student work through the provided rubric and records student scores on the Progress Tracker.

In the Benchmark Assessment at the end of the module, student teams use what they have learned throughout the module to research, build, and test a water pollution cleanup device. This teamwork prepares students for the final individual task—a written design argument that requires students to use scientific reasoning to explain why cleaning polluted water is necessary, how their design solution works, and how well their design meets the criteria. This final task is evaluated using rubrics.

[13] *Performance Assessment Quality Criteria* by Stanford Center for Assessment, Learning, & Equity (SCALE). 2017.

Tools for 3-D Learning

Teacher Resources

The framework for each Twig Science module is provided through the print and digital versions of the Teacher Edition. The Teacher Edition includes critical foundational elements such as the Framework Alignment and grade-level Scope and Sequence, detailing how Twig Science fully addresses the NGSS Performance Expectations through each module at each grade, and academic progressions for each dimension across grades. In addition, it provides recommendations on how to prepare for and deliver each lesson, including discussion prompts with possible student responses, as well as differentiation, guidance for follow-up to assessment, interdisciplinary connections, and leveled reader activities. The digital platform also provides teachers with access to professional learning, multimedia supplemental resources to enrich learning and teaching, and the Twig Assessment Platform, which provides data on performance at the student, class, school, and district level.

Student Resources

Throughout each Driving Question, students record data, observations, and predictions; develop models; engage in metacognitive reflection; and read and annotate informational text in their print or interactive digital Twig Book. The Twig Book encourages students to take responsibility for their own sense-making as it develops their ability to cite and synthesize evidence and share, justify, and revise their thinking. In addition, it serves as a platform for students to demonstrate and provide evidence of their growing mastery of the assessed elements of the three dimensions.

Each module is accompanied by a science Leveled Reader that puts a focus on navigating informational text, text structures, text features, vocabulary strategies, and building science content knowledge. The format, which includes real-world images and animated graphics, is designed to pique curiosity, motivating students to read about phenomena. Every Leveled Reader includes an interview with a scientist or engineer from diverse backgrounds that applies the concepts explored in the module to their STEM career. Leveled Readers are available in On, Below, and Above-Learner levels in both English and Spanish, with differentiated instruction scaffolds. Instructional materials for the readers are provided online and at the back of each Teacher Edition.



Hands-on, Digital, and Video Resources

Each module includes a toolkit of materials for engaging modeling, investigation, and engineering design activities designed to provide students with memorable, meaningful experiences along their sense-making journeys. Many modules include digital interactives that allow students to engage in rich investigative and modeling experiences with phenomena that would be difficult, if not impossible, to complete in the classroom because of the scales at which they occur.

Embedded throughout the program are high-quality, engaging videos developed in alignment with the curriculum by documentary filmmakers using a rich repository of science footage and captivating animation. Videos are embedded for several different purposes and are carefully crafted to align with the content while allowing students the space to construct their own ideas based on the evidence they gather. Each module includes an exciting movie-trailer style module trailer that introduces the module storyline. In some cases, videos are provided as a means for students to gather observation data—for example, on wildlife in the field or on states of matter at the particle level. Students may obtain ideas from videos and synthesize them with information from other sources. Videos also may introduce phenomena, consolidate learning, or invite students to consider the ideas they have been constructing in new contexts.