imagine learning | twig SCIENCE

INSTRUCTIONAL DESIGN

GRADES 6–8



What Is Twig Science?

Twig Science is a comprehensive, phenomena-driven grade 6–8 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 and gave us access to a global network of diverse research scientists and contributors that are featured in the product. 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 "wonder 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 science advisor to a movie production company, meteorologist, or deep-ocean explorer—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.

[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

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 each module, students think and act like scientists and engineers as they explore, employ, and demonstrate their growing facility with the SEPs. In addition, leveraging our network of research and technology professionals around the world, Twig Science highlights more than 100 STEM careers throughout the middle school program. Real research scientists and engineers conducting cutting-edge research and solutions-building are highlighted in the student Twig Journal through interviews and blog-style articles, as well as featuring in video interviews and narrative videos. In our scientist-led modules, students even follow diverse professionals into exciting locations in the field in an exciting ongoing vlog-style format. Driven by the understanding that "if they can see it, they can be it," Twig Science strives to inspire all students to consider future pathways in STEM by ensuring that the professions represented throughout the program reflect the diversity of the students we serve.

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.

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 session 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

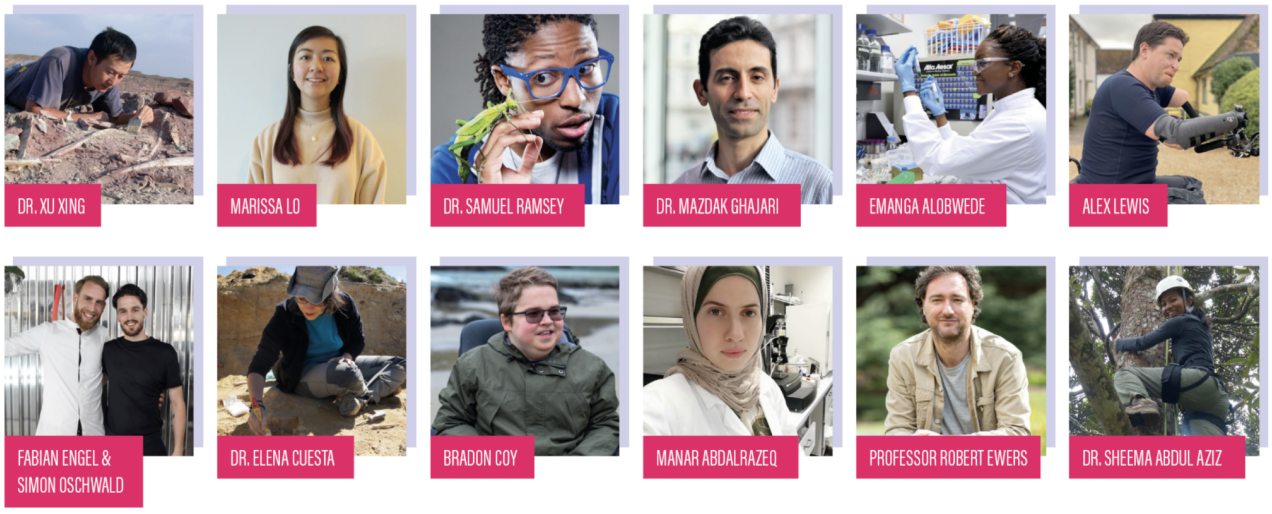
[2] National Research Council. 2012. A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.
[3] National Research Council. 2012. A Framework for K–12 Science Education: Practices, Crosscutting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

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].

Each module includes numerous opportunities for students to construct and communicate ideas through different modalities[5],[6]. Throughout the program, students sense-make and demonstrate learning through visual, auditory, reading, writing, and kinesthetic modes. These multimodal experiences support ELs and those with diverse learning needs in their sense-making.

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.

Career Explorations With Diverse Experts From the Field



Program Design

The NGSS Performance Expectations for grades 6–8 are bundled into interdisciplinary volumes 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

[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

[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.

understand and be able to explain it. Each module was built around specific Performance Expectations 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 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 and students for ongoing reference. Students' questions are then used to drive investigation and sense-making throughout the module. In addition, student wonder questions are tied to the module Driving Questions, which are central investigable questions around which multisession instructional segments (called lessons) are built. Students are introduced to smaller investigative phenomena that drive student inquiry throughout each lesson. In order to explain the investigative phenomena, 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 ultimately explain the AP. Students use a Phenomena Tracker to synthesize their evidence and track their new ideas about the AP throughout each module and to answer their initial wonder questions, with facilitation support from the teacher. The Phenomena Tracker is a tool that supports metacognition and drives further investigation as students take control of their own learning[8] and reflect on their own sense-making, identifying what they now know and what they still need to figure out.

As they step through each session of a lesson, students experience a coherent journey toward mastery of the grade level elements of the three dimensions of the module Performance Expectations. Each session 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 workshop, known as the Twig Journal, the "I will…" statements for each lesson explain the three dimensions in student-friendly language, giving students visibility and ownership of their learning journey.

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[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: Into The Abyss Module



Lesson 1

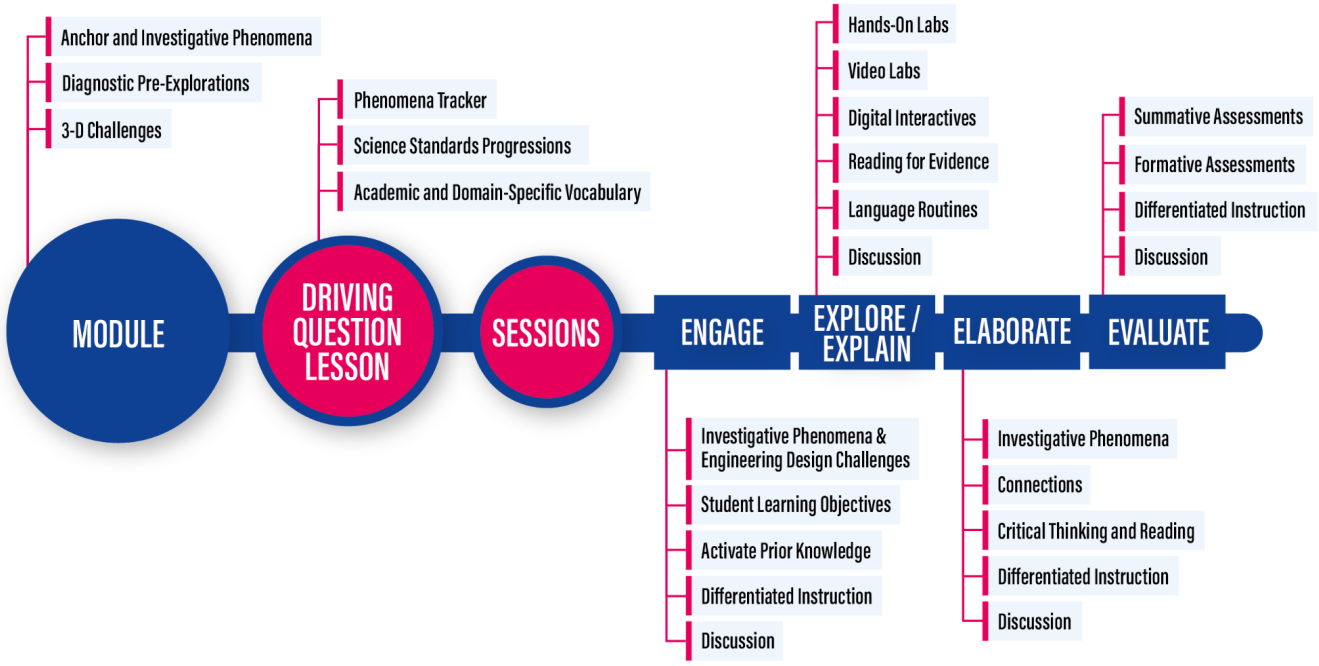
In the Into The Abyss module, students plan a submarine expedition into the deep, dark, and mysterious Mariana Trench as they investigate to explain the Anchor Phenomenon “It can be hard to study the deep ocean. It is not possible to see far into the ocean from above. It is dark in the deep ocean, making it hard to observe the ecosystem. To overcome these challenges, scientists use a variety of different tools for observing the ocean environment.” Students engage with the Anchor Phenomenon as they use a digital interactive to explore previous deep-sea expeditions. Students ask, record, and share Wonder Questions about the Anchor Phenomenon that the teacher synthesizes and uses to drive instruction. The class begins by trying to figure out why it is dark in the deep ocean. Through a series of hands-on investigations, students observe the effect of light and different materials on our ability to see and how we perceive color. They investigate how light travels through air and water and develop models to describe how light waves interact with different materials. Students use the phenomena tracker to activate metacognition as they reflect on how they have used science practices, core concepts, and ideas to figure out and explain the investigative phenomena they have encountered. Next, an informational text about the ocean zones introduces students to the relationship between wavelength and color and how different wavelengths are absorbed at different depths. In a formative assessment, students develop a model to describe how light interacts with different materials at different ocean depths and to explain why glass is a good material to function as an undersea camera lens. Students apply their ideas about the absorption of different wavelengths (colors) at ocean depths as they investigate and explain the patterns in color that they observe between organisms in each ocean zone. They return to the phenomena tracker to reflect on their own sense-making as they record their explanations for the investigative phenomena. In a summative assessment, students develop models to describe how light waves interact with different materials at different depths. Students return to the Anchor Phenomenon and engage in metacognitive reflection as they discuss the new ideas they have that help them to understand the Anchor Phenomenon and their Wonder Questions and what they still need to figure out. Students begin to construct an explanation of the Anchor Phenomenon in their Twig Journals. They will continue to return to the Anchor Phenomenon to complete their explanation throughout the remaining two lessons of the module.

5Es Instructional Model

Following the 5Es instructional model in every lesson of each module, 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 sessions of a lesson. 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].



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

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 assessed 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 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 three dimensions of the NGSS, as well as their release of 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.

Performance tasks are built around the NGSS and allow students to employ different modalities to demonstrate mastery of the assessed elements of 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 scientific arguments[11]. 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.

Twig Science's 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). Through a combination of multiple choice and open-ended items, Benchmark Assessments provide a reliable and fair

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

[11] "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

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 new phenomena, and students are challenged to show how they construct understanding in a novel context[12]. 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: Into The Abyss Module



Lesson 3
In Lesson 3, after listening to dolphins use echolocation to map their surroundings, students investigate how they can use sound waves to map the deep ocean too. Through modeling and data collection using a digital interactive, kinesthetic modeling, an informational text, and hands-on investigation, students construct ideas about how sound waves interact with different materials. In their final summative assessment, students synthesize and apply their new ideas and practices from throughout the module. They develop a model to describe how sound waves can be used to map the Mariana Trench, using their knowledge of how sound waves interact with different materials. Using their model as a source of evidence, students construct an argument for why light waves are better suited for mapping the deep ocean than sound waves.

In the Benchmark Assessment, students read about how bats use echolocation, then respond to a series of prompts to demonstrate how they apply the three dimensions of the assessed Performance Expectations. Students develop and use a model to show how sound waves travel, analyze and describe patterns in waveforms, and apply their knowledge of waves to construct a brief explanation.

[12] *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 session, including discussion prompts with possible student responses, as well as differentiation, guidance for follow-up to assessment, and interdisciplinary connections. 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 lesson, 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 Journal. The Twig Journal 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.

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.

