How does *PhD Science®* integrate social-emotional learning (SEL) with science instruction?

Students' social and emotional well-being is intimately connected to their academic success. When students feel a sense of belonging and significance in their classroom and school environments, they have more autonomy over their learning.[1] Research demonstrates that students succeed when social-emotional needs are met and struggle when they are not.[2] Academic success requires students to develop key social-emotional skills, such as communicating effectively with others, organizing and managing tasks, and recovering from setbacks and failures.[3] These skills help students develop the productive disposition necessary for learning science. Schools must accordingly foster students' social-emotional development in seamless integration with academic learning.[4]

As a student-centered curriculum, *PhD Science* implicitly and explicitly supports students' social-emotional well-being and development. *PhD Science* was designed with the research-based understanding that social, emotional, and academic learning are interconnected multidirectionally. Not only do students perform better academically when their social and emotional needs are met, but engaging in academic learning with joy in a supportive, safe classroom helps them feel competent, significant, and successful.[5]

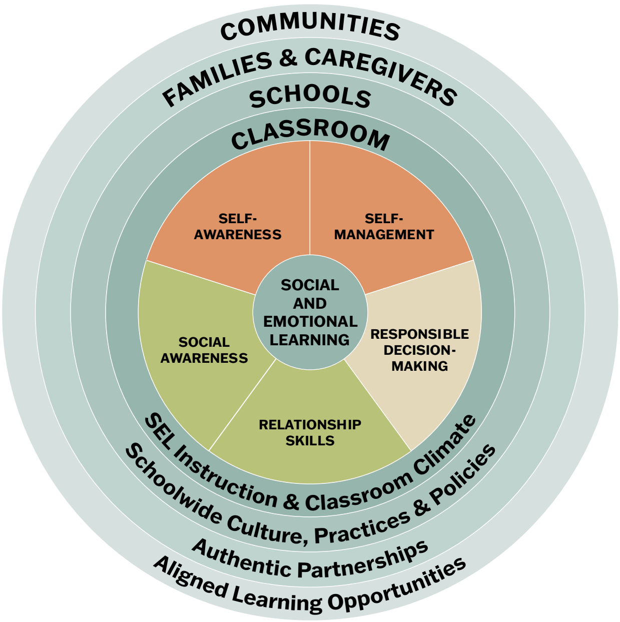
PhD Science is inquiry based. As such, it taps students' natural curiosity and helps them use that curiosity to figure out how the world works. Their curiosity sparks their independent thinking and helps them to be owners of their learning. In *PhD Science*, students analyze data and information, look at evidence, and apply reasoning to information they've been provided or to their own observations. They then synthesize that information and devise explanations to answer questions they've helped craft during the module. To drive their own learning, students must develop and practice multiple SEL competencies, including self-awareness, self-management, and responsible decision-making.

Another key benefit of student-driven, inquiry-based learning in *PhD Science* is that it encourages students to work and think collaboratively. Collaborative work builds students' relationship skills and fosters academic learning: Having done the work of analyzing information, data, and facts independently, students then bring their understanding to the whole class.

Throughout *PhD Science*, students first develop their own thinking and understanding, and then they have regular opportunities to engage in collaborative work with their classmates through activities like respectful peer-to-peer discourse, small group investigations, and the revising of anchor models. This collaborative work leads to the synthesis of ideas from all students, and active listening to peers' reasoning, claims, and evidence, so students arrive at the best solution together. Along the way, students' individual ideas may be challenged when they are presented with new evidence, causing them to reconsider their own thinking. For collaborative thinking and working to be successful, students need to engage in the SEL competencies of self-management, social awareness, and relationship skills.

As a hands-on, student-centered curriculum, *PhD Science* requires students to be responsible as they engage in investigations. The curriculum puts materials in students' hands, and they do the investigations themselves. They have the latitude to make their own plans, but they must consider the safety of the materials, including live plants and animals, as well as their own safety and that of their peers. Students must develop an understanding that all science materials must be handled carefully, and the curriculum provides explicit support in this effort. Students must exercise both self-management and responsible decision-making to responsibly carry out investigations.

Throughout the curriculum, students have ample opportunity to develop and refine all five social-emotional competencies identified by the Collaborative for Academic, Social, and Emotional Learning[6] in a variety of authentic settings while building knowledge about science and the world.



Self-awareness

Students must recognize their own emotions, thoughts, and values as they work individually and collectively in the science classroom. As students are asked to develop questions, models, predictions, and claims individually and in groups, students must also have the self-confidence to recognize their own strengths and limitations as related to the task at hand. Critical components of self-awareness that students develop for successful engagement in science learning include the ability to demonstrate integrity and honesty and to assume a growth mindset—as students learn more, they may need to alter their initial models or hypotheses.

Self-management

As they work individually and collectively to develop questions, models, hypotheses, and explanations, students must manage their own emotions, thoughts, and behaviors to accomplish the task at hand. To engage in group discussion, students must organize and convey their own thoughts while controlling emotions. When students conduct investigations, they must plan and organize their investigation work, manage their behavior, exhibit self-discipline, participate congenially in group work, maintain a safe environment during investigations, and take the initiative when needed. Successful group work requires personal and collective agency, organization, and self-discipline.

Responsible decision-making

To create a safe environment for themselves and their peers when working on science activities, students must develop and exercise strong judgment. Understanding ethical standards and safety concerns and evaluating the benefits and consequences of various actions for personal, social, and collective well-being is at the heart of science practice. In addition, students nurture their curiosity and open-mindedness, learning how to make a reasoned judgment after analyzing information, data, and facts that help them identify solutions.

Relationship skills

To collaboratively develop models, fair tests, experiments, investigations, and hypotheses, students must establish and maintain healthy and supportive relationships and effectively navigate settings with diverse individuals and groups who bring their own experiences and knowledge to the work. To be successful, students must communicate clearly, listen actively, work collaboratively, and negotiate conflict constructively, seeking or offering help or leadership when needed.

Social awareness

PhD Science was designed to help students develop and cultivate an ability to understand and empathize with others, whether they are in the classroom or on the other side of the world. Carefully selected anchor phenomena broaden students' experiences and provide opportunities for contributions from students who might have experience with a particular phenomenon or can connect that phenomenon to a personal experience. As they see how phenomena near and far are connected to their own lives, students develop a broader social context, learn to appreciate others' strengths and points of view, and come to understand the influences of organizations and systems on behavior.

The curriculum as a whole is designed to foster student discourse and support students in taking risks. It introduces and consistently uses specific structures and routines that help students feel connected to one another and to their learning; they feel safe taking the academic risks needed to be successful in the classroom. In each lesson, students interact with the teacher, the content, and one another in a variety of ways, including through instructional routines such as Chalk Talks, Inside–Outside Circles, Mix and Mingle, and Think–Pair–Share.

Beyond the integration of academic and social-emotional skills at individual grade levels, the curriculum is also vertically aligned to foster social-emotional development over time. As the science becomes more complex, so too do the social-emotional expectations. These expectations are embedded in the curriculum's tasks and routines, such as planning an investigation. Initially, teachers may take the lead in helping students plan an investigation and may guide student conversation.

As students progress through the curriculum, however, they take on more responsibility for planning investigations and completing their work. Investigations incorporate more steps and more demanding materials that require more care, so students must follow stricter safety measures. More complex investigations also require students to measure and record more complex data with greater accuracy. This progression of responsibility in planning and carrying out investigations requires students to exhibit self-awareness and self-management and to engage in responsible decision-making. From their first lesson, students practice and refine their SEL skills while deeply engaging in science.

Research has demonstrated the powerful and lasting effects of integrating academic, social, and emotional learning. Indeed, such integration is key to the success of *PhD Science*. Students thrive because they have the pedagogical, social, and emotional support needed for rigorous academic learning. A strong foundation in these areas prepares students to succeed in all aspects of life, not just in school.

The Art of *PhD Science*

Art and science both begin with a sense of wonder that invites students to observe, question, and make sense of the world around them. Each module provides a piece of art for students to notice and wonder about. Art creates an access point to the content that does not require any prior knowledge or experience. Art also allows students to make connections between their science learning and the larger world and to explore the phenomenon through a new lens.

Launch 7 minutes

Display the Bruegel the Elder and Brueghel the Younger paintings (Lesson 20 Resource). Ask students to closely observe each painting and to record what they notice and wonder about the paintings in their Science Logbooks (Lesson 20 Activity Guide). Invite students to share their responses with the class.

Reveal that the paintings were created by a father and son, Bruegel the Elder and Brueghel the Younger. Draw students' attention to the painting by Brueghel the Younger, and ask them to consider the artist's painting ability. Encourage students to think about how a person's painting ability is a behavioral trait.

- ► What do you think influenced Brueghel the Younger's ability to paint?
- ► How could we investigate whether painting ability is influenced by inheritance, environment, or both?

Elaboration: How *PhD Science*® builds SEL

The following table showcases how the components of *PhD Science* align with SEL competencies.

PhD Science Module Features	Alignment with SEL Competencies
Anchor phenomena The anchor phenomena are rich, multilayered scientific phenomena that motivate instruction throughout the module. At the beginning of each module, students explore the anchor phenomenon and use their background knowledge to develop an initial anchor model to help them understand the anchor phenomenon.	**Social awareness.** The anchor phenomenon that drives each module's learning is designed to help students connect with an authentic real-world experience that they may have no firsthand knowledge of. As they work with the anchor phenomenon, they build their understanding of the perspectives of others who have experienced the phenomenon, and they begin to learn about the diverse cultural contexts in which people use science. *Example:* In Level 5 Module 3, students learn about Balinese rice farmers and how their traditional methods of rice farming have endured for more than 1,000 years, proving more effective than many modern techniques. The Balinese rice farming anchor phenomenon introduces concepts related to the interactions of Earth's biosphere, hydrosphere, atmosphere, and geosphere. These ideas can be hard to conceptualize, but the anchor phenomenon shows students tangible examples of these scientific processes and how humans can design sustainable systems by using their understanding of natural processes.
Student-generated phenomena Throughout a module, students share related phenomena they have experienced in their lives. By connecting students' experiences to the phenomena and concepts presented in the module, the curriculum helps teachers gain insight into students' current knowledge.	**Self-awareness.** Students integrate their personal social identities when they connect phenomena they see in their lives to the anchor phenomenon. Making these connections also gives students more control over their learning. **Social awareness.** As they identify related phenomena, students hear about and learn from the experiences of other students in the classroom. Students can demonstrate empathy and compassion for other students and benefit from being exposed to new experiences. Students also practice sharing their own experiences with the class. *Example:* In Level 3 Module 1, students learn about the 1900 Galveston hurricane as the anchor phenomenon. Even if students do not live in an area where hurricanes occur, they can connect weather experiences in their own lives, such as tornadoes, earthquakes, and nor'easters to the anchor phenomenon.
Anchor model development The anchor model is a class model that students develop together. It is displayed in the classroom so students can refer to and update it throughout the module. By the end of a module, the anchor model reflects students' explanation of the anchor phenomenon.	**Self-awareness.** In developing anchor models, students must advocate for what they think should be included while recognizing the potential limits of their model and considering where it might be improved. (Note: Students create their own anchor models and then use them to contribute ideas to the class anchor model.) Sharing and comparing their individual models to help develop the class anchor model also allows students to notice similarities and differences between their ideas and others' ideas, which opens them to new information that might change their thinking and improve their understanding. **Self-management.** Students must manage their thoughts and behaviors as the class works together to develop the anchor model. They need to self-monitor to make sure they contribute appropriately to the collective goal and use planning skills to decide when to share their ideas. They must also have courage to share their contribution to the class to help create the class anchor model.

PhD Science Module Features	Alignment with SEL Competencies
Anchor model development *(continued)* The anchor model is a class model that students develop together. It is displayed in the classroom so students can refer to and update it throughout the module. By the end of a module, the anchor model reflects students' explanation of the anchor phenomenon.	**Responsible decision-making.** As students work to develop the class anchor model, they can demonstrate curiosity and open-mindedness as they hear their classmates' ideas. Students are also encouraged to make reasoned judgments as they analyze the information, data, and facts that arise in the course of their module learning and determine how to use them to refine the model. **Relationship skills.** Students establish and maintain supportive relationships as they work together to build the best model based on current information. Students must clearly communicate their ideas, listen to their classmates, and work collaboratively to solve problems, resolve differences, and support one another in learning. **Social awareness.** Developing an anchor model requires students to consider the perspectives of others and assess how they may think differently or similarly about the model. Developing a collective anchor model also requires students to be active in the conversation and recognize opportunities to support consensus building throughout the process. ***Example:*** In Level 5 Module 2, after students have developed their own model of a mangrove tree ecosystem, they are encouraged to explain to a partner or small group what they included in their model, providing provide evidence as to why they included what they did, and elaborate on the perspective from which they designed the model. By sharing their models of the anchor phenomenon, students can see models from the perspectives of other students and adjust their thinking about their own models, which prepares them well for the development of the class anchor model. Students work collaboratively to develop the class model, deciding what to include where and why based on evidence.
Driving question board development The driving question board is a tool that organizes student questions about the anchor phenomenon. Work with the board increases student engagement, highlights connections between concepts, and records the enduring knowledge students acquire throughout the module.	**Self-management.** Students must demonstrate personal agency when they share a question to contribute to the collective goals of developing the driving question board and guiding class learning. Students must identify whether their question aligns with one already on the board and take the initiative to place it in the appropriate location on the board. Students must also collaborate reasonably as they work together to develop the Focus Question categories. **Responsible decision-making.** Students demonstrate curiosity and open-mindedness by developing a question to share, and they make reasoned judgments as they listen to other students' questions and decide where their own question aligns with those already on the board. **Relationship skills.** After students form their own questions about the phenomenon, they communicate those questions to others and practice teamwork and collaborative problem-solving by categorizing all of their questions as a group. Once the questions are categorized, students collaboratively investigate them to build knowledge and answer the module's Essential Question. This collaborative thinking

PhD Science Module Features	Alignment with SEL Competencies
Driving question board development *(continued)* The driving question board is a tool that organizes student questions about the anchor phenomenon. Work with the board increases student engagement, highlights connections between concepts, and records the enduring knowledge students acquire throughout the module.	session also helps students develop positive relationships with one another as they work collectively to define the Focus Questions for the driving question board and constructively resolve any conflicts that may arise during their work. Students may also show leadership by taking the lead in developing the Focus Questions or by standing up for the ideas of others. **Social awareness.** Students take in the perspectives of others when they hear other students' driving questions and relate them to their own. Students show concern for others' feelings by seeking to understand others' questions instead of criticizing them. *Example:* In Level 3 Module 4, students are asked to refer to their questions in their notice and wonder charts and choose the question they are most interested in answering. After one student reads a question and places it on the driving question board, students are asked who has a related question to read and place on the board to form categories of related questions. After all students have their questions on the board, the class works together to develop a Focus Question for each category and adds the Focus Questions to the driving question board. To successfully develop the driving question board, students have to exhibit self-management and autonomy, listen to their peers, decide where their question should go, and then work collaboratively and communicate effectively to develop the Focus Questions
Collaborative conversations An instructional routine such as collaborative conversations is a classroom procedure that supports the development of content knowledge and academic skills in an engaging and active way. These routines increase student engagement and make students' thinking and learning visible. Collaborative conversation routines include Fishbowl, Inside–Outside Circles, Mix and Mingle, Question Corners, Response Techniques, Socratic Seminars, Think–Pair–Share, Value Line-Up, Vote–Discuss–Revote, and Whip Around.	**Self-awareness.** Through Think–Pair–Share partner activities and Stop and Jot individual activities, students are asked to bring their own thinking and experiences to the lessons, sharing them first with a partner and then with the class. **Relationship skills.** Throughout a module, students gather evidence to answer questions they have about what they are learning. They use this evidence to make arguments and to justify to their peers why their position is valid. In doing so and in observing others doing the same, they come to understand that one's position may change based on the evidence presented. These experiences help students practice relationship and speaking and listening skills. **Responsible decision-making.** In Socratic Seminars, students have the opportunity to make a reasoned judgment after analyzing and synthesizing data, information, and facts. When students are asked to discuss the Essential Question, they must synthesize all the work they've done in the module to arrive at an explanation of the anchor phenomenon. *Example:* In Level 4 Module 1, students engage in a Socratic Seminar to discuss the Essential Question: How did the Grand Canyon's features form? For a successful discussion, students must incorporate their new science knowledge and draw on the anchor models for evidence and support. Students must regulate themselves during the discussion while listening actively and communicating clearly and effectively. Students largely moderate themselves, responding to one another directly with minimal teacher facilitation.

***PhD Science* Module Features**	**Alignment with SEL Competencies**
Investigations Students engage in the practice of planning and carrying out investigations in nearly every module of *PhD Science*. As students engage in phenomenon-based instruction, the investigations they plan and carry out are key to building deep understanding of scientific concepts.	**Self-management.** Students regularly work in small groups and must manage themselves in a way that serves the group. Students must demonstrate self-discipline to ensure personal and collective safety, and they must practice self-motivation to contribute fairly to the assignment so other group members do not do all the work. Students also set personal and collective goals to complete the assignment and must use planning and organizational skills to successfully coordinate all the required steps of the assignment. **Relationship skills.** Successful small group work requires students to establish and maintain healthy and supportive relationships and to effectively navigate the assignment with diverse individuals. Students must communicate clearly, listen actively, and work collaboratively to complete the assignments safely and on time. Small group work helps students develop their ability to collaborate to solve problems and to negotiate conflict constructively. For example, they may need to settle differences of opinion about the assignment or about how best to develop fair tests. **Social awareness.** Working successfully as a small group requires students to understand others' perspectives and recognize each person's strengths as they all work toward a shared goal. In addition to identifying roles and responsibilities for the small group activity, students contribute different ideas and skills to complete the task successfully. ***Example:*** In Level 4 Module 2, students work together to design a fair test investigation of the impact of energy on speed. They use a ball bearing, a ruler, and a textbook to demonstrate energy transfer. To successfully design and execute this fair test, students have to work collaboratively, communicate effectively, consider each other's viewpoints, and agree on an investigation plan. Team members must also successfully execute their individual assignments during the fair test, collecting valid data to analyze and use to draw conclusions based on evidence.
Engineering Challenges Engineering Challenges allow students to apply their conceptual knowledge to solve real-world problems through the process of engineering.	**Self-awareness.** In Engineering Challenges, students focus on designing solutions and then evaluating those solutions to determine how they might be improved. As part of this process, students practice the growth mindset skills of embracing challenges and believing effort is the path to mastery as they create one solution and then iterate that solution, adjusting it to increase its effectiveness. They learn to question their original design and assumptions when presented with new information. **Self-management.** Students practice sharing and receiving input and feedback to improve the work they do toward completing the Engineering Challenge. **Social awareness.** As students design their models and solutions, they can draw on others' strengths and learn from one another. Depending on the challenge, some students may have additional background knowledge or contextual information they can apply

PhD Science Module Features	Alignment with SEL Competencies
Engineering Challenges *(continued)* Engineering Challenges allow students to apply their conceptual knowledge to solve real-world problems through the process of engineering.	to the design solution. Students must consider each other's perspectives, especially as they relate to the development of the design solution, to produce a viable solution that addresses the challenge presented.
	Example: In Level 4 Module 1, students participate in an Engineering Challenge in which they consider how people can reduce damage related to erosion. For this challenge, students add a house to a stream table environment and use an engineering design process to modify the area around the house to protect the house from erosion. They then test the effectiveness of their solution with simulated rainfall.

Broader SEL impact of *PhD Science*

Family and Community Engagement

PhD Science helps strengthen family and community engagement by offering the following resources:

- Family Tip Sheets, which are available in both English and Spanish, describe what students are learning and how families can support their learning (e.g., talking about science, watching science videos, or visiting community locations such as a museum, park, or zoo).
- Optional homework assignments reinforce learning and connect students' science learning to their everyday lives, often including ideas to discuss with family members or questions that prompt a simple exploration.

Schoolwide Impact

PhD Science supports SEL development at the whole school through its

- consistent approach to SEL and science integration,
- intentional vertical alignment and increasing sophistication of SEL skills across grades, and
- collaborative approach to professional development that mirrors the structure of the student curriculum and fosters a strong community of adult learners.

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Social emotional competencies are at the core of *PhD Science*. While the discussion above provides examples of opportunities for students to develop and practice SEL throughout the year and across levels, the deeper dive into one module below highlights the SEL opportunities students experience in one module.

The following annotations explain how this module offers students rich opportunities to develop social and emotional learning competencies, including social awareness, self-awareness, self-management, relationship skills, and decision-making skills.

To achieve the module outcomes, students must successfully manage themselves, their work, and their relationships with peers. Teachers provide support and guidance to students while allowing them to take ownership of and direct their own learning.

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Social awareness.
Listening to classmates describe their experiences with dangerous weather in Level 3 Module 1 Lesson 1 helps students understand the experiences of others, feel empathy and show compassion toward others, and take in others' perspectives about what they define as dangerous weather.

Self-awareness and social awareness.
Notice and wonder activities offer all students a sense of purposeful exploration as they articulate their own understandings and questions about a shared image. After individually completing the task of noticing and wondering, students share their observations with the whole class. They come to understand multiple perspectives and see how observations may differ based on the diverse backgrounds and experiences of their classmates.

Lesson 1

Objective: Observe photographs of Galveston, Texas, before and after the 1900 hurricane and describe the damage.

Launch 5 minutes

Teacher Note

In this module, students investigate several instances of severe weather and related weather hazards. Be aware of students' social and emotional needs. Some may have had traumatic personal experiences related to topics discussed throughout the module (e.g., hurricanes, tornadoes).

To begin, ask students to think about a time they experienced dangerous weather. Invite several students to share their experiences with the class.

Sample student responses:

- *There was a big thunderstorm that blew down a few trees in my yard.*
- *One time during the winter, the roads got so icy that cars were sliding on the road.*
- *The basement in my house flooded because it rained so much during a storm.*
- *My family had to get in the basement when there was a tornado.*
- *We lost electricity in our apartment during a storm.*

▶ Can you describe a time when you were surprised by dangerous weather?

- *I was playing at the pool and had to get out quickly because I heard thunder and saw lightning.*

Learn 35 minutes

Observe Photographs of St. John's Church 10 minutes

Display the photographs of St. John's church (Lesson 1 Resource A). Ask students to record what they notice and wonder about the photographs in their Science Logbooks (Lesson 1 Activity Guide). Explain that students should list their observations about the photographs in the I Notice column and any questions they have after examining the photographs in the I Wonder column.

Sample student responses:

I Notice	I Wonder
• *In one picture, the building looks fine, but in the other picture, the building looks destroyed.* • *Both photos look very old.* • *The power lines in the second picture look like they got bent and broken.* • *There are broken pieces of the building lying on the ground in the second picture.*	• *Why is only one part of the building still standing in the second picture?* • *When were these photographs taken?* • *What happened to the building?* • *Did this happen to other buildings nearby?* • *What happened to the trees in front of the building?*

Invite students to share what they notice and wonder about the photographs. While students listen to their peers, they can use nonverbal signals to indicate whether they recorded a similar thought. As students share, record their observations and questions on a class notice and wonder chart.

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Relationship skills.
A collaborative conversation about new terms and an exercise in summarizing the main idea help students learn to communicate effectively, listen actively, practice teamwork, and seek or offer support and help when needed. The collaborative conversation helps students establish and maintain healthy and supportive relationships and learn to process new material together.

Explore the 1900 Galveston Hurricane 25 minutes

Tell students that the photographs of St. John's church were taken in Galveston, Texas. Display a map of the United States and point to the location of Galveston on the map. Draw students' attention to the body of water next to Galveston, and explain that this body of water is called the Gulf of Mexico.

Next tell students that the first photograph was taken before a storm passed through Galveston in 1900 and the second photograph was taken after the storm. Show students the excerpt from the National Public Radio (NPR) broadcast, "The Tempest at Galveston: 'We Knew There Was a Storm Coming, but We Had No Idea'" (Burnett 2017) (Lesson 1 Resource B), and explain that the broadcast tells the story of the 1900 storm. Read the broadcast excerpt aloud to students. Students may ask about the meaning of Category 4 hurricane. If needed, explain to students that hurricanes are categorized by strength from 1 to 5 and a Category 4 hurricane is a very strong storm.

Differentiation

As needed, provide visual supports and realia to help further clarify new terms from the reading (e.g., *estimated*, *primitive*). English learners may especially benefit from additional support during the read aloud. Consider sharing Spanish cognates for terms such as *primitive* (*primitivo*), *estimate* (*estimar*), and *status* (*estatus*).

Use a collaborative conversation routine such as Inside–Outside Circles and the following questions to help students clarify new terms and summarize the main idea of the broadcast excerpt.

▶ What happened on September 8, 1900, in Galveston, Texas?
- *A strong hurricane hit Galveston, Texas. It was one of the worst hurricanes in history.*
- *A dangerous storm hit the city and destroyed almost everything.*

Self-awareness and self-management.
As students develop their initial models, they are asked to demonstrate confidence in what they've learned so far, organizing that information into a model. They know that their model may be incomplete or look different from a classmate's model, which encourages them to act with conviction about what they know but remain flexible and adaptable enough to change their model in light of new information.

Lesson 2

Objective: Develop a class anchor model to explain what happened in Galveston, Texas, during the 1900 hurricane.

Learn 35 minutes

Develop Initial Models 20 minutes

Project the images of Galveston after the storm (Lesson 1 Resource C), and ask students to look back at their descriptions of what the weather is like during a storm. Have students Think–Pair–Share about what parts of a storm might cause damage like that shown in the photographs.

Sample student responses:

- *The wind might have blown over the buildings.*
- *The puddle in the first picture could have been caused by rain during the storm.*

Remind students of this quote from the NPR broadcast excerpt (Lesson 1 Resource B): "About half past 3 … Jacob and Allen came running, shouting excitedly that the Gulf looked like a great gray wall about 50-feet high and moving slowly toward the island."

▶ What do you think the gray wall that Jacob and Allen saw was?
- *The quote says that the Gulf looked like a gray wall, so I think they were looking at the ocean.*
- *I think Jacob and Allen saw water coming toward the island. Maybe it was a wave.*
- *Maybe they saw a big wave. I think 50 feet high must be really tall.*

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Self-management. As students draw a model in Level 3 Module 1 Lesson 2, they must exhibit self-discipline and self-motivation to complete the model, engage planning and organizational skills to draw their model, and take initiative to draw what they know at this point. In sharing their models, students develop relationship skills by explaining their model to their partner and discussing similarities and differences in models.

Responsible decision-making. In the Land section of this lesson, students are asked to provide evidence from their observations to decide whether the Galveston hurricane is an example of severe weather. As they analyze their observations, students learn how to make a reasoned judgment about the hurricane.

Develop Anchor Model 15 minutes

Explain that the class will now develop an anchor model to demonstrate an understanding of what caused the destruction in Galveston in 1900. Tell students that they will develop this model together as a class to reflect their thinking.

Explain that the first step in developing an anchor model is to determine what important components to include. Ask students what components the anchor model should include. As students share components, ask the rest of the class to use nonverbal signals to indicate whether they agree that a new component correctly describes what happened in Galveston or accurately represents a part of the hurricane that caused the damage. Call on students to justify their agreement or disagreement with evidence. As needed, ask additional questions to help students build on the ideas of others and express their own ideas clearly.

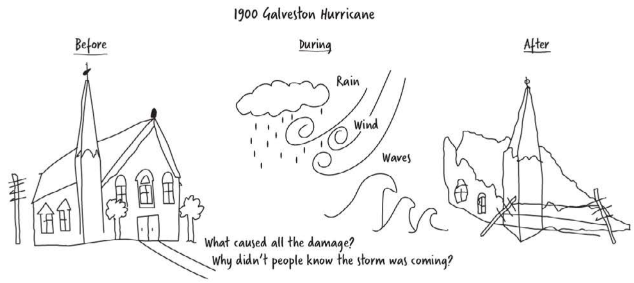
Sample student responses:

- *I agree that we should add waves to our model because the reading said the Gulf of Mexico looked like a big wall.*
- *I disagree with drawing a tornado because we don't know if tornadoes are a part of hurricanes.*

If most students agree with adding a component and can justify its inclusion, draw it on the anchor model. Anchor models will vary for each class, but they should include two main components:

- Information about weather conditions and events possibly associated with hurricanes (e.g., wind, rain, waves), even if there is some uncertainty about these conditions and events
- Open questions about what caused all the damage and why people did not know the storm was coming

Be sure to also include a title and an explanation on the anchor model.



A hurricane hit the city of Galveston, Texas, on September 8, 1900. Before the hurricane, Galveston was a successful city. The hurricane destroyed the city. We're not sure how the hurricane caused all the damage.

When the class anchor model is complete, use it to guide students' learning throughout the module.

Land 5 minutes

Explain that scientists often refer to dangerous weather as **severe weather**. Severe weather is any weather that poses a threat, or danger, to life and property. Ask students if they think that the Galveston hurricane is an example of severe weather. Ask them to use what they have observed about the hurricane as evidence.

Sample student responses:

- *Yes, the hurricane is an example of severe weather because we saw property destroyed in the photographs of Galveston.*
- *Yes, the Galveston hurricane is an example of severe weather because the reading said that many people died.*

Explain that severe weather is made up of components, or parts, of weather that pose threats to life and property, which are called **weather hazards**. Weather hazards include strong winds and heavy rain.

▶ What on our anchor model might be considered a weather hazard?

- *I think the wind is a weather hazard because wind can blow things down.*
- *I don't think a little bit of rain is dangerous, but maybe rain could be a weather hazard if it rains a lot.*
- *A big wave might be a hazard if the wave hits a person or a house.*

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Self-awareness.
As they discuss related phenomena in Level 3 Module 1 Lesson 3, students bring their own experiences and identities to the conversation. While they may not have prior experience with the particular phenomenon being discussed, they likely have knowledge of a related topic. When students share related phenomena, they integrate their own experiences into the conversation and make connections between what they already know and what they are learning.

Relationship skills.
Building a driving question board in Lesson 3 requires students to communicate clearly about their questions and how their questions relate to their classmates' questions. Students need to listen actively to one another and work collaboratively to group their questions into related categories. Throughout this activity, students support one another, show leadership, and seek help when needed.

Lesson 3

Objective: Ask questions about how a hurricane can cause a disaster such as the disaster in Galveston, Texas.

Learn 35 minutes

Discuss Related Phenomena 10 minutes

To help students think more deeply about the anchor phenomenon, ask them to share any familiar phenomena they think might be related to severe weather such as the 1900 Galveston hurricane. Use the following question to draw out student knowledge.

- **Have you ever heard of or experienced any severe weather like what people in Galveston experienced in 1900?**
  - *I've heard of floods damaging homes.*
  - *I know that a tornado can knock down big trees and buildings.*
  - *I've seen a mudslide make houses fall and cover up roads.*
  - *In the winter, blizzards can bury cars and homes in snow.*
  - *Lightning can strike trees, buildings, and people if they are not careful.*
  - *Hurricanes, like the one in Galveston, can cause an entire city to be destroyed.*
  - *During a bad storm, my mom's car was hit by hail, and it broke the windshield.*
  - *Droughts can cause plants to die.*

Add student responses to the bottom of the piece of chart paper that will become the driving question board. Label the section Related Phenomena. Refer to this student-generated list of phenomena throughout the module and add to the list any time students suggest relevant related phenomena.

> For this particular phenomenon, related phenomena will likely vary by region. Students in the Northeast may relate to nor'easters, students on the West Coast to earthquakes, and students in the Midwest to tornadoes. Students may also think of other phenomena such as tsunamis, tidal waves, and the like.

Build a Driving Question Board 25 minutes

Return to the class notice and wonder chart created in Lesson 1, and ask students if they have any additional questions to add to the chart. Then ask students to choose at least one question they are most interested in and to write it on a sticky note.

Tell students they will now use their questions to develop a driving question board. Explain that they will refer to this driving question board throughout the module as they seek to answer their questions about the 1900 Galveston hurricane.

Lead a class discussion in which students share the questions from their sticky notes. After one student reads a question and places it on the driving question board, invite students who think they have a related question to read theirs and place it next to that question on the driving question board. Throughout the discussion, ask students follow-up questions or make suggestions to help students group their related questions. Guide students toward grouping their questions into the three categories listed below. After students have finished posting their questions, work together to develop and post the Focus Question for each category on the driving question board.

Concept 1 Focus Question: **How do we describe weather?**

Related student questions may include the following:

- *Was there a lot of wind?*
- *How much rain fell during the storm?*
- *What did it look like during the hurricane?*

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

As students work together to plan and create a design solution, they engage in **all the social-emotional competencies.**

To work efficiently and effectively as a group, students must be self-aware and manage their behavior as they contribute to the collective goal. Students also need to be aware of the different perspectives other members of their group bring to the task and the situational demands and opportunities for leadership and for supporting other group members' ideas.

In creating the design solution prototype, students will need to build consensus by communicating clearly and effectively, and they will need to collaborate to solve problems and negotiate conflict.

Additionally, the process of improving the design solution reinforces students' growth mindsets. They learn that developing an engineering design is an iterative process; their solution may not necessarily be optimal or correct the first time.

Lesson 22

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Plan a Design Solution 15 minutes

Tell student groups they are now ready to develop a plan for building and testing their design solutions. Remind students of the materials available for them to use, and direct them to create a diagram of their design in the Plan section of their Science Logbooks (Lesson 22 Activity Guide). Students' diagrams should show both the proposed placement of the seawall in the plastic bin and the shape of the seawall they will build. Students should also indicate what materials they will use for each part.

If needed, prompt students to recognize that they can use modeling clay to build the seawall. Also guide students toward the idea of placing the foil ramp in the hole of the plastic bin, and explain that holding the ramp at an incline while pouring water down it can simulate storm surge. Students should plan to build their seawall near the middle of the plastic bin to leave enough space for water to travel down the ramp and toward the community.

Lesson 23

Objective: Apply the engineering design process to design a structure that reduces the impact of flooding caused by storm surge.

Learn 40 minutes

Create a Design Solution 25 minutes

Safety Note

The engineering challenge poses a potential hazard. Explain that spilled water could cause slippery surfaces that might lead to falls. To minimize this risk, review with students that spills must always be cleaned up immediately.

Tell students to begin building and testing their prototypes, or the working sample of their designs. Encourage students to refer to the diagrams they created in the Plan stage as they work. As students test their prototypes, they should respond to the questions in the Create section of their Science Logbooks (Lesson 22 Activity Guide).

Sample student responses to questions in the Lesson 22 Activity Guide:

What works well?

- *The seawall blocks almost all the water.*

What needs improvement?

- *Some water still gets past the seawall.*
- *The wall is too tall and keeps falling over.*

Improve a Design Solution 15 minutes

As students finish testing their prototypes, encourage them to brainstorm potential improvements. Have students document their ideas in the Improve section of their Science Logbooks (Lesson 22 Activity Guide).

Once students have documented their ideas, they should clean up the area where they built and tested their prototypes. Support students in safely drying all water spills. Have students keep their seawall designs intact, instructing them to discard any water that remains in the plastic bins.

Module Example: How *PhD Science* builds SEL Across Lessons in Level 3 Module 1

Socratic Seminars are excellent opportunities for students to develop **self-awareness, self-management, and relationship skills.**

Since the conversation is student-led with minimal teacher facilitation, students must demonstrate self-control and follow the guidelines for the Socratic Seminar.

To engage in Socratic Seminars, students must organize their own thoughts and manage their behavior during the classroom discussion while examining prejudices and biases that might arise in the course of the conversation. Students are asked to reflect on their responses immediately following the seminar to see how their thoughts might have changed as a result of the discussion.

For the Socratic Seminar to be successful, students must communicate their thinking clearly, listen to their classmates closely, and work to resolve any disagreements that arise.

Lesson 27

Objective: Explain how understanding weather and climate can help people anticipate future weather conditions and develop solutions to reduce the impact of weather hazards. (Socratic Seminar)

Learn 33 minutes

Prepare for Socratic Seminar 8 minutes

Tell students they will share their understanding of the Essential Question with one another through a Socratic Seminar discussion. First, students write an initial response to the Essential Question: **How can we prevent a storm from becoming a disaster?** in their Science Logbooks (Lesson 27 Activity Guide B) as a Quick Write. When students finish, ask them to draw a line below their responses. At the end of the seminar, students will revisit their responses to see how their thoughts have changed.

Engage in Socratic Seminar 25 minutes

As needed, review the routines and expectations for participating effectively in a Socratic Seminar, including classroom guidelines and resources for speaking and listening. Have students review the collaborative conversation strategies in their Science Logbooks (Lesson 27 Activity Guide C). Explain that this resource reminds students of different ways they can participate in a collaborative conversation and provides sentence frames to support student participation. Instruct students to choose one or two conversation strategies to use as a visual reminder of effective ways to contribute to the discussion and to cut out or circle those strategies as a visual reminder.

Remind students that during the seminar they should incorporate science terminology learned during the module. Students can refer to their relationship map from this lesson's Launch, the anchor chart, the anchor model, and other classroom resources to support their discussion.

Display and read aloud the Essential Question to prompt the discussion: **How can we prevent a storm from becoming a disaster?**

Students discuss the question. In the Socratic Seminar, students respond to one another directly, with minimal teacher facilitation. Students can remind one another of conversation norms, ask for evidence, and pose questions to extend the conversation.

As needed, step in briefly to reinforce norms for collaborative conversations. Consider posing one or two questions midway through the seminar to spur additional conversation, such as the following:

- What did we learn about weather, climate, and weather hazards from studying the 1900 Galveston hurricane?
- How do hurricanes compare to other types of severe weather that we studied?
- Think of ______ (an interesting severe weather event that students are familiar with). How do you think weather hazards from this severe weather event relate to the weather hazards that hurricanes present?

Land 5 minutes

Students reread their Quick Write from the beginning of the lesson. Below the line, they summarize how the Socratic Seminar reinforced or changed their thinking. Encourage students to share examples of how their thinking evolved during the discussion.

Explain that in the next lesson, students will apply their understanding of weather, climate, and weather hazards in an End-of-Module Assessment.

Conclusion

PhD Science seamlessly integrates social-emotional learning, preparing all students to succeed at school and beyond. Students immerse themselves in inquiry-based lessons by asking and answering questions; designing and conducting investigations; arguing from evidence, facts, and data; and building knowledge and enduring understanding of science—all while cultivating their social and emotional learning and skills.

Students interact with their classmates to analyze, design, build, observe, and argue from evidence, building a strong learning community in which they feel safe taking the risks needed to learn. Their learning is collaborative, and their interactions with classmates lead them to deeper knowledge and understanding. The social-emotional skills needed to be successful in the science classroom are the same ones needed for success outside the classroom.

Students who engage in science learning through *PhD Science* build deep science knowledge and understanding and strong social and emotional skills that will serve them well in all aspects of life.

GREAT MINDS™

every child is capable of greatness

[1] Maslow, A. H. Motivation and Personality. New York: Harper & Row, 1970.

[2] Adolphs, R. "Cognitive Neuroscience of Human Social Behaviour." Nature Reviews Neuroscience, vol. 4, no. 3, p. 165.

[3] Payton, J., R. P. Weissberg, J. A. Durlak, A. B. Dymnicki, R. D. Taylor, K. B. Schellinger and M. Pachan. "The Positive Impact of Social and Emotional Learning for Kindergarten to Eighth-Grade Students: Findings from Three Scientific Reviews." Chicago: Collaborative for Academic, Social, and Emotional Learning, 2008.

[4] Jones, Stephanie M., and Jennifer Kahn. The Evidence Base for How We Learn: Supporting Students' Social, Emotional and Academic Development. National Commission on Social, Emotional, and Academic Development, Aspen Institute, 13, September 13, 2017. https://assets.aspeninstitute.org/content/uploads/2017/09/SEAD-Research-Brief-9.12_updated-web.pdf.

[5] Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., and Schellinger, K. B. "The Impact of Enhancing Students' Social and Emotional Learning: A Meta-Analysis of School-Based Universal Interventions." Child Development, vol. 82, no. 1, 2011, pp. 405–32; see also Jones et al.

[6] Collaborative for Academic, Social, and Emotional Learning (CASEL). "What is SEL?" https://casel.org/what-is-sel/. Accessed 16 March 2021. See also Payton et al.