PhD SCIENCE™

GREAT MINDS™

PhD Science™ Grade Levels 3–5 Reviewer Guide

Contents

Criteria of Effective Science Programs ***PhD Science* Grade Levels 3–5: Alignment at a Glance**	**Meets Criteria**	
	Yes	**No**
1. Phenomenon-Driven Instruction Student learning is driven by making sense of **authentic, real-world phenomena** and designing solutions to problems.	✓	
2. Three-Dimensional Learning a. Students have multiple opportunities in each lesson set and module to **apply and reveal the three dimensions**. b. The curriculum supports students in using the **three dimensions in concert** to make sense of phenomena and to design solutions to problems. c. **Students drive the instruction** and own the practices.	✓	
3. Relevant & Authentic Phenomena a. Students engage with authentic and meaningful phenomena that reflect **science and engineering practices in the real world**. b. Students connect their explanation of phenomena from the classroom to **their own experiences**.	✓	
4. Knowledge Building a. Through their work, students systematically build knowledge of **enduring scientific understandings**. b. **Key scientific terminology** is established after conceptual understanding.	✓	
5. Coherent Design a. **Coherence** is evident from the student perspective across lessons, modules, and grade levels. b. Student learning progression is carefully planned and **clearly organized in a coherent manner** to prevent student misunderstandings and support student mastery of the Performance Expectations.	✓	
6. Alignment & Accuracy a. Instructional materials are designed for ***The Framework* and the Next Generation Science Standards** (NGSS). b. Science content is **accurate and grade appropriate**, reflecting the most current and widely accepted explanations.	✓	
7. Scaffolding & Support a. The curriculum provides appropriate suggestions and materials for **differentiated instruction**, empowering teachers to support varying student needs at the module and lesson levels. b. The curriculum supports teachers by helping them identify **prior student learning** and clearly explains how skills and concepts build in future levels. c. Curriculum materials help **strengthen teachers' knowledge** of scientific concepts so they have the tools to effectively instruct students.	✓	
8. Interdisciplinary Connections a. Students explore connections to **mathematics, English language arts, fine arts, geography, and history**. b. Authentic trade books frame phenomena and provide insight into science content while **strengthening literacy skills**. c. Students engage with **authentic sources** and incorporate **speaking, reading, and writing** to develop scientific literacy.	✓	

9. Assessment a. Multiple types of **formative and summative assessments** are embedded in content materials and indicate student progress toward learning targets. b. Assessment items and tasks **integrate the three dimensions in the context of a new phenomenon**, giving students the opportunity to transfer knowledge. c. **Scoring guidelines and rubrics** align with performance expectations and incorporate criteria that are specific, observable, and measurable. d. Assessments are **accessible and unbiased for** all students.	✓	
10. Organization & Usability a. Curricular content is purposefully sequenced and designed for ease of use for a **full academic year**. b. The curriculum **includes all necessary components for implementation**, including trade books and investigation materials. c. Science classroom and laboratory **safety guidelines** are embedded in the curriculum. d. Student access to **computer technology** is required for lessons.	✓ **(a, b, c)**	✓ **(d)**

Criteria of Effective Science Programs	Meets Criteria		Evidence from *PhD Science*
1. Phenomenon-Driven Instruction	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
Student learning is driven by making sense of **authentic, real-world phenomena** and designing solutions to problems.	✓		Phenomena are observable events that can be explained or predicted through scientific understanding. By carefully selecting and introducing a variety of phenomena, *PhD Science* lays out a coherent path for students to learn about the world around them. All *PhD Science* modules include a web of interrelated phenomena that play various roles in instruction. Because the phenomena are interrelated, students can more easily transfer and apply their learning in new contexts. Each module centers on an anchor phenomenon, a rich, multilayered scientific phenomenon that motivates student learning. As students ask and investigate questions about the phenomenon, they uncover new ideas that both increase their understanding of the phenomenon and reveal new avenues of investigation. At the end of each concept, students create and update a model to demonstrate their latest thinking about the phenomenon. By the end of the module, students explain the science behind the phenomenon and/or design a solution to a real-world problem related to the phenomenon. **Example** Level 5 Module 3: Earth Systems Anchor Phenomenon: Balinese Rice Farming Students identify and explore the components of rice cultivation in Bali to develop an answer to the Essential Question: *How has Balinese rice farming endured for 1,000 years?* As they explore each concept in the module, students refine a model representing the movement of fresh water used to farm rice in Bali. By the end of the module, students use their knowledge of Earth's interacting systems to explain the anchor phenomenon and extend their understanding to new contexts. Students put their knowledge into practice in an Engineering Challenge, in which groups use the engineering design process to develop solutions to a problem associated with the world water crisis.
2. Three-Dimensional Learning	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. Students have multiple opportunities in each lesson set and module to **apply and reveal the three dimensions**.	✓		*PhD Science* students regularly engage in the three key dimensions of science education. During each lesson set, students apply the Science and Engineering Practices (SEPs) to construct understanding of Disciplinary Core Ideas (DCIs) through the lens of Crosscutting Concepts (CCs). Throughout a module, students revisit practices, concepts, and core ideas while deepening their understandings. Students apply their new knowledge and skills during culminating challenges, assessments, and discussions at the end of each module.

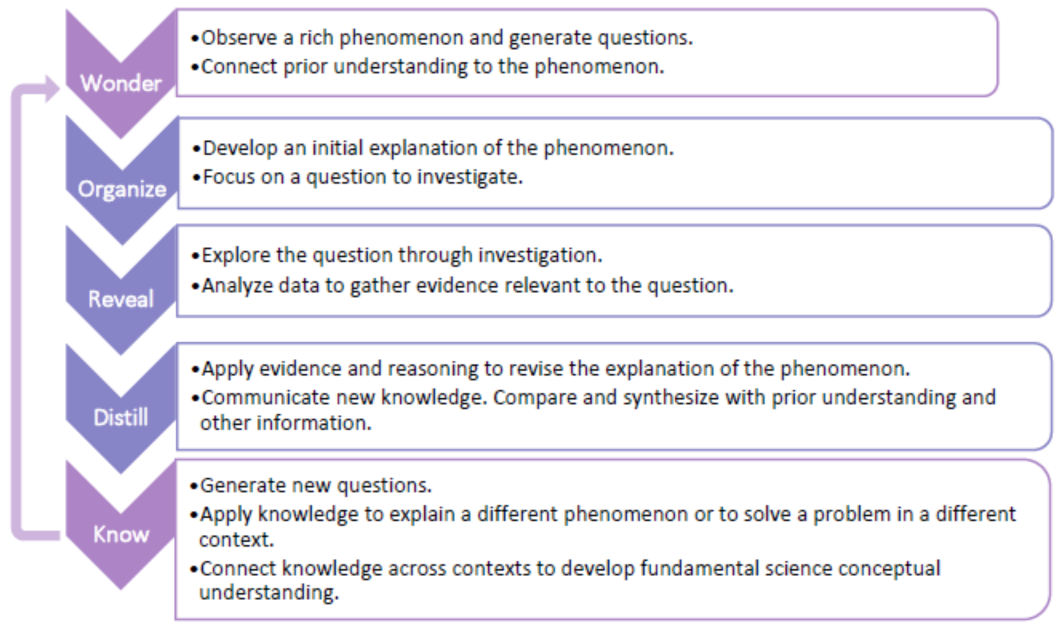
			The Prepare section at the start of the lesson set highlights the standards students will engage with in that set, while the Focus Standards section of the Module Overview outlines the standards covered in the module as a whole. At key moments when students engage with these standards, a Spotlight note related to DCIs, SEPs, and/or CCs note may appear alongside the lesson content to clarify how the task supports the standards or to provide suggestions for supporting students. **Examples** Level 3 Module 4 In Lessons 7–9, students use a series of SEPs in succession to elucidate how patterns (CC.1) can be used to predict an object's motion (PS2.A). Students begin by exploring the motion of a system of objects including a pendulum and a toy car as they refine an investigation question (SEP.1) about the effect of the pendulum release position on the motion of the car. They then collaboratively plan and conduct an investigation (SEP.3) to collect data to answer their investigation question. After conducting the investigation, they organize the class data into line plots and analyze the data (SEP.4) to explain that a greater pendulum release distance causes the toy car to travel a longer distance. Students then use this conclusion and their collected data as evidence to predict the motion of the system in future situations. Level 4 Module 1 Throughout the module, students apply ideas about cause and effect (CC.2) and stability and change (CC.7) to explain the formation of the Grand Canyon. In Lessons 3–5 students begin to consider evidence that the formation of the canyon occurred over a long time (ESS1.C) and use analogies to describe the time scale of the changes. In Lessons 6 and 7 students wonder about the causes of natural rock features in a photograph. They begin to investigate the processes of weathering and create a cause and effect chart to capture the results. In Lessons 8–11 they then use a stream table to investigate the effects of wind, water, and gravity (ESS2.A), eventually identifying factors that determine the rates of change associated with the effects of weathering and erosion. Students continue to apply ideas about cause and effect in Lessons 21–24 as they explore the effects of human interactions with the environment, such as building dams (ESS3.A). They make predictions about the effects of building a dam and use models to test their predictions (SEP.2). They use evidence (SEP.7) to support or refute claims about the effects of dams on the environment.
b. The curriculum supports students in using the **three dimensions in concert** to make sense of phenomena and to design solutions to problems.	✓		*PhD Science* students integrate the three dimensions to develop coherent understandings of the world around them and the ways people gain scientific knowledge. In each *PhD Science* lesson set, students apply at least one element from each of the three dimensions in concert as they tackle the Phenomenon Question. The curriculum purposefully combines three-dimensional elements to help students achieve the learning goals and to demonstrate authentic scientific methodology. For information about the three-dimensional elements in focus in each lesson set, see the Spotlight on Three-Dimensional Integration in each section of the Module Storyline.

			Example Level 4 Module 2 In Lessons 10 and 11, students visit a series of stations at which they observe transformations of energy between various forms and objects (CC.5), such as the transformation of energy from light into sound through a horn powered by a solar cell, and they develop models (SEP.2) to represent their observations. They look for patterns in their observations (CC.1) and discover that the indicator of energy at each station changes form. Students apply this learning to help expand prior understandings about energy to include the idea that in addition to transferring from place to place (PS3.A), energy can transform from one indicator to another, such as light to sound (PS3.B). Later in the module, students use their new understandings when they design (SEP.6) and construct a device to transform energy (PS3.B, CC.5) during a power outage.
c. **Students drive the instruction** and own the practices.	✓		*PhD Science* students drive the instruction, with teachers in the role of a guide. Students' engagement propels the exploration of phenomena, and their growing knowledge moves the lessons and modules forward. This participation promotes ownership of the practices as students authentically build their science and engineering skills. **Example** Level 4 Module 3 In Lesson 7, students develop a model (SEP.2) of a wave from the top and side views. Through constructing this model, students learn that waves are a repetitive pattern of motion. Developing the model then motivates students to plan an investigation (SEP.3) that would allow them to directly observe waves from the side. Students carry out their investigation in Lesson 8 to learn about the cause and effect relationship in their observations. These observations then drive students to construct another model (SEP.2), which leads to their learning about amplitude and wavelength.
3. Relevant & Authentic Phenomena	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. Students engage with authentic and meaningful phenomena in ways that reflect **science and engineering practices in the real world**.	✓		The learning design of *PhD Science* reflects the authentic practices of scientists and engineers. Students come to see science and engineering as processes of understanding and improving the world in which they live—not just as blocks of time in the school day. Students are prepared to apply their understanding to novel problems and to critically evaluate information as participants in society, whether or not they pursue careers in science, engineering, and technology. In *PhD Science*, students begin each module by making observations of phenomena and asking questions. Their investigations lead to new questions, some of which are answered in the course of the module and some of which remain for future modules. Students develop models that they revisit and revise to reflect new evidence and learning, and they support claims and arguments with evidence. When confronted with a problem requiring a solution, students follow the iterative design process that engineers use.

<table>
<tr>
<td></td>
<td></td>
<td></td>
<td>
Each module also contains a Science Challenge or Engineering Challenge, a series of lessons in which students delve deeper into the cycles of asking and investigating scientific questions or identifying problems and designing solutions. Each Science Challenge or Engineering Challenge is centered on a question or problem related to the module anchor phenomenon. Students work in groups to plan and conduct their own investigation or design a solution.
<table>
<tr><th></th><th>Module 1</th><th>Module 2</th><th>Module 3</th><th>Module 4</th></tr>
<tr><td>Level 3</td><td>Lessons 21–26
How can people design better solutions to reduce the impact of weather hazards?</td><td>Lessons 22–25
How can we help monarchs survive in a changing environment?</td><td>Lessons 19–20
How does the water in a plant’s environment influence the plant’s traits?</td><td>Lessons 23–27
How can we use magnets to design a solution to help astronauts in space?</td></tr>
<tr><td>Level 4</td><td>Lessons 12–17
How can people reduce damage related to erosion?</td><td>Lessons 17–23
How can we apply our knowledge of energy to solve a problem?</td><td>Lessons 26–28
How do plants respond to their environments?</td><td>Lessons 14–17
How can you make Howland Island and the runway easier to find?</td></tr>
<tr><td>Level 5</td><td>Lessons 18–22
How can we apply our knowledge of substances to solve a problem?</td><td>Lessons 21–23
How can we reduce the damage an invasive species causes to an ecosystem?</td><td>Lessons 19–23
How can we apply our knowledge of Earth’s systems to conserve fresh water?</td><td>Lessons 9–12
How can the Earth–Sun system be used to tell time at different locations on Earth?</td></tr>
</table>
Example
Level 5 Module 1
In this module students investigate the reasons for observed changes in the appearance of the Statue of Liberty over time. They develop a model that they revise throughout the module as they gather evidence and conduct investigations about matter and its interactions. Throughout the process, students rule out certain causes of the observed changes and support other identified causes with evidence. Students continue to apply their understandings about how new substances form during the Engineering Challenge, when they design and test solutions to prevent rust build-up inside the Statue of Liberty.
</td>
</tr>
<tr>
<td>b. Students connect their explanation of phenomena from the classroom to their own experiences.</td>
<td>✓</td>
<td></td>
<td>
Students excel when their learning connects to their own interests and experiences. PhD Science draws on these experiences as students engage in scientific discourse and discovery.
As students begin to discuss and pose questions about the anchor phenomenon in each module, the curriculum also prompts them to share their own related experiences, observations, or questions. The teacher helps students capture these examples on the module driving question board so students may revisit them at relevant points later in the module. PhD Science lessons also frequently present students with everyday phenomena to question, investigate, and explain. Reflecting on these student-
</td>
</tr>
</table>

			generated and everyday phenomena throughout the module refines students' ability to use knowledge they develop in the classroom to explain the world around them and provides students with opportunities to connect their learning to their personal lives. **Examples** Level 4 Module 3 In Lesson 2, students share their own observations of animals' sensory abilities while exploring the anchor phenomenon of elephants sensing distant rainstorms. Level 5 Module 2 In Lesson 16, students do a brief physical activity to identify signs of energy use in their own bodies and connect their experiences to their learning about how all organisms need energy to survive.
4. Knowledge Building	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. Through their work, students systematically build knowledge of **enduring scientific understandings**.	✓		*PhD Science* empowers students to develop deep knowledge by focusing on a concise set of phenomena, not a large collection of discrete facts. As students distill understandings in the context of a given phenomenon, the curriculum frequently presents them with diverse new contexts in which they can recognize and apply those key understandings and draw connections between phenomena. Across modules and grades, students gain a deeper grasp of these fundamental concepts. Students reinforce these enduring understandings at the end of each module as they participate in a Socratic Seminar and create a visual map to represent the connections between key ideas and crosscutting concepts explored in the module. **Example** Level 4 Module 2 In Lessons 8–11, students conduct a series of investigations and explorations by using a variety of materials. They share and discuss results, interpret data, and develop models to build the following series of related enduring understandings: • Energy can transfer between objects through collisions, causing changes in the objects' motion. • Energy can also transfer from place to place through electric currents. • Energy transformation occurs when we observe one energy indicator changing into any other energy indicator(s).
b. **Key scientific terminology** is established after conceptual understanding.	✓		Teachers introduce terms to students only *after* they have had the opportunity to investigate and make meaning of a concept. *PhD Science* teaches terminology in context through the in-depth study of concepts rather than as decontextualized vocabulary. Students learn and use new terminology in the context of compelling phenomena as they participate in hands-on investigations, engage in classroom discussions, develop models, create anchor charts, and read scientific texts.

			Examples Level 3 Module 3 In Lesson 5 the term **variation** is introduced after students visit several stations where they observe and describe multiple individuals of a species and notice the similarities and differences in individuals' traits. Level 4 Module 4 In Lesson 3, the term **emit** is introduced after students observe a light source (a lamp) and discuss their observations; it introduces the term **light ray** after the class develops a model to represent student observations.
5. Coherent Design	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. **Coherence** is evident from the student perspective across lessons, modules, and grade levels.	✓		In *PhD Science*, each module weaves a storyline through which students make sense of compelling phenomena. At the beginning of the module, the class lays out a roadmap for their investigation of the anchor phenomenon through the development of a driving question board to capture student questions about the phenomenon. On the driving question board, students organize their questions under the umbrellas of Focus Questions, each of which guides the learning in one of three or four module concepts. As the storyline unfolds across the concepts, each lesson builds on previous ones, allowing students to reflect on their learning, generate new questions, and investigate related topics. Often at the end of a lesson, lesson set, or concept, students generate new questions that connect to future learning in upcoming lessons. At the end of a concept, they apply their learning to help explain the anchor phenomenon. Coherence is also evident in how *PhD Science* approaches important science practices such as supporting claims with evidence and designing investigations. Students engage in the science practices in diverse contexts by using similar methods and supports to connect to, build on, and deepen their prior experiences and to reinforce a coherent picture of scientific practice. As students integrate and apply new knowledge, coherence becomes evident across modules, grades, and even content areas. **Examples** The following example demonstrates the curriculum's coherence through the organization of modules around compelling phenomena. Level 5 Module 1 Students observe historic photographs that reveal color changes in the Statue of Liberty, prompting them to develop the module Essential Question: *What caused the Statue of Liberty to change over time?* They brainstorm questions related to this phenomenon and decide to first explore *How do we describe different materials?* (Concept 1 Focus Question) Examining the properties of substances in Concept 1 leads students to ask, *How do temperature changes affect substances?* (Concept 2 Focus

			Question) Investigating temperature changes reveals that matter remains the same substance during a state change, prompting students to wonder, *What happens when substances are mixed?* (Concept 3 Focus Question) Students then explore mixing materials and discover that new substances can form. Their new understandings about matter drives students to explain the change in appearance of the Statue of Liberty. The following example demonstrates the curriculum's coherent approaches to important science practices. In Level 3 Module 3 Lesson 12, students collaboratively develop fair test criteria as they design an investigation of how water conditions affect plant traits. Students consider these same criteria when developing an investigation on pendulum motion in Level 3 Module 4 Lessons 7 and 8. Coherence extends across grade levels as students develop similar criteria for fair tests in Level 5 Module 2 Lessons 3 and 4 when they investigate plant growth.
b. Student learning progression is carefully planned and **clearly organized in a coherent manner** to prevent student misunderstandings and support student mastery of the Performance Expectations.	✓		During each concept sequence in a *PhD Science* module, students engage in the following learning cycle:  Engaging in learning cycles helps teachers and students understand important actions scientists take to develop explanations of natural phenomena and how those actions are related. Before concluding a learning cycle, the class records key learning on an anchor chart that becomes a point of reference throughout the module.

			Examples Level 4 Module 1 In Concept 2 students explore Weathering and Erosion to meet Performance Expectation 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. • Lesson 6—Wonder: Students examine a photograph of Deer Creek Falls and wonder about the formation of features in the rock. • Lessons 6–11—Organize, Reveal, Distill: Over several cycles of these stages, students explore the processes of weathering and erosion through hands-on investigation, add their learning to the anchor chart, and update the anchor model. • Lesson 11—Know: Students demonstrate their learning by applying it to a new phenomenon in a Conceptual Checkpoint. For an example of the progression of an anchor chart throughout the course of a module, see Level 3 Module 1 Lessons 4, 9, 12, 15, 16, 18, or 20. **For More Detail** See the Module Map in each Module Overview for the progression of learning objectives. Additionally, read the Module Storyline to see the learning cycle sequence for each module.
6. Alignment & Accuracy	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. Instructional materials are designed for ***The Framework* and the Next Generation Science Standards**.	✓		*PhD Science* modules are designed to align with the expectations for learning defined by *The Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* and to prepare students to demonstrate the Performance Expectations defined by the NGSS. *PhD Science* teacher–writers identified focus standards for each module based on logical and coherent connections between DCIs and related Performance Expectations, ensuring comprehensive coverage of all core ideas and performance expectations in each grade level. Each standard is a focus of instruction and assessment in one or more modules. **For More Detail** • To see detailed analyses of how each grade level of *PhD Science* aligns with specific state standards, go to www.greatminds.org/science/alignment. • For a complete standards scope and sequence, see the Implementation Guide. • For each grade level module's standards list, see the Focus Standards section (in the Module Overview). The Module Map in the Module Overview also includes the targeted performance expectations for each lesson set. For lesson-level standards alignment, see each lesson set's Prepare section.

b. Science content is **accurate and grade appropriate**, reflecting the most current and widely accepted explanations.	✓		A team of expert teacher–writers and learning designers write and review *PhD Science* lessons, ensuring that the content is both accessible and rigorous at each grade level. A team of subject matter experts also carefully reviews the lessons at multiple stages of development to ensure all content is represented accurately. **Example** Level 4 Module 2 This module exemplifies how *PhD Science* takes complex topics and presents them in a way that allows students to develop age-appropriate and scientifically accurate explanations of phenomena. Students first explore how energy is needed to make things happen and then investigate how energy can be transferred and transformed. See the Introduction and the Building Knowledge Across Grades sections in the Module Overview for a more detailed explanation of the energy concepts students uncover.
7. Scaffolding & Support	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. The curriculum provides appropriate suggestions and materials for **differentiated instruction**, empowering teachers to support varying student needs at the module and lesson levels.	✓		*PhD Science* is designed to meet the needs of all students by creating flexible learning environments, supporting varied learners, and incorporating the Universal Design for Learning Guidelines put forth by the Center for Applied Special Technology. Differentiated supports are woven into each lesson and indicated for the learners they support. These supports include providing multiple means of • representation, by presenting information and content in various ways; • action and expression of ideas, by differentiating the ways students can express what they know; and • engagement, to motivate learning. Each lesson also recommends optional modifications targeted to meet specific needs of students in the following groups: learners with disabilities, learners performing below grade level, learners performing above grade level, and English learners. Extensions are suggested where appropriate to provide avenues for further exploration and investigation. **Examples** The following are examples of the many differentiation suggestions throughout *PhD Science*: • Level 4 Module 4 Lesson 21 suggests tuning a radio to different stations and/or frequencies after students observe the different colors in the visible light spectrum to supplement students' understanding of the electromagnetic spectrum. • Level 5 Module 4 Lesson 13 suggests providing sentence starters for students who need support with verbalizing their response. • Level 5 Module 4 Lesson 15 includes an extension activity if students question why the Moon is visible for different lengths of time throughout a month.

b. The curriculum supports teachers by helping them identify **prior student learning** and clearly explains how skills and concepts build in future levels.	✓		The Building Knowledge across Grades section of the Module Overview describes how the key learning in the module builds on learning from earlier grade levels and how that learning will continue to build and deepen in later grade levels. In each lesson set, the Prepare section's opening paragraph summarizes the learning activities and frequently describes how the learning fits into a context beyond that lesson set. At the lesson level, teacher notes as well as Spotlights on Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts often highlight the progression of standard elements and student understandings, providing suggestions for supporting this progression where appropriate. *PhD Science* lessons also contain embedded opportunities for teachers to engage and identify prior student learning for future application. **Examples** For examples of curriculum supports that highlight the progression of student learning, see the following: • Level 4 Module 1 Lessons 8–11—The Prepare section opening paragraph describes how the lesson set builds on knowledge from Level 2. • Level 4 Module 2 Lesson 1—Teacher notes highlight how the learning activity elicits prior student knowledge about windmills and suggests a way to arrange for students to use this knowledge in an upcoming lesson. **For More Detail** See the Building Knowledge across Grades section of each Module Overview.
c. Curriculum materials help **strengthen teachers' knowledge** of scientific concepts so they have the tools to effectively instruct students.	✓		*PhD Science* provides a variety of resources to support teachers' science knowledge so they can best facilitate authentic science learning for students at all levels. Embedded in the lessons are teacher notes that provide supplementary information and suggested resources if students wish to explore topics further. The Module Overview contains an Additional Reading for Teachers section with texts related to the module concepts. The Implementation Guide includes a Resource section that provides information about each instructional routine, speaking and listening supports, and a guide for Socratic Seminars. Additionally, the Resource section includes profiles of key innovators in science, engineering, and technology to provide information about the iterative process of discovery and invention in these fields and the diversity of contributors. **Examples** Level 4 Module 2 In Lesson 1, students learn that humans have used windmills throughout history to harness the wind to do work. A teacher note provides teachers with background information about the relationship between energy and work and clarifies that while students may have a sense of what work is at this level, work as a scientific concept is not explored until later levels. Level 5 Module 4 In Lesson 15, students notice a monthly pattern in moon visibility times. A teacher note explains why the repetition is every 29.5 days, even though it takes the Moon only 27.3 days to orbit 360 degrees

			around Earth. The next note explains that the words *month* and *Monday* are derived from the word *moon*. The note also includes websites that students can explore if they wish to learn the etymologies of other days of the week. **For More Detail** See the Implementation Guide as well as the Additional Reading for Teachers section of each Module Overview.
8. Interdisciplinary Connections	**Yes**	**No**	***PhD Science* Alignment and Program Examples**
a. Students explore connections to **mathematics, English language arts, fine arts, geography, and history**.	✓		*PhD Science* seamlessly and routinely integrates mathematics and English language arts practice into each module. Content Area Connection side notes provide opportunities for extensions or natural connections to other content areas. **Examples** Level 3 Module 3 In Lesson 20, students observe paintings by a father and son and consider whether artistic ability is influenced by individuals' inheritance and/or environment. Level 3 Module 4 In Lessons 8 and 9, students create line plots to organize and analyze data collected during an investigation of patterns of motion. The following *PhD Science* lessons provide examples of Content Area Connection side notes that suggest opportunities for further extension. • Level 4 Module 2 Lesson 1—As students notice and wonder about windmills, the lesson encourages them to ask each other to clarify questions and link their ideas to others' remarks (CCSS.ELA-Literacy.SL.4.1c). • Level 5 Module 4 Lesson 16—As students gather evidence to explain the appearance of the Moon, they can research the history of the Apollo 11 Moon landing. Students who used *Wit & Wisdom*®, Great Minds' ELA curriculum, in Grade 3 can also connect their learning to the core texts *Moonshot: The Flight of Apollo 11* by Brian Floca and *One Giant Leap* by Robert Burleigh.
b. Authentic trade books frame phenomena and provide insight into science content while **strengthening literacy skills**.	✓		Each *PhD Science* module features at least one core or supporting trade book. Core trade books directly relate to the anchor phenomenon. They introduce the phenomenon, present background knowledge, and inspire questions and investigations to help students answer the module's Essential Question. Supporting trade books build additional knowledge and promote further observations. The *PhD Science* teacher–writers intentionally included certain sections of the texts at specific points in the modules to reflect the learning cycle and support the development of core ideas and skills. Students engage with these texts in a variety of ways, such as individual reading, group discussion, choral reading, observation of illustrations, listening for evidence, and summarizing.

Module Trade Books

	Module 1	Module 2	Module 3	Module 4
Level 3	*Hurricanes!* by Gail Gibbons (2009) *Tornados!* by Gail Gibbons (2009) *Marvelous Mattie: How Margaret E. Knight Became an Inventor* by Emily Arnold McCully (2006)	*A Butterfly Is Patient* by Dianna Hutts Aston and Sylvia Long (2015) *Amos & Boris* by William Steig (2009)	*Here Come the Humpbacks!* by April Pulley Sayre (2013)	*Moonshot: The Flight of Apollo 11* by Brian Floca (2019)
Level 4	*Grand Canyon* by Jason Chin (2017) *Who Were the Wright Brothers?* by James Buckley Jr. (2014)	*The Boy Who Harnessed the Wind* by William Kamkwamba and Bryan Mealer (2010)	*The Elephant Scientist* by Caitlin O'Connell and Donna M. Jackson (2011)	*Amelia Lost: The Life and Disappearance of Amelia Earhart* by Candace Fleming (2011)
Level 5	*Statue of Liberty: A Tale of Two Countries* by Elizabeth Mann (2011)	*The Mangrove Tree* by Susan L. Roth and Cindy Trumbore (2011) *Living Sunlight* by Molly Bang and Penny Chisholm (2009)	*Cycle of Rice, Cycle of Life* by Jan Reynolds (2009) *The Buffalo Are Back* by Jean Craighead George (2010)	*Look to the Stars* by Buzz Aldrin (2009)

Examples

Level 3 Module 2

Students explore fossil evidence, suitability, and changing environments by learning about butterfly survival. *A Butterfly Is Patient* frames this anchor phenomenon as students are exposed to the text at specific points throughout the module. Students first encounter the book in Lesson 1 when they compare their own drawings of butterflies to illustrations in the book and discuss the insects' physical structures. In Lesson 9, students use evidence from the book to examine caterpillar habitat requirements. In the next lesson, students read a section of the text to revise their understanding of butterfly characteristics. In Lesson 16, another section of the text helps students explore the role

			seasons play in butterfly migration. During the Engineering Challenge, students have the option to use the book as a resource when developing their solution to help save monarch butterflies. Reading the book *Amos & Boris* in this module also helps students deepen their science knowledge and strengthen their literacy skills. In Lesson 11, students provide specific details from the text to discuss mice characteristics and suitability to their environment. In the next lesson, students summarize a passage of the book and use a section of the text to explore what happens when an environment is not suitable for an organism.
c. Students engage with **authentic sources** and incorporate **speaking, reading, and writing** to develop scientific literacy.	✓		Authentic sources give students a glimpse into science labs, field studies, and scientific thinking and processes. *PhD Science* modules feature a variety of sources, including the following: • Authentic research data from a field study or lab experiment • Primary sources such as historical photographs, notebook entries, and publications • Short informational articles about scientific concepts or phenomena • Visual texts such as maps, diagrams, and infographics • Videos and audio recordings Students experience reading, analyzing, and interpreting texts and a wide range of resources through a science lens. In each module, a variety of instructional routines, such as Chalk Talks, Quick Writes, and Question Corners, provide students opportunities to practice speaking and writing in a scientific context. **Examples** For examples of learning activities that engage students with authentic sources, see the following. • Level 3 Module 3 Lesson 6—Students read primary source observations from humpback whale watchers describing the physical and behavioral traits of individual whales. • Level 4 Module 1 Lesson 1—Students view and discuss photographs of John Wesley Powell's expedition to the Grand Canyon to motivate learning about the formation of the canyon's features. For examples of learning activities that involve speaking, reading, and writing, see the following. • Level 3 Module 3 Lesson 17—Students participate in a Question Corners instructional routine. They first discuss ideas with partners as they visit four corner stations before sharing and supporting arguments orally as a class. • Level 5 Module 2 Lesson 10—After observing raspberries at different stages of decomposition, students write a claim about where mold gets the matter necessary for growth. Students also write evidence and reasoning for their claim and share their responses with the class. **For More Detail** For a complete list and description of the instructional routines in *PhD Science*, see the Resources section in the Implementation Guide.

9. Assessment	Yes	No	*PhD Science* Alignment and Program Examples
a. Multiple types of **formative and summative assessments** are embedded in content materials and indicate student progress toward learning targets.	✓		*PhD Science* incorporates a variety of assessment types throughout the curriculum, allowing students to demonstrate their growth and teachers to track student progress toward the learning targets. Each module includes both formative and summative assessments, and each lesson contains an assessment task. **Checks for Understanding** occur in the majority of lessons and provide teachers with the opportunity to formatively monitor student comprehension about the lesson objective. The Checks for Understanding include next steps to guide instruction if students do not demonstrate specific evidence during the assessment task and need additional support to meet the learning targets. Lessons at the end of a concept sequence include a **Conceptual Checkpoint**, which assesses student mastery about the concept in a new context. Students integrate their knowledge about multiple concepts during the **Science Challenge** or **Engineering Challenge**, which typically occur near the end of the module. The Conceptual Checkpoints and Science Challenges and Engineering Challenges are flexible; teachers can use them as either formative or summative assessments. After students synthesize their understandings by answering the module Essential Question in a Socratic Seminar and reflecting on the topics in the driving question board, they individually complete the **End-of-Module Assessment**. This is a summative demonstration of the knowledge and skills students acquired during the module. Through 7–10 tasks, the End-of-Module Assessment assesses all module performance expectations. These tasks vary in both the type of stimuli (e.g., diagrams, investigation descriptions, data sets, and field notes) and the required student response (e.g., model, annotation, written summary, and multiple choice). The End-of-Module Assessment acts as both an assessment *of* learning and an assessment *for* learning, as students participate in a debriefing activity where they complete a self-evaluation of their work, read teacher feedback, look at sample responses, and discuss any remaining questions. **Examples** The following are examples of the four types of assessments embedded in the *PhD Science* lessons. Level 5 Module 3 In Lesson 12, students investigate coastal weathering, erosion, and deposition through creating waves in a shoreline model. As the **Check for Understanding**, students write a claim about how oceans shape coastal landforms, and they provide evidence and reasoning for their claim. This assessment allows teachers to gauge student understanding of the cause and effect relationship between waves and landforms students observed in the investigation. If the Check for Understanding reveals that students need more support, a “next steps” section provides instructional suggestions such as working with students to create a cause and effect chart for the investigation. Level 3 Module 1 In Concept 3, students explore weather hazards, their effects, and solutions to overcome these effects. As the **Conceptual Checkpoint** in Lesson 20, students use a map and a graph of tornado frequency

			to explain when and where tornados are likely to occur in the future. They also propose a solution to overcome the effects of these tornados. Level 5 Module 3 Throughout the module, students examine the interactions between Earth's systems. They apply their knowledge during the **Engineering Challenge** in Lessons 19–23, when they research, design, and test a sustainable irrigation system. This challenge allows teachers to assess their students' understanding of ESS3.C and ETS1.B as they explicitly engage in engineering practices.
b. Assessment items and tasks **integrate the three dimensions in the context of new phenomena**, giving students the opportunity to transfer knowledge.	✓		Like the other stages of the learning cycle, *PhD Science* assessments are phenomenon driven. But in the Conceptual Checkpoints and End-of-Module Assessment tasks, students respond to scenarios that differ from the anchor phenomenon. By completing assessment tasks in an unfamiliar context, students transfer their learning. This transfer solidifies their understandings and increases the likelihood they will apply their new knowledge in the real world. Student success on these unfamiliar assessment tasks requires integrating the three dimensions. Conceptual Checkpoints target at least one DCI and involve participating in a Science and Engineering Practice and/or using the lens of a Crosscutting Concept. The majority of End-of-Module Assessment tasks assess all three dimensions, as students must demonstrate knowledge of a DCI and a CC through practice. **Examples** Level 5 Module 2 Students explore the flow of matter and energy in a mangrove forest ecosystem. As the summative individual assessment, students then transfer their knowledge to a new context by responding to questions about space colony design in the End-of-Module Assessment. Its tasks require students to use the three dimensions. For example, in task 4 students demonstrate the importance of matter cycles (CC.5) through providing evidence for a claim (SEP.7) about how gases cycle between organisms and the environment (LS2.B). Level 5 Module 1 Students also transfer their knowledge during the Conceptual Checkpoints. For instance, in this example, students observe bread at varying temperatures in Lesson 11 to explore properties of matter. As a Conceptual Checkpoint in the next lesson, students plan an investigation (SEP.3) and explain the necessary evidence to test whether a crayon becomes a new substance (PS1.A) when it melts (CC.2).

c. **Scoring guidelines and rubrics** align with performance expectations and incorporate criteria that are specific, observable, and measurable.	✓		The *PhD Science* teacher–writers designed assessment tasks that align with performance expectations and include specific, observable, and measurable evaluation guidelines. Each End-of-Module Assessment includes sample student responses and a rubric that lists the targeted Performance Expectations, Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts for each task. The rubric includes descriptions of student work for each task that define the following four performance levels: 1—Incorrect or unreasonable response with no detail or evidence provided 2—Correct or reasonable response with no detail or evidence provided OR incorrect or unreasonable response with some detail or evidence provided 3—Correct or reasonable response with some detail or evidence provided OR incorrect or unreasonable response with sufficient detail or evidence provided 4—Correct or reasonable response with sufficient detail or evidence provided The numerical ratings associated with descriptions allow teachers to quantify student progress while providing qualitative feedback. Checks for Understanding and Conceptual Checkpoints also provide specific, observable, and measurable information about student performance. Teachers can assess their students' understanding by using the list of evidence criteria embedded in the lesson for each of these tasks. **Examples** Level 5 Module 1 Students investigate a mystery substance by mixing it with lemon juice in part II of the End-of-Module Assessment. After conducting the investigation and recording their observations, students make a claim about whether the investigation resulted in a new substance by using evidence from their observations. 5-PS1-4 is the performance expectation listed on the rubric for this task: Conduct an investigation to determine whether the mixing of two or more substances results in new substances. The description of the highest performance level for the claim is the following: • The student claims that mixing the mystery substance with lemon juice formed a new substance and provides sufficient supporting evidence, including decreased total weight, gas formation, and a change in odor. Level 4 Module 1 In Lesson 5, students complete a Conceptual Checkpoint by interpreting a model of fossil layers that construction workers found. The Standards Addressed section of the lesson lists 4-ESS1-1 as the targeted performance expectation: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. As a guideline for teachers, the Conceptual Checkpoint box embedded in the lesson explains that "students should demonstrate understanding that rock layers, and the fossils found in those layers, provide evidence of changes to Earth's surface over time." This guideline is further explained with three specific criteria students should include as evidence of their understanding.

d. Assessments are **accessible and unbiased** for all students.	✓		*PhD Science* assessments allow all students to demonstrate their science knowledge. To ensure assessments are accessible and unbiased for all students, the *PhD Science* teacher–writers designed tasks that meet the following criteria: • Assessment contexts and scenarios do not rely on experiences that only some students may have encountered. If background knowledge is necessary to succeed on an assessment task, students explore resources to build this knowledge during the lesson, or the assessment provides the information. • Students are assessed on science content, not interdisciplinary knowledge or skills such as complex calculations. The assessments focus on the NGSS core ideas, practices, and concepts. Students demonstrate their understanding of the core ideas and concepts through using the science and engineering practices. • Consistent language is used. Terminology in the assessment tasks comes from the lessons, and the same language is used across concepts, modules, and grade levels. • Appropriate scaffolding is provided for English learners. Lessons include explicit instruction for new science and academic terms, and the assessment tasks include differentiation strategies. **Examples** Level 5 Module 3 Students respond to prompts about fresh water accessibility in Mexico City as part I of the End-of-Module Assessment. Before beginning, students first build background knowledge by examining and discussing a variety of resources about Mexico City. Level 3 Module 2 The contexts and scenarios in the End-of-Module Assessment are accessible to all students. On this assessment, students complete tasks about the Everglades. The assessment includes pictures of the Everglades so all students have the necessary background information about this environment. Task 2(b) of this assessment demonstrates how tasks assess students on science content, not on skills or knowledge from other disciplines. Specifically, this task assesses understanding of LS2.D: Social Interactions and Group Behavior. Students examine a photograph of a solitary otter and a photograph of an otter in a group and then construct an argument about which otter is more likely to survive. Level 4 Module 2 In Lesson 9, the Conceptual Checkpoint uses consistent language. For this assessment, students draw a model of a golf club hitting a ball and use their knowledge of energy transfer to explain each stage of the collision, a term that is explicitly introduced in a thought experiment at the end of Lesson 7, before students complete the checkpoint. In Lessons 8 and 9, students investigate energy transfer during collisions and practice using the terms *collision* and *energy transfer* multiple times before the checkpoint through discussing their results.

<table>
<tr><td></td><td></td><td></td><td>Level 4 Module 2
An example of appropriate scaffolding for English learners is in the Check for Understanding in Lesson 12. Students revisit a photograph of a generator from the beginning of the lesson and explain the parts as the formative assessment task. When the photograph initially appears at the beginning of the lesson, the lesson instructs teachers to explicitly introduce the term generate by discussing its meaning in multiple contexts and using the process outlined in the English Language Development section of the Implementation Guide.</td></tr>
<tr><th>10. Organization & Usability</th><th>Yes</th><th>No</th><th>PhD Science Alignment and Program Examples</th></tr>
<tr><td>a. Curricular content is purposefully sequenced and designed for ease of use for a full academic year.</td><td>✓</td><td></td><td>
The module structure of PhD Science is designed to fit an academic year. Each grade level is organized into four modules of instruction, and the modules are sequenced so that learning builds on prior modules. Each module has 25–30 lessons, for a total of 105–115 lessons per grade level. Lessons are grouped into lesson sets that deal with specific phenomena, and the lesson sets are organized into concepts under broader Focus Questions. Each module features three or four concepts, along with an Application of Concepts section.
The PhD Science teacher–writers designed the lesson activities to meet the suggested time allocations for each lesson section. And thanks to thorough testing, the investigations are feasible in the time suggested. While the individual lessons are intended to take 45 minutes of class time, the lesson set structure is flexible for teachers who have longer or shorter periods for science instruction.
Examples
The following table shows how Level 5 is structured for ease of use in one academic year:
<table>
<tr><th>Module</th><th>1: Matter</th><th>2: Ecosystems</th><th>3: Earth Systems</th><th>4: Orbit and Rotation</th><th>Total</th></tr>
<tr><th>Number of Lessons</th><td>26</td><td>26</td><td>27</td><td>26</td><td>105</td></tr>
</table>
Level 4 Module 2
Lesson 9 is an example of how the lesson activities can fit in a 45-minute time frame. Students begin by spending 5 minutes comparing investigations from the preceding two lessons and deciding to model the steps in one of the investigations. Next, they spend 10 minutes on modeling each of the three steps, for a total of 30 minutes on the model construction. Finally, at the end of the lesson students spend 10 minutes to reflect on what was revealed through the modeling by updating the anchor chart and completing a Conceptual Checkpoint.
Level 3 Modules 2 and 3
These modules demonstrate how the content is purposefully sequenced. In Module 2, students explore organisms’ characteristics and suitability to their environment. In the next module, students build on these understandings as they learn about variation in individuals’ traits, how these variations arise, and how they affect individuals’ survival and reproduction.
</td></tr>
</table>

b. **The curriculum includes all necessary components for implementation**, including trade books and investigation materials.	✓		Great Minds provides materials kits for purchase from an external supplier. The kits contain all supplies needed for each module, including the materials for investigations. To accommodate the variety of school inventories and budgets, Great Minds offers the following purchasing options: individual supplies, separate module kits, a safety kit, or a complete grade level kit with all four module kits and a safety kit. Module kits are in separate bins for easy storage and restocking, and refill kits are available to replace consumable supplies. Trade books and Science Logbooks are also available for purchase through Great Minds. Science Logbooks are a consumable resource that allow students to record questions, document observations, draw models, demonstrate analyses, construct explanations, and record Conceptual Checkpoint responses. **For More Detail** See the materials list included with each lesson set.
c. Science classroom and laboratory **safety guidelines** are embedded in the curriculum.	✓		Student and school staff safety is of the utmost importance. Expert teachers thoroughly tested investigations to minimize risks, and lessons note specific safety precautions. Each Module Overview also includes general safety guidelines as well as module-specific information. The Safety section for each level's Module 1 Overview encourages teachers to stress the importance of safety at the start of the school year. The Module 1 Resources section includes a safety contract for parents and students to sign, along with a safety quiz to ensure that students know the safety rules and procedures. **Examples** Level 3 Module 2 In Lesson 10, students observe radish plants. The safety note explains that students must not place soil or any parts of the plants in their eyes or mouth and to wash their hands immediately after handling the plants. Level 5 Module 1 In Lesson 15, students mix materials to observe the formation of new substances. The safety note describes how students should use the wafting technique to smell substances, and how they should avoid drinking or tasting anything. **For More Detail** See the Safety section in the Implementation Guide, the Safety Guidelines section of each Module Overview, and the safety contract and quiz in each level's Module 1 Resources.

d. Student access to **computer technology** is required for lessons.		✓	Technology is incorporated into lessons only when it adds to student understanding and is age appropriate. The *PhD Science* curriculum is largely hands-on; while technology may be used to support the curriculum, it does not require student devices. **Examples** The following examples show how student access to computer technology is ***not*** required. Level 3 Module 2 In Lesson 16, an optional homework assignment asks students to sign up for the citizen science project Journey North, or another sighting project, and record sightings of migrating organisms. But students thoroughly explore migration in class by analyzing Journey North data together, so individual access to the website is not a requirement. Level 4 Module 3 In Lessons 8–10, students investigate waves by creating wave tanks in the classroom. An extension suggests students explore the simulation “Waves on a String” from PhET Interactive Simulations. But this simulation is not required, as students have ample opportunity to build their understanding of wave properties during the hands-on investigations and in-class demonstrations.