Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science

Unit 4 Student Profile

Providing Solutions to Problems using Simple Wave Properties

August 2023

The SIPS Grade 8 Science Unit 4 Student Profile: Providing Solutions to Problems using Simple Wave Properties was developed with funding from the U.S. Department of Education under the Competitive Grants for State Assessments Program, CFDA 84.368A. The contents of this paper do not represent the policy of the U.S. Department of Education, and no assumption of endorsement by the Federal government should be made.

SIPS Grade 8 Science Unit 4 Student Profile

The Stackable, Instructionally-embedded, Portable Science (SIPS) Assessments Unit 4 Student Profile describes what students should know and be able to demonstrate **prior to**, **during**, and at the **culmination** of three-dimensional science instruction in Unit 4 to prepare for new and increasingly sophisticated learning opportunities beyond grade 8. The student profile is intended to build science educators' understanding of the targeted student learning outcomes and how they are situated in the context of year-long instruction to promote and inform the intentional selection of curricular materials and design of instructional opportunities to achieve these outcomes for all students. In addition, the end-of-unit profile can support discussion with students, parents, and guardians about the Unit 4 topic of interest "Providing Solutions to Problems using Simple Wave Properties" and the knowledge, skills, and abilities to which teaching and opportunities to learn will be based.

The Stackable, Instructionally-embedded Portable Science (SIPS) Assessments Unit 4 student profile provides a description of:

1. The ***prior learning opportunities*** and necessary ***prior knowledge and skills*** that students are expected to have acquired for all three dimensions—Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs)—before engaging in Unit 4, "Providing Solutions to Problems using Simple Wave Properties." These prior learning opportunities and knowledge and skills serve as entry points to the unit to ensure readiness and to foster understanding of new and increasingly sophisticated learning experiences. This section also includes an explanation of how prior learning, knowledge, and skills will be built upon in the unit.
2. The ***knowledge, skills, and abilities students are expected to learn and demonstrate by the end of the unit*** when provided with opportunities to integrate scientific and engineering practices with important disciplinary core ideas and crosscutting concepts to scientifically investigate and understand natural phenomena and solve important science and engineering design problems.
3. The future ***learning experiences that will allow students to build from and expand on their learning in the SIPS grade 8 units*** to effectively engage in the SEPs to sense-make using acquired scientific knowledge and understanding of the CCCs in the context of multiple DCIs. This section highlights key connections among important scientific ideas, practices, and concepts that students investigate as they progress from one unit, course, or grade level, to the next.

The following sections describe the prior learning and knowledge, skills, and abilities that students are expected to bring to and acquire by the end of the unit, respectively, and how these knowledge, skills, and abilities prepare students to deepen their science learning in future learning experiences. The content in these sections draws from the dimensional appendices of the NGSS (Appendix E, Appendix F, Appendix G), the performance expectations articulated in the NGSS, A Framework for K12 Science Education, and Stage 1 of the SIPS Unit 4 map.

1. Prior Learning Opportunities

By building familiarity with the Unit 3 scientific practices and crosscutting concepts related to the history of Earth and how the fossil structures found within it are genetically related to present-day life forms, Unit 4 allows students to use and extend their understanding and application of these practices and crosscutting concepts to the properties of mechanical and light waves and how they can be used to define and delimit engineering problems. In Unit 3, students use the practice of developing and using models and the crosscutting concept of cause and effect to understand adaptation and changes in life on Earth. Their understanding of this SEP and CCC are further explored in the understanding of simple waves, their properties and types, and how students can determine success criteria and constraints needed to solve problems related to waves. Essential prior learning from upper elementary (grades 3–5) and middle school (grades 6 and 7) related to the DCIs, CCCs, and SEP are provided in Appendix A.

2. End-of-Unit Learning Outcomes

Measurement targets are narrative descriptions that integrate the DCIs, SEPs, and CCCs into a single statement representing what is to be taught and assessed in each unit. The SIPS Measurement Target for this unit is:

- Students are able to apply Science and Engineering Practices with an emphasis on developing and interpreting models and using mathematical representations related to how waves transfer energy and information through various materials and utilizing elements of structure and function of an object's material to determine and describe why light is reflected, absorbed, or transmitted through different materials.

By engaging in this unit, students will further deepen their knowledge of the characteristics of simple waves and how the introduction of a medium can change their behavior. They will also learn how to define and delimit engineering problems involving light and mechanical waves. In this unit, there is significant overlap and synergy between the DCI and CCC dimensions, where patterns and structure of a wave will define its characteristics and properties. Similarly, the particular SEPs allow students to define problems, use mathematical and computational thinking, and consider other evidence to develop models and explanations around wave properties.

Descriptions of the specific learning expectations associated with each dimension are elaborated below.

DCI

The Grade 8 Unit 4 topic, "**Providing Solutions to Problems using Simple Wave Properties**" organizes three performance expectations that together enable the development and use of models that explain how wave properties can be used to provide solutions to design problems. Also, through the use of mathematical and computational thinking, students can show the relationship between wavelength and frequency. In working with these disciplinary core ideas, students are positioned to understand wave properties and their applications to design problems.

CCC

Over the course of Unit 4, students will identify and represent patterns, especially as they relate to how a medium can change the behavior of a wave. Students also make use of structure (Structure and Function) in understanding characteristics and properties of different waves. In support of these crosscutting concepts, students will gain experience with cause/effect relationships that students encounter while learning about simple wave properties.

SEP

Over the course of Unit 4, students will gain much experience and practice with defining problems and developing models and using mathematical and computational thinking. When defining problems and creating explanations, they will consider the development of an object, tool, process, or system, and multiple criteria and constraints, including scientific knowledge that may limit possible solutions that use wave properties. They will also use models to describe wave phenomena. In support of these models and resulting design solutions, students will gain experience in mathematical and computational thinking to understand the relationship between wavelength and frequency.

3. Connections to Future Learning Opportunities

DCI

Unit 4 focuses extensively on understanding the properties and types of simple waves, the wave model of light, how the presence or absence of a medium influences their behavior, and how engineering design problems can be solved by determining success criteria and constraints related to wave properties. Students' learning and understanding increase in sophistication beyond grade 8 where students extend their knowledge to resonance in speech and music and also how information can be digitized by combining waves of different frequencies thereby encoding and transmitting. The wave model introduced in this unit is useful for explaining many features of electromagnetic radiation explained in later grades. The criteria and constraints they specify in this unit are later quantified and applied to global challenges facing humanity for potential solutions.

ETS1.A as found in MS-ETS1-1

The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

ETS1.A as found in HS-ETS1-1

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

PS4.A as found in MS-PS4-1

A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

PS4.A as found in HS-PS4-1

The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

PS4.A as found in MS-PS4-2

A sound wave needs a medium through which it is transmitted.

PS4.A as found in HS-PS4-2

Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

PS4.B as found in MS-PS4-2

When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

PS4.B as found in HS-PS4-3

Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

PS4.B as found in HS-PS4-4

When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

PS4.B as found in HS-PS4-5

Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

CCC

Unit 4 CCCs focus on using Cause and Effect, Patterns, and Structure & Function to describe wave properties and to identify cause and effect relationships as they pertain to how wave behavior is influenced by the presence or absence of a medium. In future high school learning experiences related to wave properties, students will use empirical evidence to differentiate between cause and correlation in wave properties and make claims about specific causes and effects (HS-PS4-1).

SEP

Unit 4 SEPs focus predominantly on asking questions and defining problems, using mathematical and computational thinking, and developing and using models, but also include planning and carrying out investigations, analyzing and interpreting data, and constructing explanations and designing solutions. Students will again visit these practices in their future learning experiences by using mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations (HS-PS-4-1). They will also evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design (HS-PS4-2).

Appendix A. DCI, CCC, and SEP Prior Learning Opportunities

DCIs – ETS1.A, PS4.A, & PS4.B (from NGSS Appendix E: DCI Progression within NGSS)

- **Prior Learning from 3-5** (NRC Framework)
  - Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)
  - Earthquakes cause seismic waves, which are waves of motion in Earth's crust.
  - A great deal of light travels through space to Earth from the sun and from distant stars.
  - An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. (Boundary: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.)
  - Possible solutions to a problem are limited by available materials and resources (constraints).
  - The success of a designed solution is determined by considering the desired features of a solution (criteria).
  - Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.
- **Prior learning from this grade band (e.g., Grades 6 & 7):**
  - Minimal/ Not Applicable

CCC - Patterns

- **Prior learning from 3-5**: Students identify similarities and differences, identify patterns related to time, and use patterns to make predictions and categorizations.
  - Ten PEs in 3-5 use this CCC. Some uses are similar to the elements of the CCC used in this unit's 2 PEs with Patterns CCC (e.g., 3-PS2-2 involves making a prediction, which is possible because of

cause-and-effect relationships; 5-ESS1-2 involves representing data in graphical displays to reveal patterns.

- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students are expected to use graphs, charts, and images to identify patterns in data. They are also expected to use cause-and-effect relationships to identify patterns in data (Appendix G).
  - Multiple MS PEs use this CCC, so students will likely have some experience with the CCC's MS elements, prior to starting Grade 8 Unit 4.

CCC – Structure & Function

- **Prior learning from 3-5:** Students move beyond structures to also consider substructures, and how substructures can sometimes be observed and serve different functions.
  - No Grade 3-5 PEs use this CCC so students will likely have minimal experience with this CCC prior to starting middle school.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students visualize, model, and describe functions in terms of how they are enabled by different structures and how materials (and their properties) can enable these functions.
  - Five MS PEs use this CCC, and MS-LS1-2 uses the same element of the Structure & Function CCC as used in this unit's PE.

CCC – Systems and System Models

- **Prior learning from 3-5:** Students are expected to understand that a system is composed of components that interact with one another and also that the system can do things that depend on the different components, which may each have a unique function, and that the components operating together can enable the system to carry out functions that individual parts cannot.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students are expected to develop additional sophistication in identifying the way that components of a system interact with one another and with the environment (surroundings) of the system.
  - Multiple MS PEs use this CCC, so students will likely have some experience with the CCC's MS elements, prior to starting Grade 8 Unit 4.

CCC – Cause & Effect

- **Prior learning from 3-5:** Students become adept at identifying/testing causes and effects and become aware that events can be correlated but not causally related.
  - 13 Grade 3-5 PEs use this CCC so students will likely have substantial experience with the CCC prior to middle school. An example PE that uses the CCC in a way that presages this unit's PE's CCC element (*Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability*) is 4-ESS3-2 (*Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans*.) because solutions' effectiveness can be impacted by multiple factors and their intended effects might be best described probabilistically.

- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students gain experience with multifaceted causal relationships, distinguishing between correlation and causation, and using cause-and-effect relationships to make predictions.
    - 15 middle school PEs use this CCC so students will likely have substantial experience with the CCC during Grades 6 and 7. For example, MS-ESS2-5 (*Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.*) implies examining multifaceted causes and probabilistic outcomes.

CCC – Structure & Function

- **Prior learning from 3-5:** Students move beyond structures to also consider substructures, and how substructures can sometimes be observed and serve different functions.
    - No Grade 3-5 PEs use this CCC so students will likely have minimal experience with this CCC prior to starting middle school.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students visualize, model, and describe functions in terms of how they are enabled by different structures and how materials (and their properties) can enable these functions.
    - Five MS PEs use this CCC and MS-LS1-2 uses the same element of the Structure & Function CCC as used in this unit's PE.

SEP- Asking Questions and Defining Problems

- **Prior learning from 3-5 (e.g., Grades 3 & 4 and/or prior SIPS G5 units):** During grades 3-5 students should progress in their ability to define problem statements and to identify how objects or tools can be used to address the problem [Appendix F].
    - Define a statement of a problem that can be addressed by an object or tool.
    - Two PEs (3-PS2-3 and 3-PS2-4) focus on Asking Questions and Defining Problems in the domain of relationships of electrical and magnetic interactions.
    - One PE (4-PS4-3) focuses on generating solutions to use patterns to transfer information. (This also integrates Connections of Science, Engineering, and Technology).
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students progress to specify relationships between variables and clarify arguments and models.
    - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 Unit 4. MS-PS2-3 is an example MS PE that uses the same SEP element as this unit's PE (MS-ETS1-1).

SEP - Developing and Using Models

- **Prior learning from 3-5:** Students continue developing their modeling skills and abilities by developing and revising different types of models, along with beginning to consider that models can have limitations. [Appendix G]
    - PE 4-PS4-2 is an example of a 3-5 grade band PE that uses a Developing and Using Models SEP element that is very similar to the SEP element used in this unit.

- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students develop, use, and revise models to describe, test, and predict more abstract phenomena and to design systems.
    - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 Unit 4. MS-PS2-3 is an example MS PE that uses the same SEP element as this unit's PE (MS-PS4-2).

SEP - Engaging in Argument from Evidence

- **Prior learning from 3-5:** Students will develop their argumentation skills and abilities by constructing arguments, supporting those arguments with evidence, and forming an argument to critique an explanation or model. (Appendix F)
- **Prior learning from this grade band (e.g., Grades 6 & 7):** Students progress to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). This will include presenting an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
    - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 Unit 4. MS-LS1-3 and MS-ETS-1-2 are examples of MS PEs that use this SEP element.

SEP – Planning and Carrying Out Investigations:

- **Prior learning from 3-5:** Students should understand how to plan and conduct investigations that provide evidence to support explanations or designs and to include the control of variables. They will be able to evaluate methods and/or tools for collecting data.
    - In grades 3-5, students will know how to carry out investigations to produce data to serve as the basis for evidence, using tests in which variables are controlled and the number of trials is considered.
    - Students should be able to make predictions about what would happen if a variable changes. [Appendix F]
- **Prior learning from this grade band (e.g., Grades 6 & 7 and/or prior SIPS G8 units):** During all MS grades will be able to plan and conduct investigations that use multiple variables and provide evidence to support explanations or solutions. This includes making decisions about the best way to get data that provides the evidence to meet the goals of the investigation**.**
    - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 Unit 4.
    - An example MS PE that uses the same SEP element (i.e., students will have had experience with this SEP if they were previously taught this MS PE): MS-PS3-4. *Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*

SEP – Using Mathematics and Computational Thinking

- **Prior learning from 3-5:** This SEP is not introduced in K-5 until Grade 5 (5-PS1-2 and 5-ESS2-2). Therefore, it is likely that students will have minimal exposure to formal learning of this SEP prior to middle school.
- **Prior learning from this grade band (e.g., Grades 6 & 7):** This SEP is only used in 2 PEs in the 6-8 grade band (MS-PS4-1 (this unit) and MS-LS4-6). Therefore, it is likely that students will have minimal exposure to formal learning of this SEP in Grades 6 and 7.