Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science
Unit 1 Student Profile
Forces and Energy
March 2023

The SIPS Grade 8 Science Unit 1 Student Profile: Forces and Energy 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 1 Student Profile

The Stackable, Instructionally-embedded, Portable Science (SIPS) Assessments Unit 1 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 1 to prepare for new and increasingly sophisticated learning opportunities in Unit 2. 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 1 topic of interest "Forces and Energy" and the knowledge, skills, and abilities to which teaching and opportunities to learn will be based.

The SIPS Assessments Unit 1 student profile provides a description of:

1. The necessary ***prior learning opportunities*** and ***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 1. 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 ***learning experiences in Unit 2 that allow students to build from and expand their learning in Unit 1*** 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 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 Unit 2. 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 the stage 1 learning goals in the SIPS Unit 1 map.

1. Prior Learning Opportunities

By building on familiarity with the previously learned ideas related to the study of forces and energy in this unit early in the school year, Unit 1 allows students to use and extend this knowledge to explain phenomena and solve design problems when investigating Earth's place in the universe and waves in later related units. Unit 1 focuses on forces and energy. Unit 2 focuses on space systems, especially those within the Earth/sun/moon system and across the solar system, with a particular focus on the role of gravitational forces on motion. By building familiarity with ideas related to forces and motion early in

the year, students are prepared to put their knowledge to work in various physical system settings in later units. Essential prior learning from grades 3-5 and the 6-8 grade band related to the DCIs, CCCs, and SEPs 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 planning investigations, related to the scale of motion of an object, interactions between objects, and constructing and interpreting graphical displays of data in support of an argument to explain interactions between energy, forces, and motion in a system.

By engaging in this unit, students will develop an understanding of the motion of objects and how interactions between objects can be explained and predicted as scientific concepts related to forces and energy by developing models, making observations, and conducting investigations to demonstrate and deepen their understanding. The DCIs and SEPs work together in allowing students to design investigations associated with the anchoring and instructional phenomena to examine important interactions associated with forces and motion, including how forces induce changes in motion. The DCIs, SEPs, and CCCs work together in allowing students to collect and/or analyze data to support their explanations of the proportions involved in describing proportional relationships between kinetic energy, mass, and velocity, including describing how those relationships define the nature of the quantities used to characterize energy. Their explorations and investigations will necessarily lead them to represent forces in a system. Finally, they will use argumentation from evidence as a basis for drawing conclusions related to the presence of forces within two-body systems, especially in systems where contact forces (collisions) are involved.

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

DCI

The Grade 8 Unit 1 topic, “Forces and Energy” organizes performance expectations to examine how forces are present in systems of two objects, and then to use the study of forces as a means to characterize the energy within the system and the changes in motion that result when two objects interact, either through contact or non-contact forces. Investigating interactions allows for the collection of data that shows that the forces that are present in an interaction are equal in magnitude but opposite in direction. The forces on an object, if unbalanced, cause changes in an object’s motion that depend on the size and direction of the forces and also on the mass of the object. Examining the changes in velocity and the masses of the objects allow students to develop explanations of the proportional relationships of energy, mass, and velocity. Students also develop knowledge of how non-contact forces allow for changes in motion and the exchange of energy, with the strength of the force dependent on both distance and mass.

By building familiarity with ideas related to forces and matter in this unit early in the school year, students are prepared to use this knowledge to develop solutions to important problems, using forces and energy to control motion and the impact of collisions in later units.

CCC

Over the course of Unit 1, students will examine the interaction of objects by considering them as an interacting system, including developing system models that account for important variables, especially mass, velocity, and energy (i.e., using the Systems and System Models CCC). These models are also characterized using the Scale, Proportion, and Quantity CCC. This includes understanding how the relative masses of objects (scale) can lead to very different changes in motion (scale); how the relationships between the size of forces and the magnitude of kinetic energy exist in proportional relationships that depend on multiple quantities, including mass, velocity, and distance. Finally, the role of forces on the change in motion and (for gravitational systems) on stable dynamic systems is related to the Stability and Change CCC.

SEP

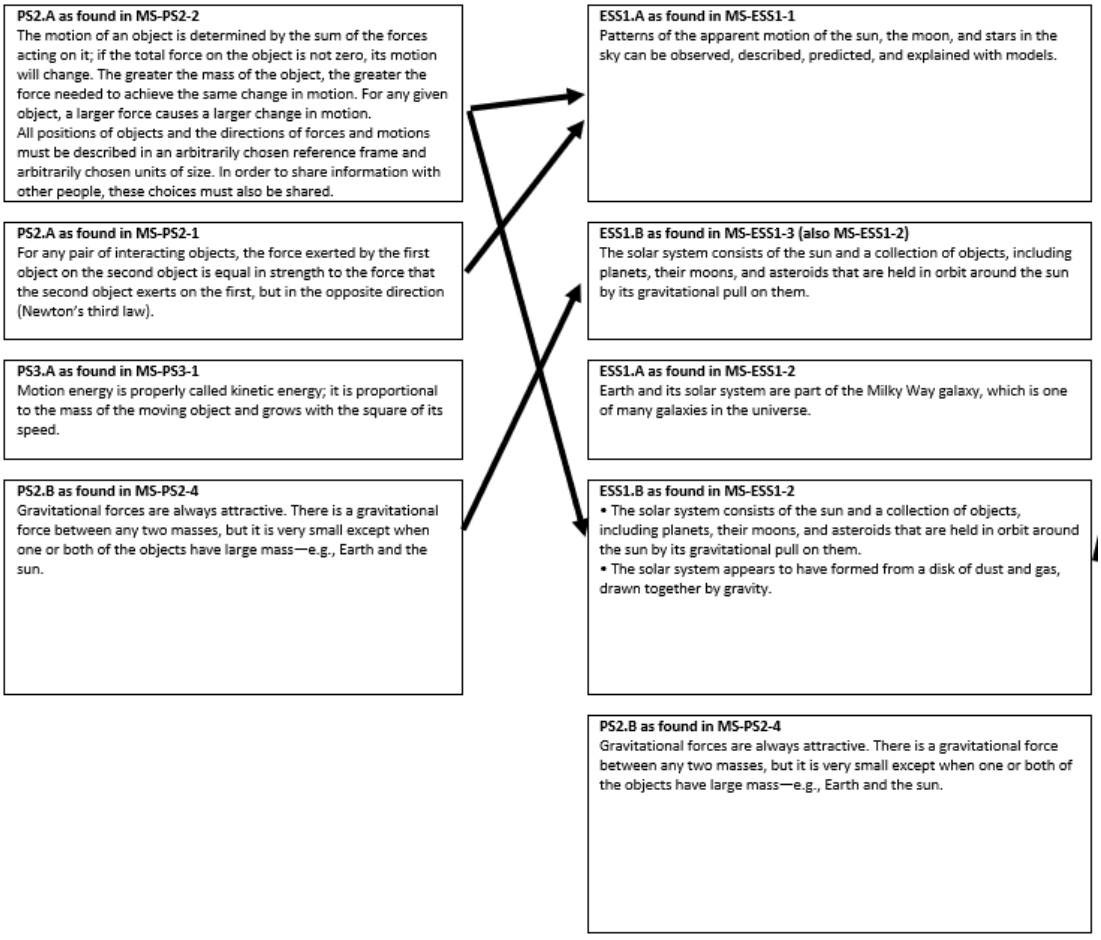
Over the course of this unit, students will engage in planning and carrying out investigations to examine how forces within a system affect different outcomes, with different variables examined using different experiments to document the role of the variable on the key outcome (changes in motion; changes in energy). The investigations will provide empirical evidence that is examined by analyzing and interpreting data to place the experimental parameters in a relationship (graphical, tabular) that can be examined to reach conclusions. These conclusions about forces, interactions, and energy will be characterized through arguments based on evidence that allow for empirically based statements about different physical laws. Finally, these conclusions will provide the basis for constructing explanations of different phenomena and designing solutions to important problems that reflect the role of forces, interactions, and energy in systems that are subject to contact and non-contact forces.

3. Connections to Unit 2 Learning Opportunities

DCI

Unit 1 deals with forces and energy with a focus on the basis of Newton's three laws of motion and how they can be observed and applied to a variety of situations to design and evaluate solutions to everyday problems. Knowing how objects in motion possess energy and how contact and non-contact forces (i.e., electric, magnetic, and gravitational) cause objects to move, accelerate, decelerate, stop, or change directions will help students to build an understanding of concepts in Unit 2 where students will learn about the Earth/sun/moon system and the solar system and the role of gravitational forces in determining the motions with these systems.

SIPS Grade 8 Disciplinary Core Ideas (DCIs) Flowchart



CCC

Unit 1 CCCs include Stability and Change, Systems and System Models, and Scale, Proportion, and Quantity. Unit 2 CCCs focus on Systems and System Models ("Systems are held together by gravitational forces.") and Scale, Proportion, and Quantity ("Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small including the motions of objects in the sun/Earth/moon system, motions of the planets in the solar system, and motions of larger astronomical objects.") While the CCC of Stability and Change is not directly examined in Unit 2, it will be important to support learning about systems such as the way that living systems, including species, exhibit stable characteristics until moments of environmental change.

SEP

Unit 1 SEPs include Planning and Carrying Out Investigations, Constructing Explanations and Designing Solutions, Analyzing and Interpreting Data, and Engaging in Arguments from Data that appear in later units. In Unit 2, the SEP of Analyzing and Interpreting Data is important in using data on the observed positions of planets and the occurrence of eclipses and seasonal behavior as positions of objects in the solar system as a basis for determining the relative positions and motions of different objects. In addition, the SEP Engaging in Argument from Evidence is a key part of understanding how gravitational

forces account for the motions of orbiting objects. The SEP Constructing Explanations and Designing Solutions is used in Unit 3 as part of understanding the role of geological data in understanding the Earth's history. Although Planning and Carrying out Investigation from Unit 1 does not appear in the PEs for later units, skill with this SEP is central to the data analysis and use of evidence in later units.

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

DCIs – PS2.A, PS2.B, & PS3.A (from NGSS Appendix E: DCI Progression within NGSS)

- **Prior Learning from 3-5**
    - The effect of unbalanced forces on an object results in a change of motion.
    - Patterns of motion can be used to predict future motion.
    - Some forces act through contact; some forces act even when the objects are not in contact.
    - The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.
    - Moving objects contain energy. The faster an object moves, the more energy it has.
    - Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions.
    - When objects collide, contact forces transfer energy to change the objects' motions.

CCC – Scale, Proportion, and Quantity:

- **Prior learning from 3-5:** Students are expected to understand that events depend on phenomena that operate at very different scales, but also that fundamental interactions are present through these differences. They are also expected to understand the importance of units and their association with observable quantities.
    - In grades 3-5, students learn to recognize that natural objects and observable phenomena exist from the very small to the immensely large.
    - They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume. [Appendix G]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students are expected to become adept at working across different scales and how phenomena observed at one scale may not be observable at another scale. They use proportional relationships (e.g., speed) to gather information about the magnitude of properties and processes.
    - Multiple MS PEs use this CCC, so students will likely have some experience with the CCC's MS elements, prior to starting Grade 8 and Unit 1.
    - An example MS PE that uses the same CCC element (i.e., students will have had experience with this CCC if they were previously taught this MS PE) is MS-LS1-1: *Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.*

CCC – Systems and System Models:

- **Prior learning from 3-5:** Students are expected to understand how a system is composed of components that are interacting with one another and also that the system can do things that depend on the different components, which may each have a unique function.
    - In grades 3-5, students understand that a system is a group of related parts that make up a whole. The system as a whole can carry out functions its individual parts cannot.
    - They learn to describe a system in terms of its components and their interactions. [Appendix G]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, 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 and Unit 1.
    - An example MS PE that uses the same CCC element (i.e., students will have had experience with this CCC if they were previously taught this MS PE) is MS-LS1-3: *Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

CCC – Stability and Change:

- **Prior learning from 1-2 (NOTE: Stability and Change is not referenced by any Grade 3-5 PEs)**.
    - In grades 1-2, Students learn that some things change while others stay the same and that change can occur over short and long time periods.
    - Students learn that some systems appear stable, but over long periods of time, they will eventually change. [Appendix G]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students are expected to be able to characterize how systems change, including using changes over time and considering forces at different scales. Students learn that changes in one part of a system might cause large changes in another part and how some systems are cases of dynamic equilibrium.
    - Multiple MS PEs use this CCC, so students will likely have some experience with the CCC's MS elements, prior to starting Grade 8 and Unit 1.
    - An example MS PE that uses the same CCC element (i.e., students will have had experience with this CCC if they were previously taught this MS PE) is MS-LS2-4: *Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

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):** 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 provide 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 and Unit 1.
  - 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) is 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 – Analyzing and Interpreting Data:

- **Prior learning from 3-5:** Students will have understanding and experience with the collection of data using quantitative approaches *to* collecting data and conducting multiple trials of qualitative observations. They will be able to carry out the analysis and interpretation of the data using logical reasoning, mathematics, and/or computation.
  - In grades 3-5, students will represent data in tables and/or various graphical displays to reveal patterns that indicate relationships.
  - They will analyze data to refine a problem statement or the design of a proposed object, tool, or process. mathematics, and/or computation. [Appendix F]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades students will build understanding and skills with quantitative analysis of investigations. They will distinguish between correlation and causation and carry out basic statistical techniques of data and error analysis.
  - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 and Unit 1.
  - 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) is MS-LS2-1: *Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.*

SEP –Engaging in Argument from Evidence:

- **Prior learning from 3-5:** Students will have the ability to construct scientific explanations or solutions and to critique those proposed by peers by citing relevant evidence about the natural and designed world(s).

- In grades 3-5, students will develop understanding and skills for how to construct and/or support an argument with evidence, data, and/or a model.
- They will be able to distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- They will use relevant evidence and pose specific questions in the process of respectfully providing and receiving critiques from peers about a proposed procedure, explanation, or model. [Appendix F]

- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades students will 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 and Unit 1.
  - 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) is MS-LS1-3: *Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

SEP – Constructing Explanations and Designing Solutions:

- **Prior learning from 3-5:** Students will use variables that describe and predict phenomena in order to construct explanations and to design multiple solutions to design problems.
  - In grades 3-5, students will be able to identify evidence that supports particular points in an explanation.
  - They will be able to generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. [Appendix F]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students will construct explanations and design solutions that are supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
  - Multiple MS PEs use this SEP, so students will likely have some experience with the SEP's MS elements, prior to starting Grade 8 and Unit 1.
  - 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) is MS-ESS2-2: *Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*