## Sample Integration of Science and ELD Standards in the Classroom

Students have been collecting local weather data on a daily calendar. They work as a whole group near a large chart that shows labeled images of various types of severe weather (different from those on the daily calendar) and view a video of severe weather (such as heavy rain and wind, blizzard, or heavy snowstorm). Students explore the phenomena, asking questions about the purpose of weather forecasting and how to respond to severe weather in their locality (K-ESS3-2). For example, students may ask, "What if the forecast were this type of weather for our community? What would be the problems for our community if we had this type of weather? What things could we do to prepare for this type of weather? How can forecasting the weather help us prepare and be ready for severe weather?" The teacher supports English learners at the Emerging and Expanding levels of English language proficiency in asking and answering these questions by providing sentence frames (e.g., If ____, then we could ___. We should ___ if ___). The teacher encourages students to refer to the labeled images of weather when they ask and answer questions. When necessary, the teacher asks probing questions and recasts students' responses, affirming their ideas and helping them use vocabulary and structure their statements in ways appropriate for a science discussion.

**CA ELD Standards**: ELD.PI.K.1

*Source*: Lagunoff et al. 2015, 206–207)

IS4

### Kindergarten Instructional Segment 4: Pushes and Pulls

Even very young children have an intuitive sense—a mental model—of the way objects move. They express surprise if they see a ball change its direction of motion or suddenly speed up or slow down with no visible reason for the change. They know how to push or pull toys to get them moving, and they are overjoyed by their own body's ability to move large objects. IS4 builds on this intuitive sense of how the world works and develops a language of words and diagrams for talking and thinking about these experiences. The segment includes three activity sequences in which students progressively refine a model of motion:

- We can change the motion of objects (marble track).
- Pushes and pulls cause objects to speed up, slow down, or change direction (kickball and tug of war).
- Pushes and pulls can have different strengths and directions. The bigger the push or pull, the faster the motion (school-yard box challenge).

## KINDERGARTEN INSTRUCTIONAL SEGMENT 4: PUSHES AND PULLS

**Guiding Questions**

- What happens when you push or pull on an object?
- How can you make an object move faster or in a different direction?

**Performance Expectations**

Students who demonstrate understanding can do the following:

**K-PS2-1.** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [*Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.*]

**K-PS2-2.** Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.*]

**K–2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

| Highlighted Science and Engineering Practices | Highlighted Disciplinary Core Ideas | Highlighted Crosscutting Concepts |
|---|---|---|
| [SEP-1] Asking Questions and Defining Problems<br>[SEP-3] Planning and Carrying Out Investigations<br>[SEP-4] Analyzing and Interpreting Data | PS2.A: Forces and Motion<br>PS2.B: Types of Interactions<br>PS3.C: Relationship Between Energy and Forces<br>ETS1.A: Defining Engineering Problems | [CCC-2] Cause and Effect: Mechanism and Explanation<br>[CCC-7] Stability and Change |

**CA CCSS Math Connections:** MP.2; K.CC.4–6; K.MD.1-2; K.G.1, 4–6

**CA CCSS for ELA/Literacy Connections:** L.K.5b–c; L.1e–f; RL.K.10a–b; RI.K.1–10

**CA ELD Standards Connections:** ELD.PI.K.A1, PI.K.A3, PI.K.B5

Learning and playing are closely related for young children. When given materials and freedom, they **investigate [SEP-3]**, **ask questions [SEP-1]**, and **solve problems [SEP-6]**. Instructional segment 1 begins with students exploring the laws of motion using marbles on a ramp or toy cars on a track. Strips of molding from home improvement stores make low-cost marble ramps that can be supported by blocks or everyday objects around the classroom (University of Northern Iowa n.d.). Even though students individually direct their own investigation, the teacher constantly facilitates learning. Students **ask more questions [SEP-1]** and explore more boldly when their teacher demonstrates his or her own curiosity (Engel 2013). During one-on-one exchanges, teachers can remark, I wonder if the size of the marble matters… or What happens if you make your ramp with three blocks instead of two? Teachers can invite student **explanations [SEP-6]** (Why does the marble fall off the track there? What did you notice about the marble's speed?) or challenge students to try something else (Can you push the marble hard enough that it goes up to the top of the ramp? Can you make the marble turn a corner?). These exchanges help students develop mental **models [SEP-2]** of events that **cause [CCC-2]** motion to **change [CCC-7]**. Teachers also document the process through photographs and videos and use them during whole-class discussions to highlight specific learning opportunities. Because this activity resembles play, it does not need to be introduced as a separate learning activity and can be used throughout the school year (for rainy day recess, during unstructured play times, or during IS3 to develop language about how the wind pushes against things, etc.). There are strong connections to the CA CCSS in mathematics, including counting blocks (K.CC.4–5), describing the weight of marbles (K.MD.1), comparing them (K.MD.2), analyzing and constructing shapes (K.G.4–6), and describing relative position (K.G.1). The more time students spend, the richer their mental models of motion become.

How can we get an object to start moving? How do we stop it? What causes the motion to change? Students are now ready to describe the **cause and effect relationships [CCC-2]** more explicitly and to add words that label them. Objects don't move unless they interact with some other object that pushes or pulls them. Pushes or pulls can cause a change in motion, meaning an object speeds up, slows down, or changes direction. Students can actually feel these pushes during a class game of kickball (When you push the ball, what happens to it? Can you feel the ball pushing against your hands when you catch it?) and the pulls during a class tug-of-war (Can you feel how your body starts to move when the rope pulls it?). Every time an object changes motion, there must be a push or pull that is causing that change. Recognizing these pushes and pulls can be hard when students can't feel them directly. A push can occur during a collision, like a marble hitting the wall of the track and changing direction when moving from one ramp to the next at a 90-degree turn in the track. Sometimes an interaction is not visible, like the marble interacting with the Earth by the pull of gravity. Teachers can help make some of these pushes tangible by inviting students to gently touch the track and feel the vibrations of the collision when the marble makes its turn. A student can lie on the ground while a ball rolls towards the soles of their shoes—they feel a gentle push when the ball bounces off and changes directions just like the wall feels a push when the ball bounces off. Students continue to explore the motion of objects in the classroom, including toy cars and marbles, noting the pushes and pulls that change their motion (figure 3.3). These experiences help students refine their **mental models [SEP-2]** of motion, adding the concept that *every change in motion requires a push or pull to cause it*. They can apply that model and new language labels (*push* and *pull*) to **explain [SEP-6]** a novel situation (The bat pushes the baseball, so it changes direction). Students might also come up with **questions [SEP-1]** that teachers may or may not have considered before such as, Where is the push or pull that moves a car on the road? While it is understandable for teachers to feel a little intimidated by questions that they cannot answer, they can embrace these questions as markers of success and use them to highlight the nature of science and explicitly discuss how crosscutting concepts are tools for thinking about things. By focusing on **cause and effect [CCC-2]**, the student who asked about cars realizes that there must be a push or a pull somewhere but they cannot see it. Physicists use similar questions to discover new phenomena, and engineers use them to improve their designs.

**Figure 3.3. Diagram Illustrating How Pushes Cause Changes in Motion**

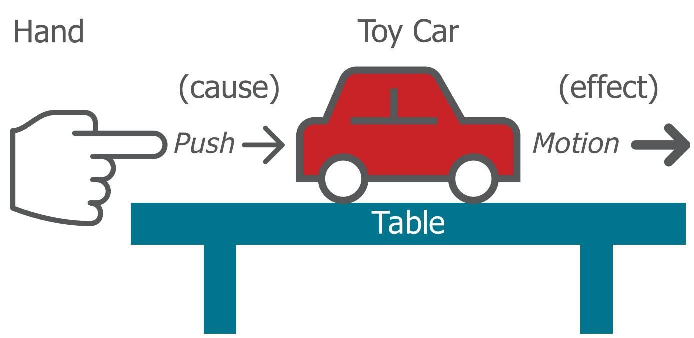



Diagram by M. d’Alessio

All the observable parts (hand, car, and table) are represented schematically and are labeled. The push is indicated with an arrow, and the movement of the block is indicated by a thicker arrow. Graphically distinguishing between the two arrows makes clear what is the cause (the push) and what is the effect (the movement). The diagram also shows that the direction of the movement is the same direction as the push.

## Opportunities for Mathematics Connections

Students can keep track of the results of their motion experiments in a table format, serving as a prelude to picture graphs introduced in grade two. They can compare results using greater than/less than vocabulary, such as, “The ball went farther after it hit the cardboard tube than after it hit the bubble wrap.” Students in kindergarten have not yet been introduced to standard measurement, such as using a ruler.

**CA Math Standards:** MP.2, K.CC.6, K.MD.1–2

## Opportunities for ELA/ELD Connections

Teachers can supplement the discussion of motion and pushes and pulls using any book where motion is depicted. Looking at an illustration, students can describe the direction the object is moving, what push or pull caused it to start moving, and which direction that the push or pull was acting (CA CCSS for ELA/Literacy RL.K.10a–b). Informational texts can reinforce some of the DCIs encountered during instruction while the firsthand experiences provide context for mastering CA CCSS for ELA/Literacy on reading informational texts (RI.K.1–10). Example texts include *Move It!: Motion, Forces, and You (Primary Physical Science)* by Adrienne Mason; *Motion: Push and Pull, Fast and Slow (Amazing Science)* by Darlene Stille; and *Forces Make Things Move (Let's-Read-and-Find-Out Science 2)* by Kimberly Brubaker Bradley. Students can compare the explanations of similar topics from two of the texts (CA CCSS for ELA/Literacy RI.K.9).

**CA CCSS for ELA/Literacy:** RI.K.1, 2, 3, 9, 10a–b; SL.K.1, 2, 3; L.K.6
**CA ELD Standards:** ELD.PI.K.5

## Kindergarten Snapshot 3.3: Classroom Talk about Pushes and Pulls

Since the beginning of the school year, Mr. H has worked each day to establish a safe and respectful environment for his students to discuss ideas throughout their learning and have productive conversations in which all students participate. Mr. H recognizes students need to feel safe to talk before their ideas are fully developed so that they can collaboratively work through problems with peers (ELD.PI.K.1) and so that he can redirect his teaching to meet their current thinking.

Mr. H introduced the norms for Classroom Talk at the beginning of the school year to promote respectful speaking (ELD.PI.K.3) and listening (ELD.PI.K.5), and he reinforces them every time he uses this technique. He established the following norms with the help of his students:

**Classroom Talk Rules**

- We can think and learn together by talking about our ideas.
- We talk to share ideas with others.
- We listen carefully to learn from others.
- We have to ask questions when we do not hear or understand somebody.
- We have to take turns so everybody gets a chance to talk.
- Each person's thinking is different and unique.

Mr. H designed a short unit using the 5E instructional model (See chapter 11 on instructional strategies) that introduces his students to the foundation of forces: the push and pull. Unlike many other snapshots in this framework that provide a glimpse at a single lesson, this snapshot provides a full sequence of lessons.

**Everyday phenomenon:** Students feel pushes and pulls.

He engaged them by drawing on their everyday life experiences with a Classroom Talk session. Mr. H started this Classroom Talk session by singing a Talk Song that invites children to the circle. Mr. H asked students, "Tell me about when you pushed or pulled something here at school." Mr. H wanted students to develop the language required for precisely describing actions of motion (CA CCSS for ELA/Literacy L.K.5b), and his question tied these language labels directly to student experiences (CA CCSS for ELA/Literacy L.K.5c). One student described pushing a friend on a swing. Others focused on activities in the school garden: pushing a cart full of compost, pulling a weed out of the ground, pushing a small shovel in the soil. Mr. H used some of the talk moves from chapter 11 of this framework ("Instructional Strategies"): "Cynthia, what about the push you described is similar to the pull Stephanie described? What's different?" "Tom, tell us more about how your body feels when you pull a really big weed." Mr. H also used the Classroom Talk to develop rich prepositional phrases such as "Maria pushes the cart slowly *around the garden*" (CA CCSS for ELA/Literacy K.L.1e). He discussed the meaning of this sentence and provided

## Kindergarten Snapshot 3.3: Classroom Talk about Pushes and Pulls

opportunities for students to add prepositional sentences to the push-pull examples they shared already (CA CCSS for ELA/Literacy K.L.1f). Throughout the sequence, he highlighted these types of sentences in texts that the class read about pushes and pulls.

**Investigative phenomenon:** Objects can be both pushed and pulled, which causes them to change their motion.

Mr. H then provided several opportunities to *explore* pushing and pulling different objects through different hands-on **investigations [SEP-3]**. Using a sentence frame, students predicted a ball's pathway based on how they planned to push the ball: "I predict that when I push the ball ____, it will ____." They also pushed and pulled plastic crates filled with heavy blocks around the schoolyard.

During the *explain* stage of the 5E model, students had to be able to formulate their own **explanations [SEP-6]** of how pushes and pulls affected objects. Mr. H brought the class back together to another Classroom Talk circle. Mr. H asked students to agree or disagree with the statement, "The only way to get an object to move around a corner is to pull it." When students disagreed with the statement, he prompted them to provide evidence from their investigations. Maria stood up and used her body to show how she would push the object this way and then that. Mr. H introduced the necessary academic vocabulary of *direction* and *motion* and repeated her idea by saying, "When you change the direction you push, you can change the crate's motion." Kirk added, "And when you push harder, it goes faster." Mr. H then added the academic vocabulary of speed. After the Classroom Talk, students drew diagrams in their notebooks showing how they could move an object around a corner using a push and then a second diagram showing how they could use a pull (**pictorial models [SEP-2]**).

In the *elaborate* stage of the 5E model, students applied their ideas and academic vocabulary to new situations. Students labeled objects around the school according to how they applied pushes and pulls to them. The food tray in the school cafeteria could be pushed or pulled to move it to the end of the line, and the classroom door could be pulled or pushed to open or close it. Students made entries into their notebooks giving at least one example of an object and whether it would be pushed, pulled or both. Mr. H again provided a sentence frame for his students: "An example of an object that is (pushed, pulled, or pushed and pulled) is __________." Mr. H used these observations of constructed devices to motivate an engineering challenge in which students designed a replacement handle for a wagon with a handle that had broken off. (They built prototypes using string, toothpicks, and tape attached to toy cars.)

Mr. H then *evaluated* his students with a structured assessment in which students predicted the effects of different strengths and directions of pushes and pulls on different objects and explained the basis for their predictions.

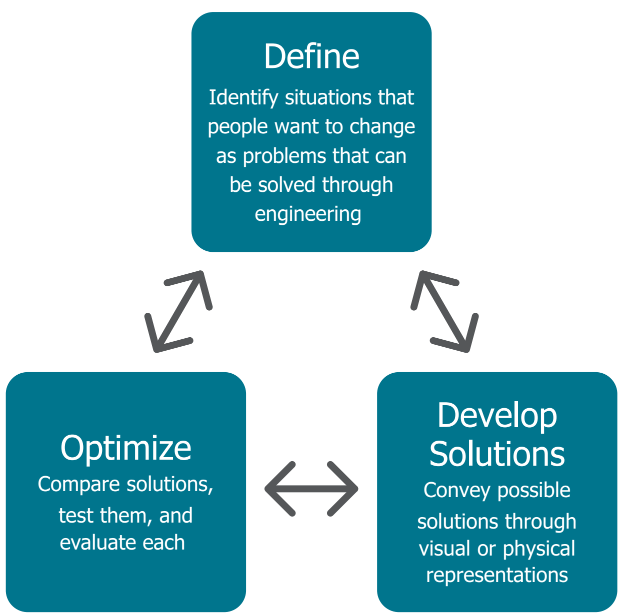
Students next refine their models to describe the strength and direction of pushes and pulls. To a physicist, pushes and pulls are the same thing—they both make objects change motion, and they differ only in their direction. Stronger pushes and pulls cause quicker changes in motion. The different effects of different pushes and pulls are well illustrated when students are given the challenge to move a heavy object with their own bodies (K-PS2-1, K-PS2-2). Students can move a heavy box of copy paper or a sturdy cardboard box with a child riding inside around an obstacle course on the schoolyard or around the classroom. To move the box around corners, they must push from a different side. To go faster, they must push harder. They can use a rope looped around the box to see that they can complete the course by either pushing or pulling. Students can decorate the cardboard boxes using a particular technique that ties to the art curriculum. They then perform similar investigations in other physical systems. For example, they can play air hockey (or make a homemade hockey table using cups to push a marble on a tabletop surrounded by hardcover books on all sides) or design a cardboard pinball machine (in which the speed and angle of the flappers makes the marble bounce off at different speeds and directions). Teachers can assess understanding by asking students to **explain [SEP-6]** why a certain motion caused a specific effect or **apply their models [SEP-2]** of motion to predict how a certain push or pull will affect an object.

## Engineering Design Challenge: Save a Structure

Students design a way to change the direction or decrease the speed of a ball that is moving towards a structure made of blocks, thus saving the structure from being destroyed. Because students are natural engineers, they will approach the problem using their own implementation of the steps of the engineering design process. Rather than explicitly introducing the engineering design cycle, the teacher could let students complete the task first and then ask them guiding questions about how they solved the problem. Most students use an intuitive trial-and-error method and probably don't talk much about the first stage of the engineering process. The teacher can help students define the problem by asking, "Does it count if the marble causes the blocks to move but not fall over?" or, "What would you do differently if I took away some of the materials you used?" The teacher can then introduce a simplified graphic of the engineering design process and discuss some of the unknown vocabulary.

Figure 3.4 describes the engineering design process for K–2. In kindergarten, teachers guide students to look at situations or events that may be considered as problems. The focus of the engineering design process is not to transform activities into competitions to see which solution is best. Rather, the idea is to have students collaboratively generate multiple ideas, design solutions, and test those solutions to determine if they are appropriate for the goal. Throughout the process, the emphasis is on developing students' collaboration and communication skills.

**Figure 3.4. Engineering Design Cycle for Kindergarten Through Grade Two**




*Source*: NGSS Lead States 2013a