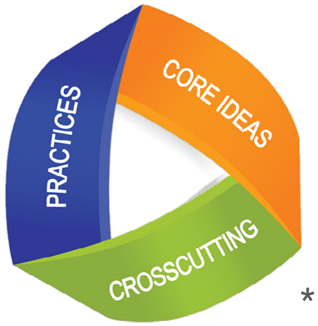
What is The Framework for K-12 Science Education?



In 2012, the National Research Council published a Framework for K-12 Science Education: **Practices**, **Crosscutting Concepts**, and **Core Ideas** that articulates a broad set of expectations for students in science. The Framework serves as the underlying foundation for The **Next Generation Science Standards (NGSS)**, that will replace older standards such as the National Science Education Standards.

What is the Purpose of The Framework?

The Framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields. The learning experiences provided to students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Throughout the K–12 grades, students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas. By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to have the skills to enter careers of their choice, including (but not limited to) careers in science, technology, engineering, and mathematics.

How does The Framework Impact NGSS Standards?

As previously mentioned, The Framework serves as the underlying foundation for The Next Generation Science Standards and shows up explicitly in all of the standards (see example below). Each NGSS standard defines what a student should be able to do or "perform" in order to demonstrate their understanding of a specific concept. As a part of their performance, students will use scientific and engineering practices, and apply crosscutting concepts as they explore different disciplinary core ideas.

NGSS Standard K-PS2-1 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

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.]*

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

- With guidance, plan and conduct an investigation in collaboration with peers.

Connections to the Nature of Science

Scientific Investigations Use a Variety of Methods

- Scientists use different ways to study the world.

Disciplinary Core Ideas

PS2.A: Forces and Motion

- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

PS2.B: Types of Interactions

- When objects touch or collide, they push on one another and can change motion.

PS3.C: Relationship Between Energy and Forces

- A bigger push or pull makes things speed up or slow down more quickly. *(secondary)*

Crosscutting Concepts

Cause and Effect

- Simple tests can be designed to gather evidence to support or refute student ideas about causes.

How does Kid Spark Education Support The Framework?

Kid Spark Education is a non-profit organization whose mission is to help all children prepare for a lifetime of interest in science and technology. Kid Spark's Elementary and Middle School STEM programs help guide teachers and students into the practices and crosscutting concepts of The Framework by promoting four key strategies:

1. Teach STEM through Engineering - Hands-on engineering education is a strategic gateway for children to learn disciplines and develop a strong STEM identity. Research indicates children learn math and scientific inquiry best through hands-on engagement as tool-makers, designers, and builders: essentially, as engineers. When children can construct their sense of math and science with relatable projects, when they learn through their mistakes and succeed through persistence, they develop a growth mindset towards STEM.

2. Start Young Don't Stop - The most effective way to close the STEM achievement gap is to expose young children to STEM subjects as soon as they enter their first classroom and to continue offering applied STEM experiences every year. Kid Spark programs do just that. They are designed to follow children through their entire elementary and middle-school careers, starting with preschoolers and continuing with progressive STEM learning all the way through 8th grade.

3. Mentors Matter - Having a teacher who is an instructor, role model, and STEM mentor all in one is critical. Teachers who serve as STEM mentors ensure that students stay at their learning edge, the zone where skills and fluency may be just shy of what's required to accomplish the task at hand. A STEM mentor's encouragement can mean the difference between a child giving up on STEM and excelling in STEM.

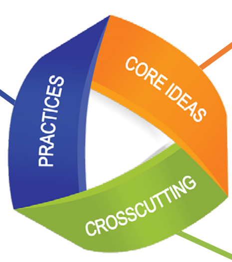
4. Make Project-Based STEM Easy & Affordable - Kid Spark curriculum, professional learning, and mobile STEM labs are highly effective, easily managed, and affordable for schools.

How does Kid Spark Education Specifically Align to The Framework?

The chart below is a synopsis of The Framework. Notably, The Framework includes engineering as one of four disciplinary core ideas, and posits that the practices and crosscutting concepts employed in the study of engineering are essentially the same as those employed in the study of science. Kid Spark programs introduce students as early as preschool to the following practices and crosscutting concepts of The Framework, and sustain engagement throughout the primary and middle school grades.

Scientific and Engineering Practices

1. Asking Questions & Defining Problems
2. Developing & Using Models
3. Planning & Carrying Out Investigations
4. Analyzing & Interpreting Data
5. Using Mathematics & Computational Thinking
6. Constructing Explanations & Designing Solutions
7. Engaging in Argument From Evidence
8. Obtaining, Evaluating, and Communicating Information



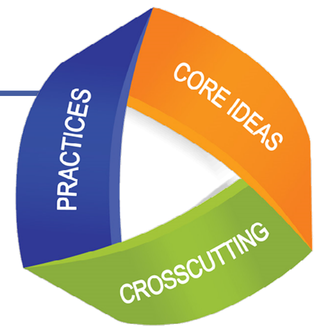
Disciplinary Core Ideas

1. Physical Science
2. Life Science
3. Earth Science
4. Engineering

Crosscutting Concepts

1. Patterns
2. Cause & Effect: Mechanism & Explanation
3. Scale, Proportion, and Quality
4. Systems & System Models
5. Energy & Matter: Flows, Cycles, & Conservation
6. Structure & Function
7. Stability & Change

Scientific & Engineering Practices



Scientific and engineering practices describe what scientists do to investigate the natural world and what engineers do to design and build systems. Students engage in practices to build, deepen, and apply their knowledge of core ideas and crosscutting concepts. Kid Spark Education engages students in the following eight practices, through the study of engineering and physical science:

1. **Asking Questions & Defining Problems**
   Kid Spark's focus on engineering challenges students to question how the world works and how they might contribute to improve it. Students learn to define problems and develop creative solutions of their own design.

2. **Developing & Using Models**
   Kid Spark believes every student can see like a designer, and think like an engineer. An important component of the Kid Spark learning progression is for students to visualize design solutions and then create physical models that can be tested and improved.

3. **Planning & Carrying Out Investigations**
   All Kid Spark curriculum follows a similar pattern of convergent learning to divergent making. Students learn important STEM fluencies and concepts through guided step-by-step instruction, where they assemble and test highly-refined teaching models. Then students are challenged to apply what they have learned through a divergent (open-ended) design challenge. During this phase, students must brainstorm ideas, develop prototypes, and carry out investigations on designs as they develop solutions to problems

4. **Analyzing & Interpreting Data**
   A major part of the Kid Spark Design & Engineering Process is the ability for students to test and improve designs. During this process, students must analyze and record how well a design is performing, and then use that information to improve the design.

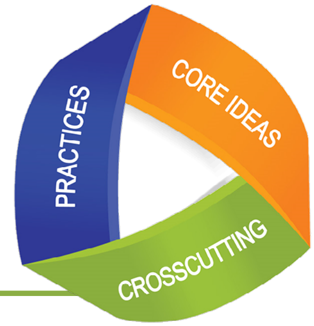
5. **Using Mathematics & Computational Thinking**
   Students have an early introduction to applied math and computational thinking when using Kid Spark engineering materials. These engineering materials are based on a one centimeter grid, and students measure and calculate area, volume, ratio, and mechanical advantage by directly observing their prototypes. This process continues into compound machine design, robotics, and coding.

6. **Constructing Explanations & Designing Solutions**
   Kid Spark's divergent design challenges require students to demonstrate their own understanding of various STEM concepts. Students are challenged to design and engineer solutions to problems that meet certain specifications, and demonstrate specific ideas or concepts.

7. **Engaging in Argument from Evidence**
   In engineering, reasoning and argument are essential to finding the best solution to a problem. Kid Spark challenges students to collaborate with peers throughout the design & engineering process to select the most promising solution to a problem, and then build, test, and refine the design.

8. **Obtaining, Evaluating, & Communicating Information**
   Kid Spark learning experiences include reading, writing, and verbally communicating information. Students are required to read and interpret scientific information through hands-on convergent learning. Then students apply what they have learned in divergent design challenges, and must effectively communicate their data, evaluations, ideas, and conclusions to others, both verbally and in writing.

Crosscutting Concepts



Crosscutting concepts help students explore connections across the four domains of science, including **physical science**, life science, earth and space science, and **engineering design**. Kid Spark Education encourages students to apply the following crosscutting concepts through the study of engineering and physical science:

1. **Patterns**
   Noticing patterns is often a first step to organizing and asking scientific questions about why and how the pattern occurs. Young students learn basic pattern recognition through classification (*e.g. students organize and classify engineering materials based upon their characteristics or function*), as they build, test, and analyze different models (*e.g. students diagnose patterns of failure in a design in order to improve it*), and as they learn to develop efficient programs that can be uploaded to a robotic controller.

2. **Cause & Effect: Mechanism & Explanation**
   Engineering and the process of design is a good place to help students begin to think in terms of cause and effect, because they must understand the underlying casual relationships in order to devise and explain a design that can achieve a specific objective. With Kid Spark, students learn to analyze how and why things work, where they are used in the real world, and how they might be improved or used to create something new.

3. **Scale, Proportion, and Quantity**
   Kid Spark introduces very young students to dimension, scale, quantity, and measurement. Over time, the concepts of mass, time, proportion, ratio and estimation are integrated into Kid Spark curriculum. Kid Spark builds and projects are often scale models of large, easily relatable, real-world structures. The metric grid inherent in Kid Spark engineering materials is particularly supportive of instruction needed for students to assign meaning to the types of ratios and proportional relationships they encounter in science and engineering.

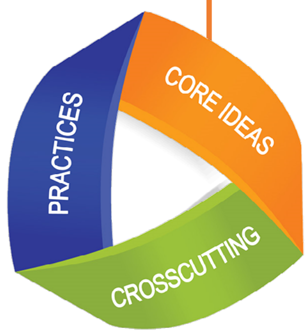
4. **Systems & System Models**
   Students learn how different parts of a system work and how they can be used to create more complex designs or models (*e.g. students learn how each simple machine works and then explore how to combine them to make a compound machine*). This experience teaches students to analyze systems and be able to describe how each part of the system contributes towards the overall design.

5. **Energy and Matter: Flows, Cycles, and Conservation**
   According to The Framework, the role of energy transfers and flows is only fully developed until high school. Kid Spark programs do not currently address this concept.

6. **Structure & Function**
   Kid Spark engineering materials include many different types of building components. Students explore how each component can be used within a design (*e.g. students learn how components can be used to make things strong or make things move*). This encourages students to understand the relationship between the structure and function of each component, and how it can be used in developing more complex designs or systems.

7. **Stability & Change**
   In engineering, an understanding of stability and change will contribute towards better designs. With Kid Spark, students learn about evaluating a design from their earliest lessons, and explore what types of modifications can be made to improve it. Progressively, explorations include making a design stronger, more precise in movement, or able to react to outside factors that might create instability (*e.g. students design a robotic system that reacts based on information received from connected sensors*).

Disciplinary Core Ideas



Disciplinary core ideas (DCIs) are the key ideas in science that have broad importance within or across multiple science or engineering disciplines. These core ideas build on each other as students progress through grade levels and are grouped into the following four domains: **physical science**, life science, earth and space science, and **engineering**. Kid Spark specializes in hands-on engineering education which provides a strategic gateway for children to learn STEM disciplines, and to develop a strong STEM identity.

1. **Engineering, Technology, & Applications of Science**
   Students start with basic engineering concepts like how to make things strong and how to make things move. As students progress, they build on that foundation and explore: mechanical and structural engineering; rapid prototyping and 3D printing; the mechanical, programmable, and sensor driven aspects of robotics; and integrated STEM projects that explore professional design cycles.

2. **Physical Science**
   Explorations include:
   a. Motion & Stability: Forces & Interactions

The Framework for K-12 Science Education

	Scientific & Engineering Practices								Crosscutting Concepts							Core Ideas	
	Asking Questions & Defining Problems	Developing & Using Models	Planning & Carrying Out Investigations	Analyzing & Interpreting Data	Using Mathematics & Computational Thinking	Constructing Explanations & Designing Solutions	Engaging in Argument from Evidence	Obtain, Evaluate, & Communicate Information	Patterns	Cause & Effect: Mechanism & Explanation	Scale, Proportion, & Quantity	Systems & System Models	Energy, & Matter: Flows, Cycles, and Conservation	Structure and Function	Stability & Change	Engineering Design	Physical Science
Elementary School Program Units of Instruction																	
Grades Pre-K - 1																	
1. It's All About The Blocks	●	●			●						●			●		●	
2. I Am An Engineer	●	●			●				●		●			●		●	
3. Making Things Strong	●	●	●							●	●			●		●	
4. Making Things Move	●	●	●							●	●			●		●	●
Grades 2 - 5																	
1. Kid Spark Basics	●		●		●	●					●	●		●	●	●	
2. Mechanisms & Movement	●	●	●		●	●				●	●	●		●		●	●
3. Applied Mathematics	●	●	●		●	●		●	●		●					●	
4. Robotics & Coding 101	●	●	●		●			●	●		●	●		●		●	
5. Exploring Sensors		●	●	●	●	●			●	●	●	●		●		●	
Middle School Program Units of Instruction																	
Grades 6 - 8																	
1. Kid Spark Basics	●		●		●	●					●	●		●	●	●	●
2. Simple Machines	●	●	●		●	●		●	●	●	●	●				●	●
3. Compound Machines	●	●			●	●				●	●	●		●		●	
4. Rapid Prototyping & 3D Printing	●	●	●		●						●	●		●	●	●	
5. Loops & Variables	●	●	●		●					●	●	●		●		●	
6. Integrated Engineering Challenges	●	●	●	●	●		●			●	●	●		●	●	●	