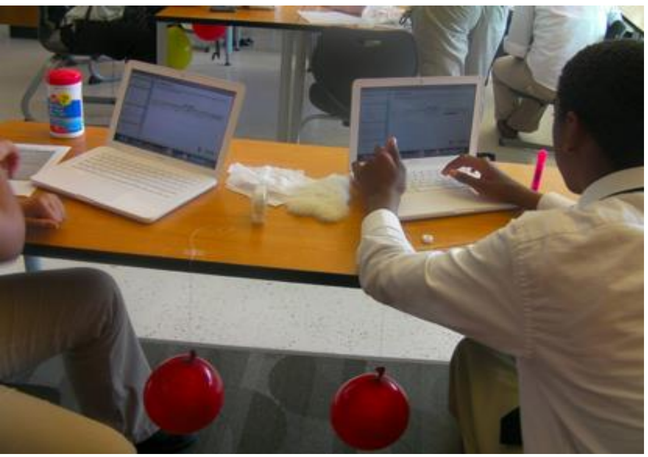
CREATE for STEM Institute

MICHIGAN STATE UNIVERSITY

Supporting high school students in understanding electrical interactions at the microscopic level: using technology in the era of NGSS



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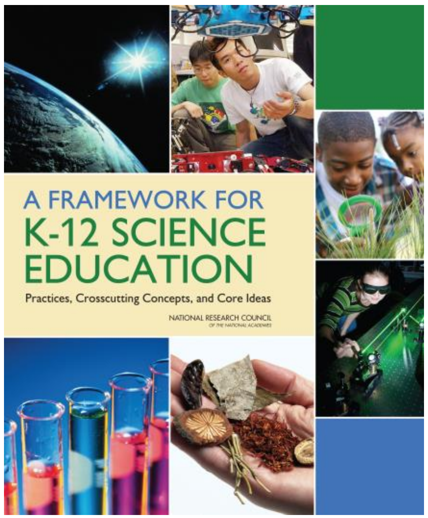
What are the major shifts in the Framework and NGSS?

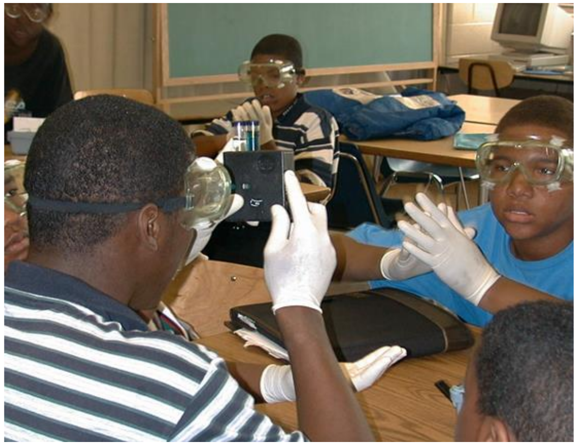


NEXT GENERATION SCIENCE STANDARDS

1. Focus on explaining phenomena or designing solutions to problems
2. 3-Dimensional Learning
    1. Organized around disciplinary core explanatory ideas
    2. Central role of scientific and engineering practices
    3. Use of crosscutting concepts
3. Coherence: building and applying ideas across time

What is three 3-Dimensional Learning Learning?

- The working together of the three dimensions (core ideas, crosscutting concepts and scientific and engineering practices) to focus instruction and assessment on explain phenomena and design solutions to problems



- Three-dimensional learning shifts the focus of the science classroom to environments where students use core ideas, crosscutting concepts with scientific practices to **explore, examine, and use science ideas** to explain how and why phenomena occur and/or to design and explain solutions to problems.

Build toward Performance Expectations

HS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education

Scientific and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ▪ Use mathematical representations of phenomena to describe explanations.	**PS2.B: Types of Interactions** ▪ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. ▪ Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-

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Scientific and Engineering Practices

Using Mathematics and Computational Thinking

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- Use mathematical representations of phenomena to describe explanations.

Disciplinary Core Idea

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
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Crosscutting Concepts

Patterns

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Blend DCIs and CCCs with a variety of practices to build toward the performance expectation

Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-4. Develop and use models Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*]

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Scientific and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.

Disciplinary Core Idea

PS2.B: Types of Interactions

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

Crosscutting Concepts

Patterns

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Purpose and Goals

New approaches of teaching interactions governed by electric forces

- Focusing on the electrical interactions among atoms and molecules will support students in understanding inter- and intra molecular bonding and avoid an over-dependence on memorized rules (Levy Nahum, 2007; Taber & Coll, 2002).

- Students need support to understand and apply scientific ideas and models that explain a broad range of phenomena related to electrical interactions.

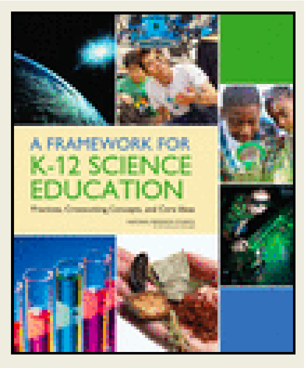
Promote students building explanations and models about key phenomena in various disciplines

Support students understanding of interactions governed by electric forces

Provide a foundation for a broad range of future STEM learning

Design principles

Link to the Framework and NGSS



- **Core idea**
  - PS1: Matter and its interactions
  - PS2: Motion and stability: Forces and interactions
  - PS3: **Energy**
- **Scientific practices**
  - Developing and using models
  - Analyzing and interpreting data
  - Constructing explanations
  - Obtaining, evaluating, and communicating information

NEXT GENERATION SCIENCE STANDARDS
For States, By States

- HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Design principles

Learning goal focused

- **Performance driven** learning goals for task development
  - **<u>Develop and use models of electrostatic interactions</u> to provide mechanistic causes for and make predictions about the behavior of one or more charged objects.** (Part 1)
    - *By the end of this part, students should have models of electrostatic interactions that includes: patterns in the way that charged objects interact, representations of electrostatic interactions within the electric fields to represent a qualitative concept of Coulomb's Law.*

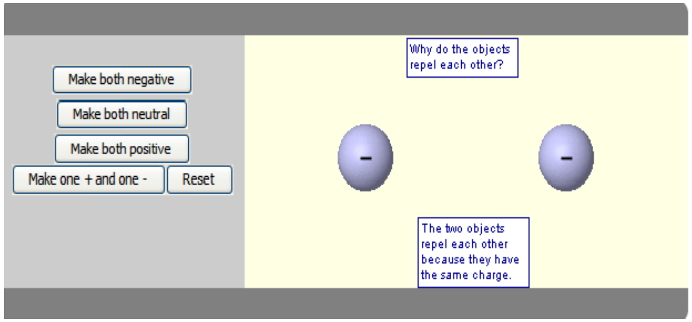
Contextualization

- Phenomena and examples from everyday life
- Use of Driving Questions
  - **<u>Why do some things stick together while other things don't?</u>**

Design principles

Multiple representation

- Electronically delivered student material
- Combination of physical representation and computer representation
- Interpreting various representation and building own models by hand-on activity in which learners experience phenomena, using simulation and drawing tools
- [Interactions Portal]



Build toward Performance Expectations

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Instruction Builds Toward PEs

- My question:
- What design features can be use to design technology learning environments to support students in meeting performance expectations (i.e., engage in 3-dimensional learning) so learners are meaningfully engaged in explaining phenomena or designing solution to problems?
- How can we use features of technology to meaningful monitor students 3-dimensional learning?

Thanks to Team Members

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