Can we enhance curriculum with cyberlearning resources?

Presented at Successful STEM Education
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Jeremy Roschelle, Director
Center for Technology in Learning
What is cyberlearning?

1. Jeremy Roschelle: SRI
   *Overview Cyberlearning*

2. Kathy Perkins, University of Colorado, Boulder
   *PhET Sims*

3. Jennie Chiu: University of Virginia
   *Engineering and Science Practices*
What is Cyberlearning?

New technologies change what and how people learn. Informed by the learning sciences, cyberlearning is the use of new technology to create effective new learning experiences that were never possible or practical before.
Represents over 200 separately funded NSF projects.
Innovating Pedagogy ’15 *(50,000 downloads!)*

Ten Pedagogies

1. Crossover Learning
2. Learning through Argumentation
3. Incidental Learning
4. Context-based Learning
5. Computational Thinking
Innovating Pedagogy ’15 *(50,000 downloads!)*

Ten Pedagogies

6. Remote Scientific Labs
7. Embodied Learning
8. Adaptive Teaching
9. Analytics of Emotion
10. Stealth Assessment
Investigating the Safety of Nuclear Energy Using Real Radioactivity Data

STUDENT PAGE

iLab: Radioactivity iLab

In this lab, you can explore how radioactive radiation changes as a function of distance. This curriculum sets the Radioactivity iLab in the context of nuclear energy, and asks you to consider:

How safe is it to live next to a nuclear reactor?
National Educational Technology Plan ‘16

Includes section on Cyberlearning (p. 16)
PhET Interactive Simulations and the NGSS

Kathy Perkins

http://phet.colorado.edu

STEM Smart Conference
Feb 2, 2016
What is PhET?

- Suite of 130 free interactive science and math sims
- 75+ Languages
- Run online or download

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What is PhET?

- Suite of 130 free interactive science and math sims
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FREE at http://phet.colorado.edu
PhET seeks to make STEM learning more ...

**ENGAGING**  Interact and discover key ideas.

**RELEVANT**  Connect to everyday life.

**ACCESSIBLE**  Intuitive and understandable.

**EFFECTIVE**  Use science and math practices.

  Develop conceptual understanding.

**PERSONALIZED**  Students direct their learning.
Sim tour

Build an Atom

Energy Skate Park

Forces and Motion
A flexible tool

Teachers use PhET sims in many ways

Instructor-led

Lecture or lab demos
  • Clicker questions
  • Class discussion

Student-led

Group / individual work
  • In-class guided-inquiry
  • Lab or pre-lab activities
  • Homework
NGSS and Teaching with PhET

NGSS alignment involves....

PhET Sim + Lesson Design + Teacher Facilitation

... fits within the Driving Question or Problem
NGSS and Teaching with PhET

Coupled Interactions

Teacher Facilitation

PhET Sim

Lesson
NEXT GENERATION
SCIENCE
STANDARDS

Science & Engineering Practices
Disciplinary Core Ideas
Crosscutting Concepts

NGSS @ NSTA
http://ngss.nsta.org
Finding PhET NGSS-Ready Sims

Alignment of PhET sims with NGSS

- HS NGSS Alignment 10-7.docx - 65 kB
- MS NGSS Alignment 10-12.docx - 65 kB

Download all files as a compressed .zip
Focus in on NGSS Practices

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

Students who demonstrate understanding can:

Performance Expectations

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. MS-PS2-2

Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

Science and Engineering Practices

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 5–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

Plan an investigation individually and collaboratively, and in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)

Connections to Nature of Science

Science Knowledge Is Based on Empirical Evidence
Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2)

Disciplinary Core Ideas

PS2 A: Forces and Motion

1. The motion of an object is determined by the sum of the forces acting on it if the total force on the object is not zero. Its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)

2. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)

Crosscutting Concepts

Stability and Change

1. Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2)
Students who demonstrate understanding can:

**Performance Expectations**

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1)

- **Clarification Statement and Assessment Boundary**

  Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.

  Assessment Boundary: none

**Science and Engineering Practices**

- **Analyzing and Interpreting Data**
  
  Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

  Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)

**Disciplinary Core Ideas**

- **PS3.A: Definitions of Energy**

  Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)

**Crosscutting Concepts**

- **Scale, Proportion, and Quantity**

  Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1)
Think-pair-share

- Pick a sim:  Forces and Motion
  ![Forces and Motion](image)

- Energy Skate Park
  ![Energy Skate Park](image)

- What types of questions could you use in your lesson that engages students in a science practice?
Mini-design: Prompts a practice

**Examples**

Explore the skater’s motion, and her potential energy and kinetic energy. What do you notice?

Design an experiment to determine ...

Provide evidence from the sim to defend your claim ....
Teacher Resources

Tips for Using PhET

PhET simulations are very flexible tools that can be used in many ways. Here, you will find videos and resources for learning about effective ways of integrating PhET simulations into your class.

A Brief Introduction to PhET:
An overview of the PhET Simulations (Download Video)

Tips and Resources for Teaching with PhET

- Planning to Use PhET
- Using PhET in Lecture: An Overview
- Interactive Lecture Demonstrations
- Using PhET with Clickers
- Designing PhET Activities for the K12 Classroom
- Facilitating PhET Activities for the K12 Classroom
- Take a Virtual PhET Workshop

Guidance for using particular simulations:

- Browse our activities for use with each simulation
- Find teacher tips for use with specific simulations on individual simulation pages (where applicable)
Next Generation PhET

• Coming soon in HTML5
  
  Pendulum Lab  Charges & Fields  Neuron
  States of Matter  Masses and Springs  Trig Tour

• More teacher resources
  
  – Video primers for sims
  – Updated Tips for Teachers

• Accessibly designed sims
  
  – Keyboard Navigable
  – Screen Reader Compatible
  – Sonification
PhET is free thanks to our sponsors

PhET is supported by users like you!

Carl Wieman & Sarah Gilbert
WISE and WISEngineering Connections Between NGSS Content and Practices

Jennifer Chiu
jlchiu@virginina.edu

STEM Smart workshops are funded by the National Science Foundation grant #1449550. Any opinions, findings, and conclusions or recommendations at this event or in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Goals

• Provide technology-enhanced 3D NGSS curricular resources to help connect practices with content
• Combine curricula, assessment, teacher tools
• Engineering DCIs and practices

Can we enhance our curriculum with cyberlearning resources?  YES
Design Challenge

- Create a school garden
- Must grow some edible plants and be student maintained
- Total space = 20’ x 20’
- Total budget = $400
- Total time = 2 weeks

What would your next steps be?
NGSS Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
WISE: Web-based Inquiry Science Environment: https://wise.berkeley.edu
Supporting NGSS practices

Features to support NGSS DCI’s and CC’s

Inquiry

Map

Embedded Simulations
Features to support NGSS DCI’s and CC’s

Automatic feedback
Features to support NGSS DCI’s and CC’s
Supporting NGSS practices

Asking questions

1. Which do you think will be more useful in analyzing a crash, the POSITION–TIME graph or the VELOCITY–TIME graph? Explain.

2. Why do you think shorter drivers are more at risk for harm from an airbag than taller drivers?

3. Is a driver more likely to be harmed by an airbag in a high speed or low speed collision? Explain.

4. How do you think a car's ability to crumple affects a driver's risk for harm from an airbag?
Supporting NGSS practices

Developing and using models
Supporting NGSS practices

Planning and Carrying out Investigations

Let's explore how the amount of light energy affects the amount of glucose produced.
1. Click on "FULL SCREEN" above.
2. Scroll down and enter your predictions about how much glucose the chloroplast would produce in each condition (none, small, medium or large).
3. Test your predictions and record your observations.
Supporting NGSS practices

Analyzing and Interpreting Data

Video screenshot showing a WISE v4 interface with graphs and instructions for analyzing and interpreting data.
Constructing Explanations

Based on the model, add some evidence to your basket about how energy from the sun warms the earth.

Idea Basket

This is great

Energy in = energy out

Trash (0) (Click to show)
Supporting NGSS practices

Constructing Explanations

Explanation Builder

Look over your ideas. Which of them do you think you can use to explain why seasons happen? Drag and organize your ideas using the space below.

Your Ideas | Flag
---|---
Earth is tilted on its axis | Helpful
Planets move around the sun | Not Sure

HELPFUL

Earth is tilted on its axis

NOT HELPFUL

NOT SURE

Planets move around the sun

How did you decide whether an idea would be helpful or not helpful to use?

ADD NEW IDEA +
Engaging in argument from evidence
Obtaining, evaluating, communicating
Teacher Supports

- Student Monitors/progress
- Automatic scoring of student work
Features to support teachers

• Scoring of student work
• Feedback/displaying student work

### Graphing Stories

**[Project ID: 490]**

#### 2.5 What's the Difference? Your Thoughts

**Question:**

- [ ] All Periods
- [ ] P1
- [ ] P2
- [ ] P3
- [ ] P5
- [ ] P6

**Hide/Show the Question**

**Hide Personal Info**

**Show Flagged Items Only**

**Enlarge Student Work Text**

**Show All Revisions**

**Student Work**

1. The graphs look different because Antonio is using kilometers and Vijay is using meters. Vijay's y-axis is labeled Elevation of Campsite and goes up by 200 meters. Antonio's y-axis is labeled Total Distance Traveled and goes up by 10 kilometers. The highest point on Antonio's graph shows 55 kilometers. It represents 55 kilometers traveled in 8 days. The highest point on Vijay's graph shows 1,100. It represents 1,100 meters at 5 days.

**Comment:** Open Premade Comments

**Flag**

**Score:** 2 / 4

**Comment:** You are not reading the question correctly. Please review and revise your answer.

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### Example Revision

**Brianna Sanchez** (BriannaS1029)

**marissa molina** (marissam122)

**Revision 2**

1. There graph is different because they both started at different places at the camp.
2. For Antonio his highest point on the graph on the 8th day was 55 kilometers. Then Vijay's highest point was on the 5th day and was 1,100 meters.

**Timestamp:** Wed Oct 20 2010 09:40:47 GMT-0800 (PST)

**Brianna Sanchez** (BriannaS1029)

**marissa molina** (marissam122)

**Revision 1**

1. The graphs look different because Vijay is going faster. The highest point on Antonio's graph shows that on the 8th day he ran a total of 55 kilometers. The highest point on Vijay's graph shows the 5th day he ran a total of 1,100 meters.

**Timestamp:** Mon Oct 18 2010 09:24:08 GMT-0700 (PST)
• Authoring and research tools
• Defining problems, designing solutions?

• NGSS means also teaching engineering!
www.wisengineering.org
Supporting Engineering Design

**Design Challenge**

We all use electricity at home, at school, and elsewhere. Electric power stations transform various kinds of energy into electricity. There are many different kinds of power stations (click on the pictures to learn more).

**Your challenge** is to design a water-driven electric generator that converts mechanical energy to electrical energy given the materials provided to you.

**Project goals** are to: (1) Output the largest amount of electricity, as measured by average maximum voltage. (2) Demonstrate your model and describe how it works, paying special attention to energy transformations. Your generator must be water-powered.

You will be provided with an electric motor and some materials to construct your generator in class. You have up to one and a half class periods to complete the challenge.
Defining problems

Specifications and Constraints

To design a solution to our challenge, we need to know the specifications and constraints.

Specifications are what your solution must do. They are the requirements.

Constraints are things that limit your solution. For example, a constraint may be how much you can spend or how much time you have to complete the challenge.

Where are the specifications and constraints for this challenge? Hint: You may need to go back to the Introduction.

1. List all the specifications:
   The specifications of this challenge are...

2. List all the constraints:
   The constraints of this challenge are...
Developing and using models
Using mathematics and computational thinking

Dance Party!

Everything from cell phones, videogames, and even how your electricity depends on software engineering. Software Engineers make a difference by designing programs that tell computers what to do, resulting in videogames, cell phones, and even how power gets into your house or school.

Your challenge is to work as a software engineer and make a program for a dance party. You are given an environment called Scratch. Your program must:

- Have one dancer do at least two dance moves
- Play two different instruments as part of your program
- Have your dancer say something by pressing a button
Planning and carrying out investigations

**Optimum Potato Chip**

Welcome Test User!

**Design Cycle**
- Design Challenge
- Collaboration
- Define Design
- Specifications
- Constrain
- Develop Knowledge
- Systems Thinking
- Test and Evaluate Design
- Build Prototype
- Innovate Solutions
- Creativity

**Design Challenge**
- Step 1.1: Your Challenge
- What Makes a Good Chip?
- Testing 1,2,3
- Step 3.1: Testing instructions

**Chip A**
You will be testing four different potato chips: Chips A, B, C, and D. It is essential to make sure that the chips are about the same size when testing for each quality. When comparing different chips, you want to make sure the test is "fair".

You will be ranking these chips from 1 to 4 (1 = the worst, 2 = a little better, 3 = pretty good, 4 = the best) based upon your preference. Each chip must be ranked a different number.

**Chip B**

**Chip C**

**Chip D**

You will test all four potato chips for one quality, before moving to the next quality.
Designing solutions
Engaging in argument from evidence

Community Garden Design Challenge

A local company has just agreed to donate some of its field area to design a community garden. The company is looking for young engineers and mathematicians who can help design the garden. Students at your school, as well as 50 others, have been selected to submit a potential design.

Your challenge is to design a model of the garden using 3D pop-ups to represent the vegetables. The company is looking for a design that will produce the greatest amount of vegetables at the lowest cost to feed those in need in the community.

Your model must be a 3D, pop-up model, must be no larger than 5400 square cm. There must be at least 20 plants and no more than 32 plants in the garden, and must contain corn, tomatoes, squash, zucchini and carrots. Your budget is $50 from the Community Garden fund to purchase the plants, and you have 6 class periods to complete the challenge.
• Currently have Common Core mathematics (TEM), NGSS Science units (STE), Informal activities with tablet computers

• Working on integrating math and science in schools
• Engineering is applying science to real-world problems – science teachers already do this well
• Potentially very motivating for students
• Difficult to assess, implement
Thank you!
WISE and WISEngineering teachers
Marcia Linn, M. David Burghardt

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Thanks!

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