Next Generation PhET Simulations: New Opportunities for Education Research in Science and Math

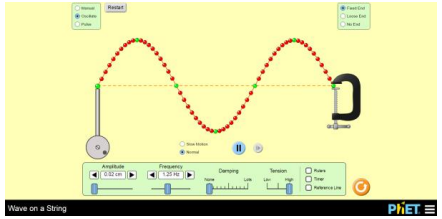
Kathy Perkins

University of Colorado Boulder

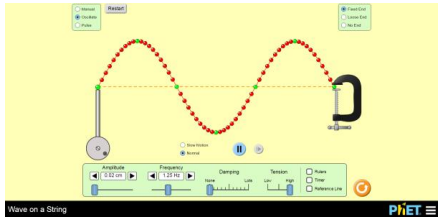
Brief Introduction to PhET

Intro to PhET

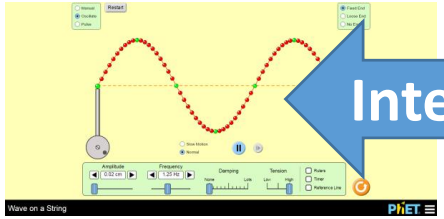
Product Development



Research



Classroom



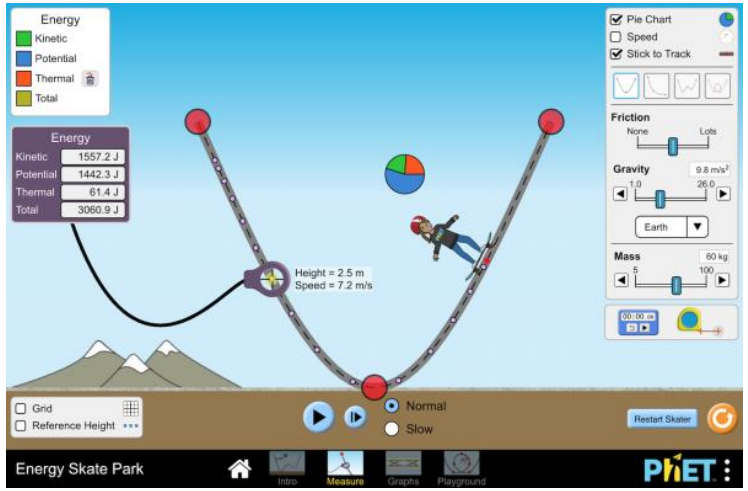
Integration

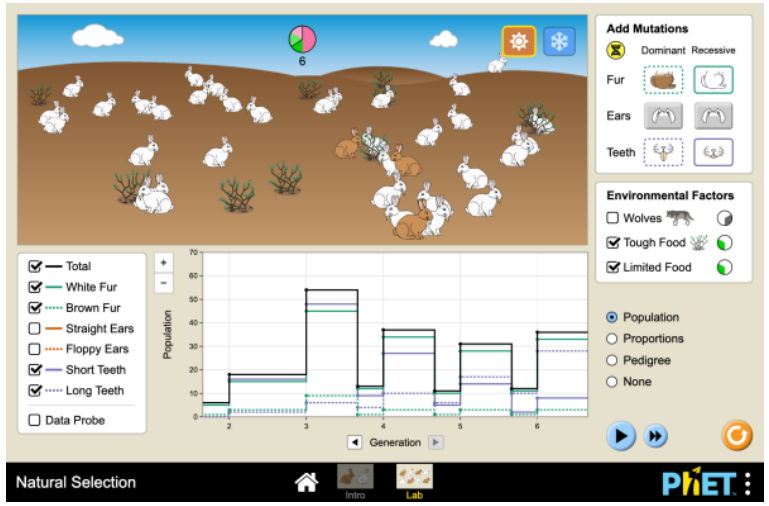
Teacher

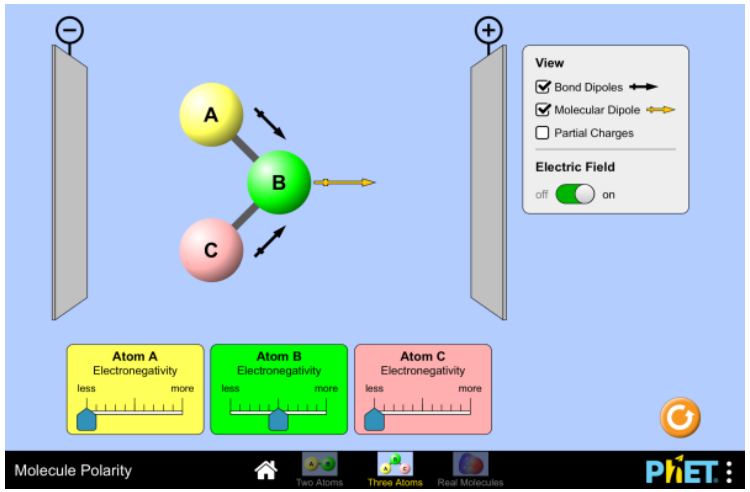
Student ⟷ Student

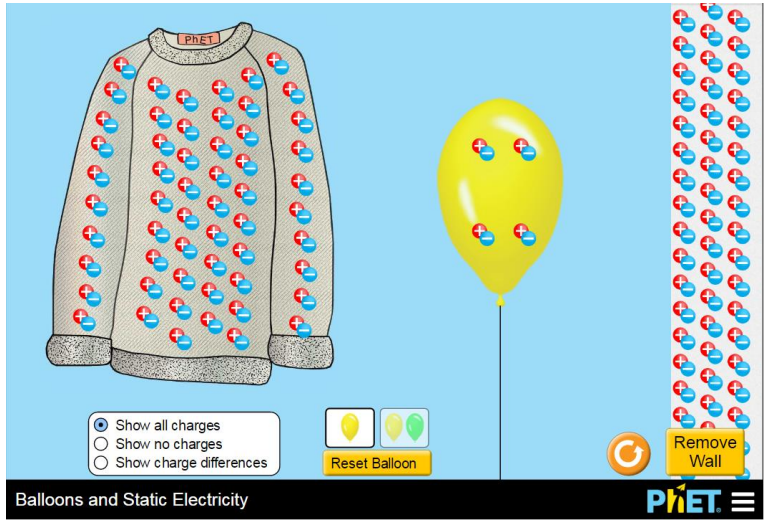
Intro to PhET

Examples









Intro to PhET

Multiple Goals

Content: Concepts, Models, Representations, Relationships

Process: Explore, Question, Design, Predict, Data, Evidence, Discuss

Affective: Enjoyable, Understandable, Relevant, **Student-centered**

Dissemination: Flexible, Easy, Free

Intro to PhET

PhET Today

Over 158 simulations (85 in HTML5) & 2000+ sim-based lessons

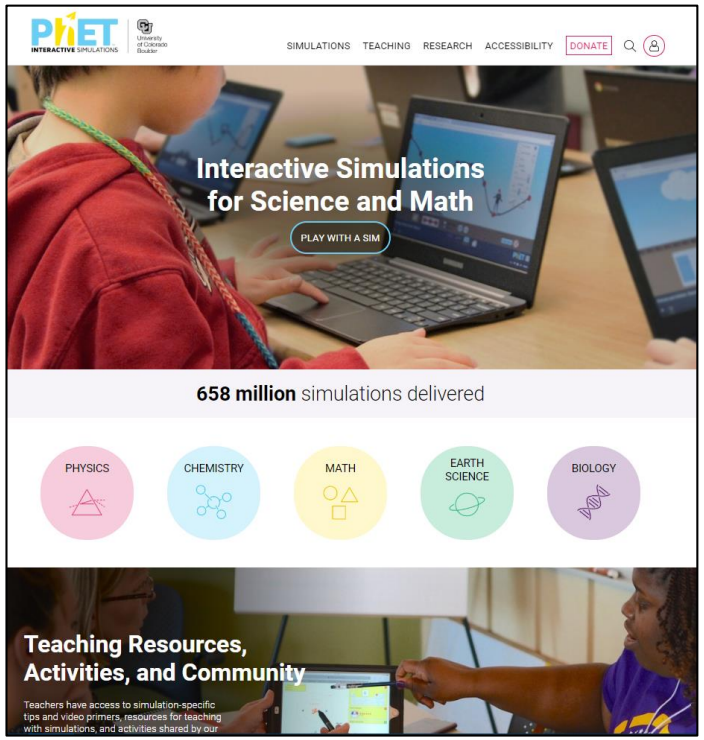
Physics, Chemistry, Math, Biology, Earth Science

K-12 and College

Open education resources (free)

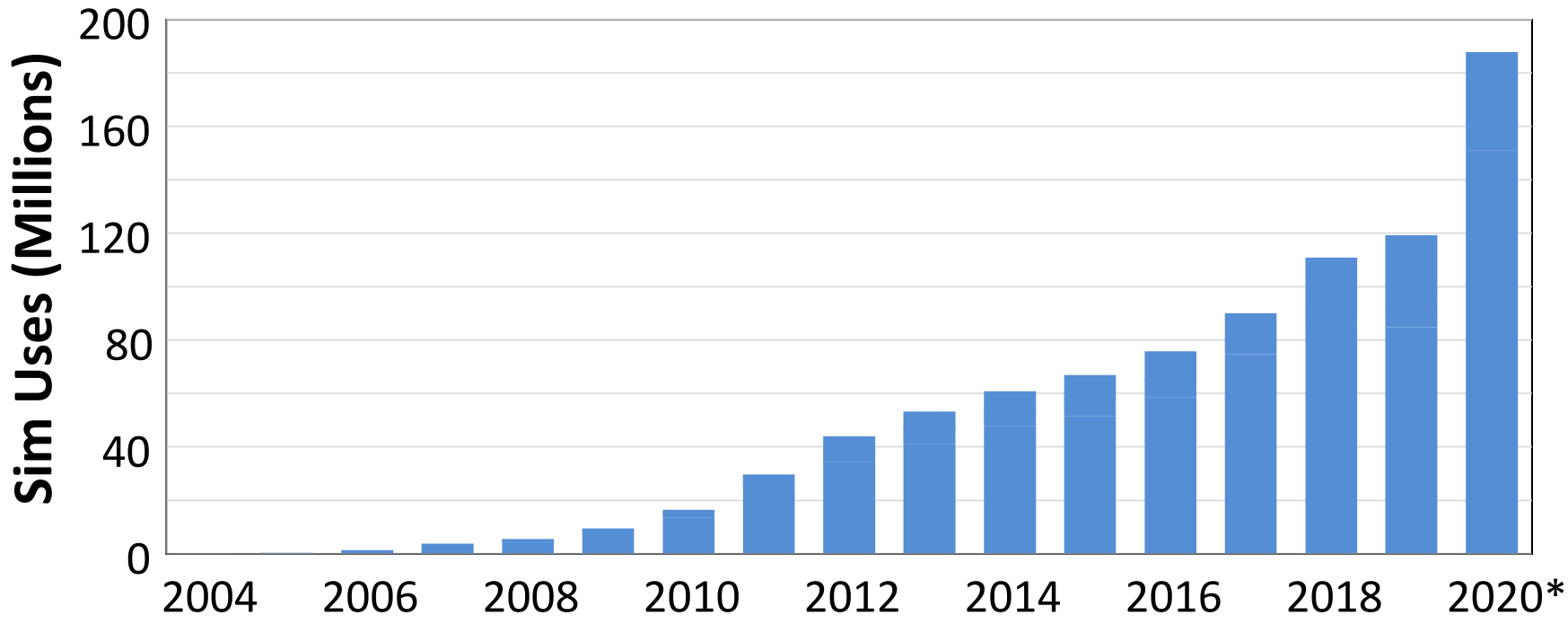
Translated into 90+ languages

Run online or offline



Intro to PhET

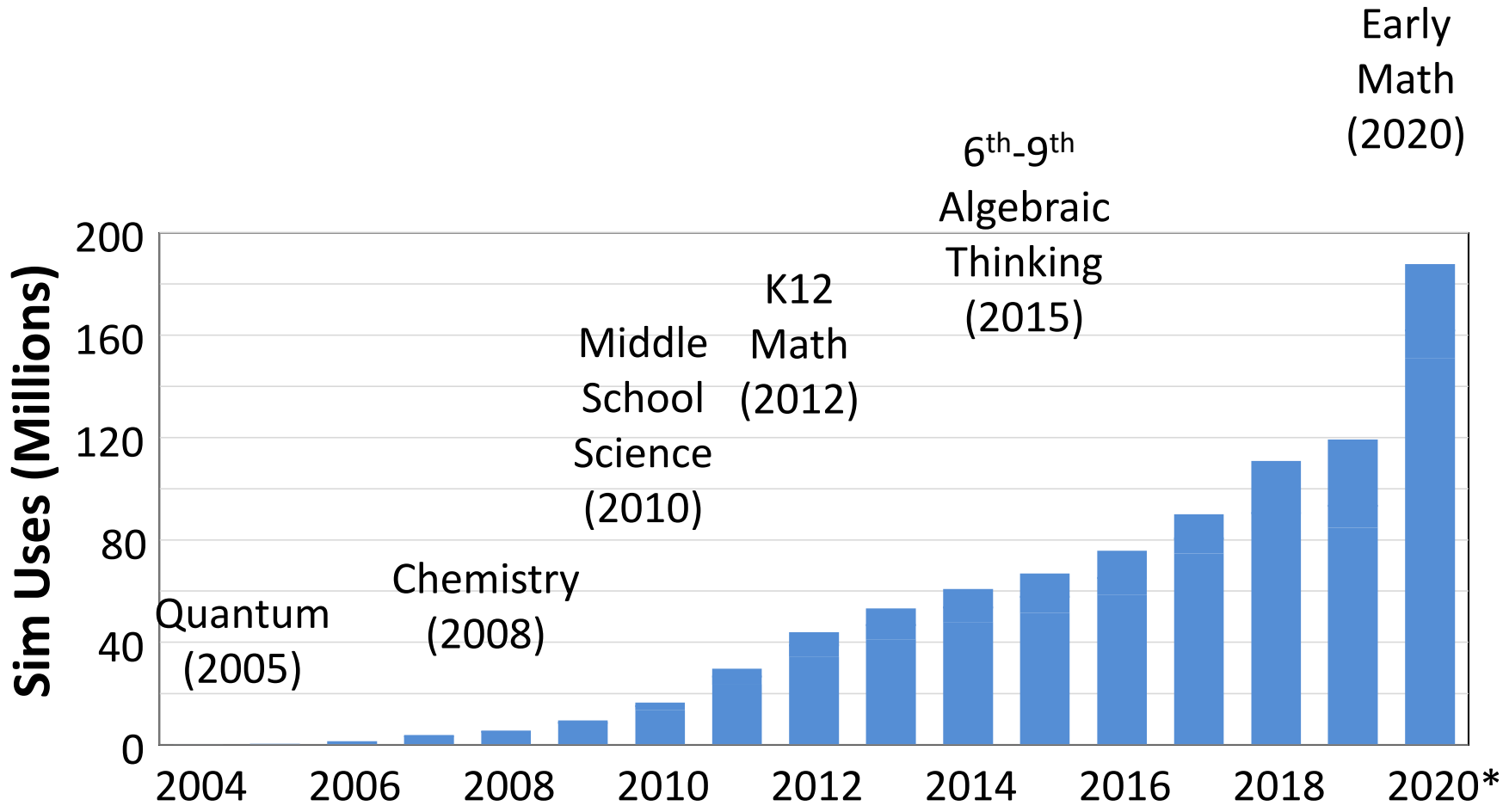
Over 200 Million Uses/Year



**Estimated projection for 9/20-12/20*

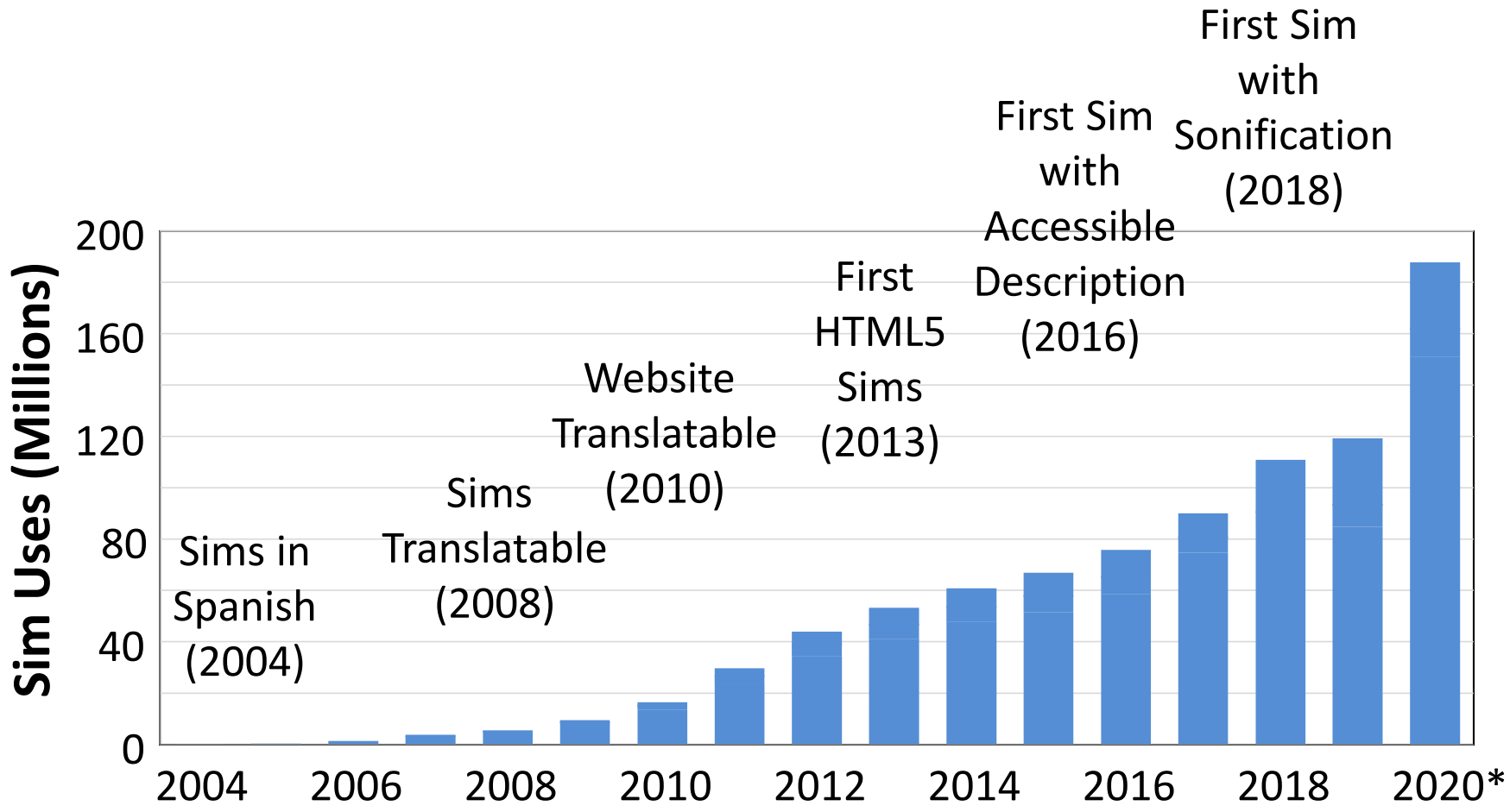
Intro to PhET

Content Expansion



Intro to PhET

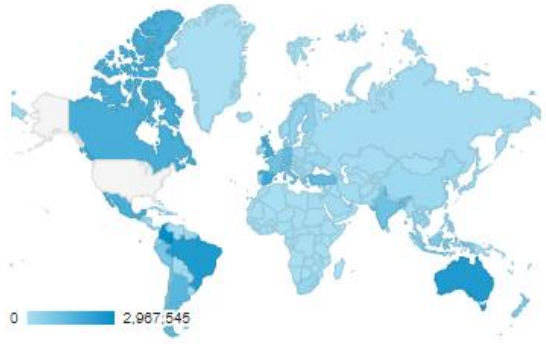
Technology Advancement

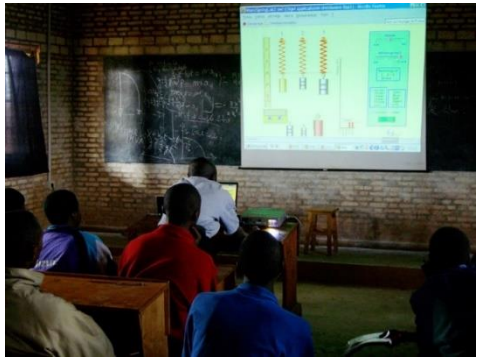


Intro to PhET

Global

~50% International. In 90 languages.





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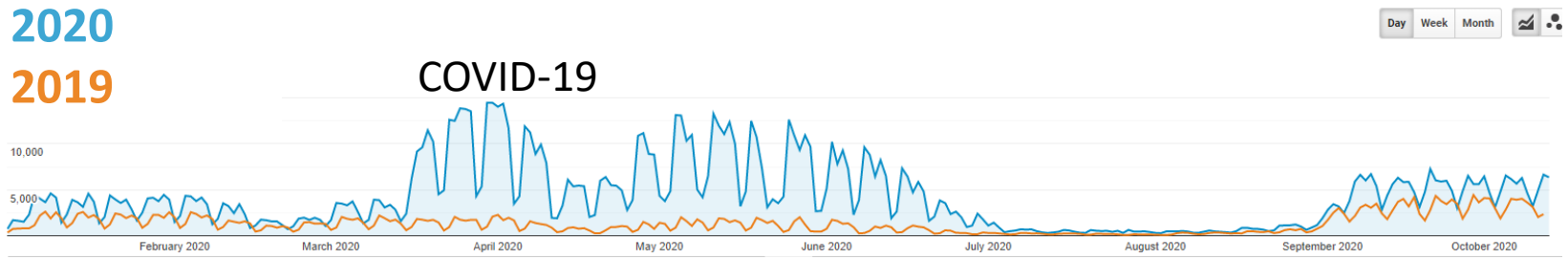
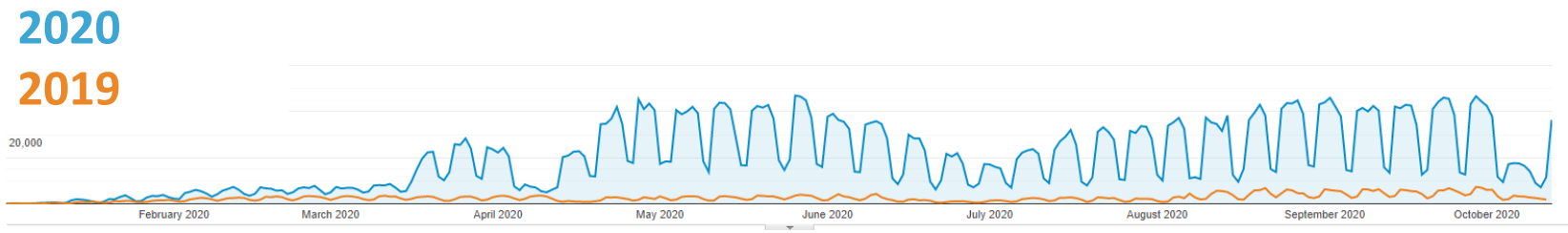


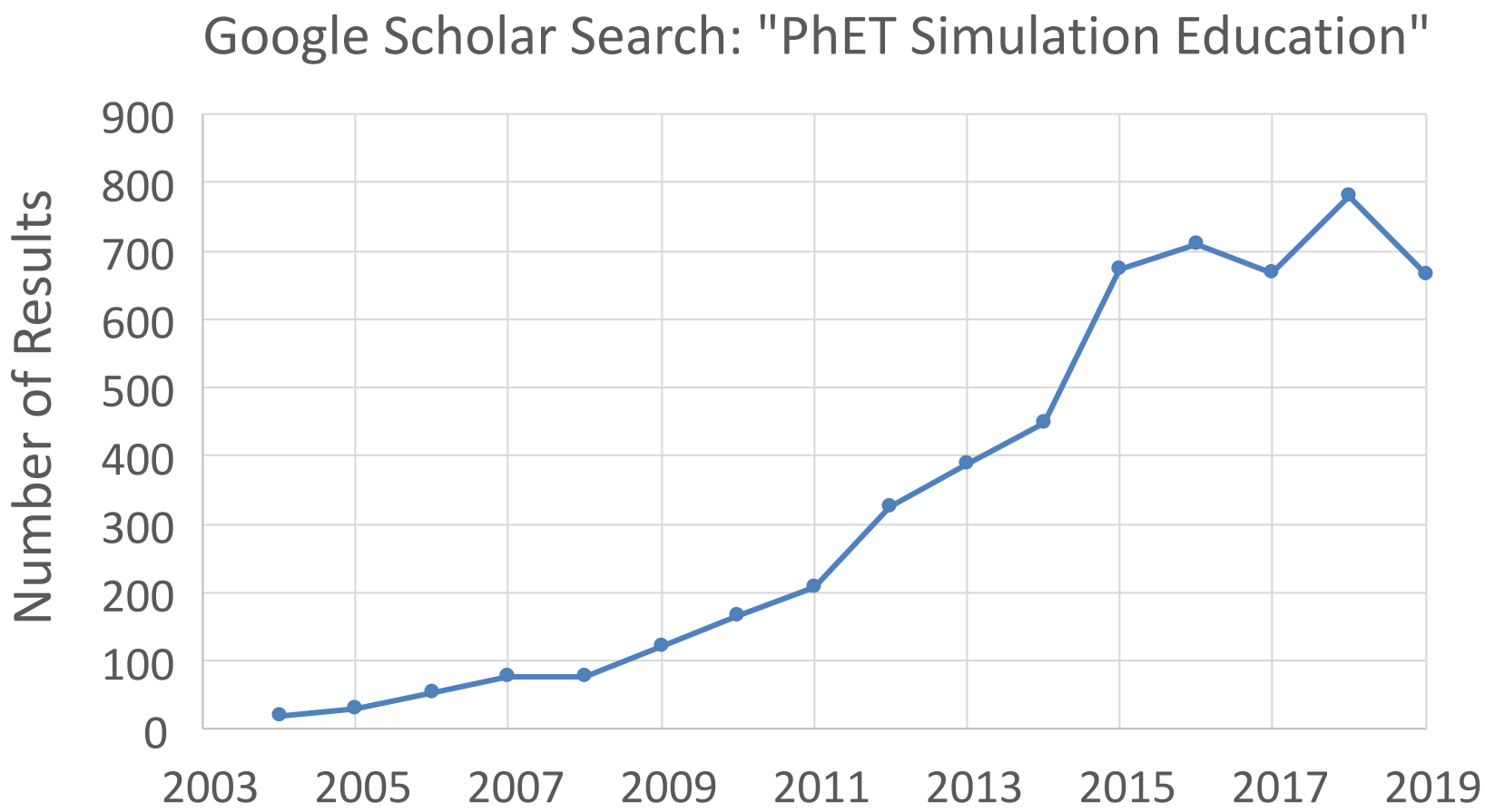
France
1.2M for 2020



Colombia
3.9M for 2020

Intro to PhET

Research on PhET sims



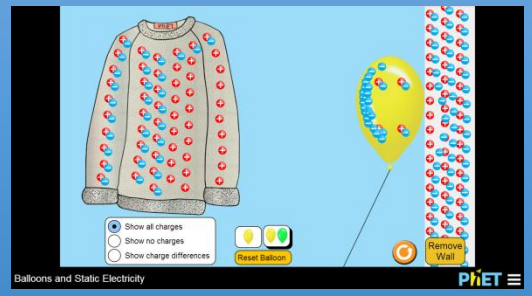
Next Generation PhET Sims

Next Gen PhET Sims

128 Java and Flash Simulations

PhET's design principles, process, and goals

HTML5 Sim Design Work



Community Needs

Next Generation Simulations

Research

Next Gen PhET Sims

Community Stakeholders

Educators
Learning Designers
Assessment Professionals
Researchers: DBER and Learning Sciences
Inclusive Design / Accessibility Experts
Education Technology Companies

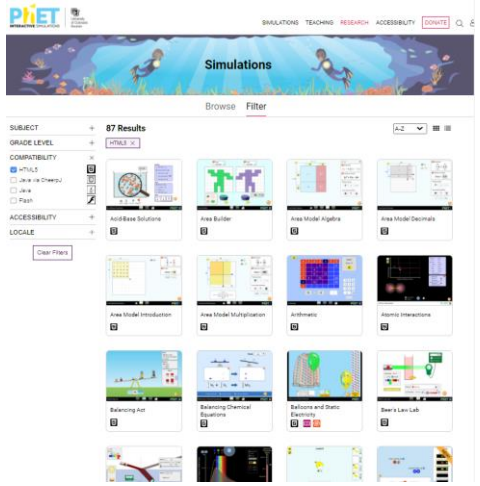
2014 Skateholders' Meeting: Envisioning Next-Gen PhET Sims

Next Gen PhET Sims

PhET INTERACTIVE SIMULATIONS

All devices (HTML5)
Translatable
Embeddable
Highly Accessible (in progress)

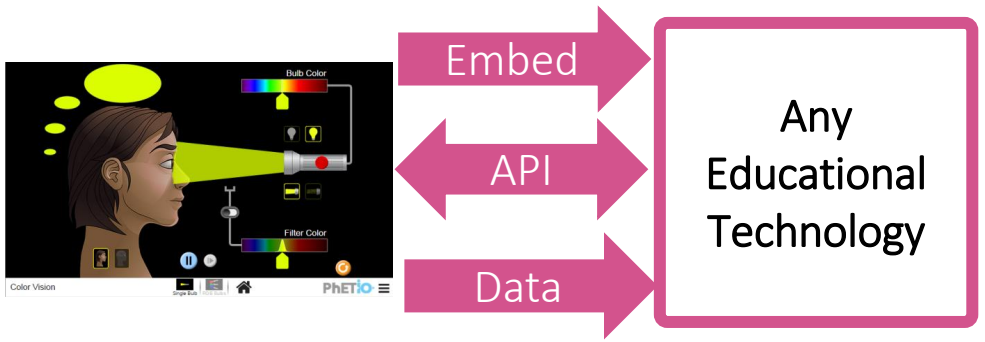
(87sims)



PhET-iO INTERACTIVE SIMULATIONS WITH INTEROPERABLE FEATURES

Customizable
Interoperable
Backend Data Collection

(~20 sims, but growing)

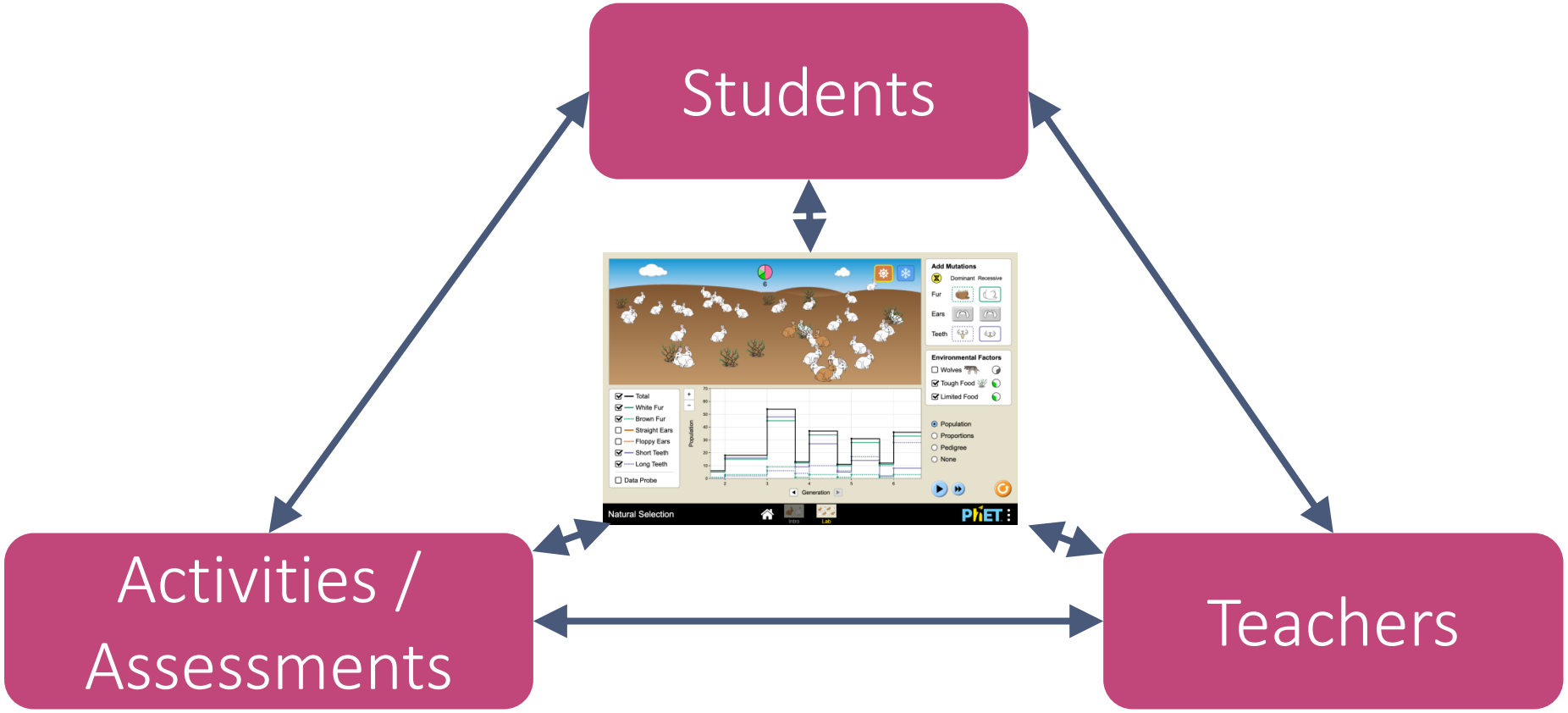


https://phet-io.colorado.edu

Next Gen PhET Sims

New Learning and Research Opportunities

New Structures, Roles, Activities, Feedback, Measures

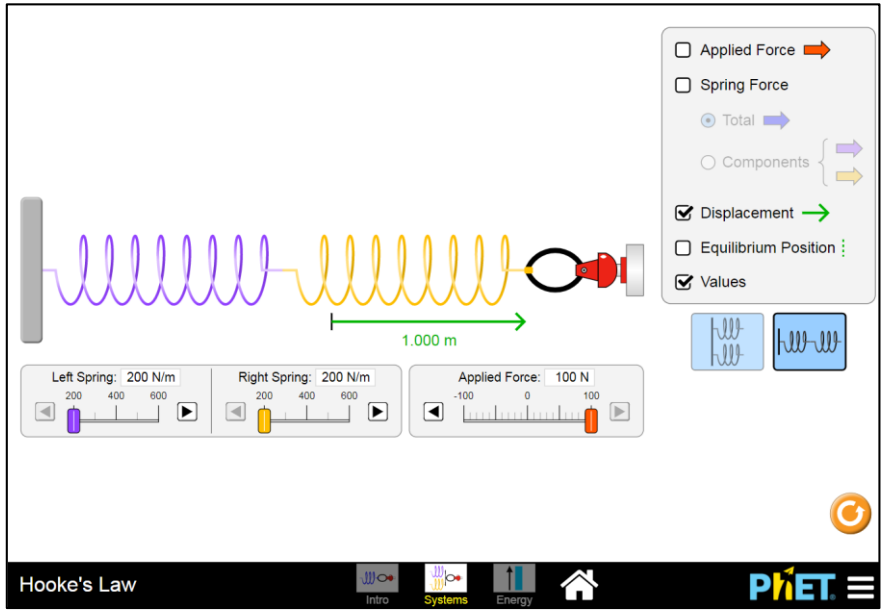


Sim-based learning

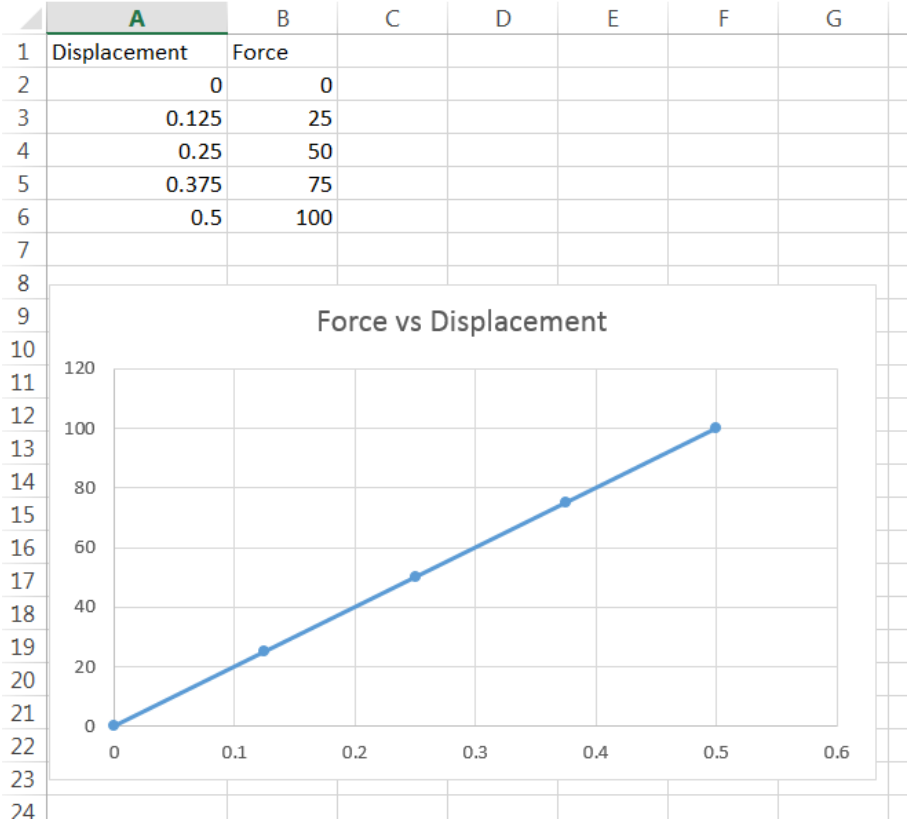
Andy Gavrin
IUPUI

Sim-based Lab: Process + Content Goals

Sim: Hooke's Law



Spreadsheet



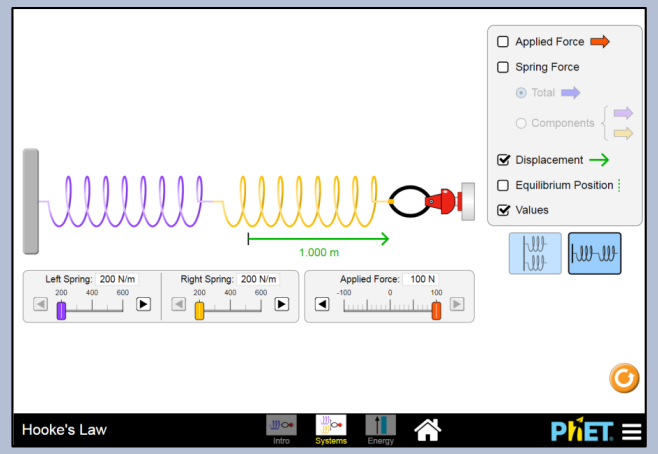
PhET

Sim-based learning

Andy Gavrin
IUPUI

Online Sim-based Lab:

Sim: Hooke's Law (PhET-iO)



Customize the Sim
Design Instructional Wrapper
Follow Student Actions
Provide Adaptive Feedback
Assess on Process and Content

Learning Platform

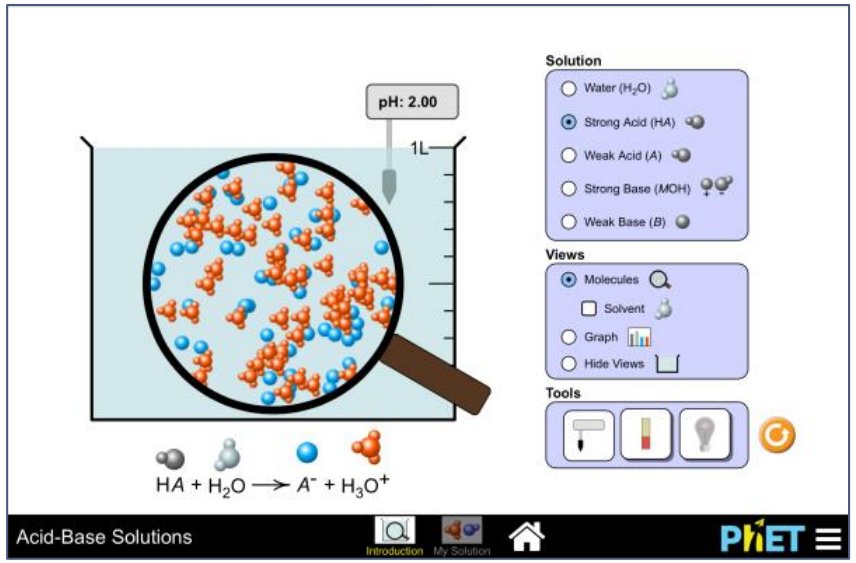
PhET

Research Examples

Sim-based Learning

Julia Chamberlain

Research on Activity Design: Guidance



Context

College Chem 1 Lab Sections

3 Activities:

Different Levels of Guidance

Logged Event Stream of User Interactions

Chamberlain, J. M. *et al.* How guidance affects student engagement with an interactive simulation. *Chem. Educ. Res. Pract.* **15,** 628–638 (2014).

Sim-based Learning

Julia Chamberlain

Activity Design: Impact of guidance

Guidance

Heavy

In the “Solutions” section of the control panel, select “Strong Acid.” Record the equation.

Moderate

Use the “Introduction” tab to compare **strong** and **weak** acid solutions. Describe all the ways that the solutions are similar and different.

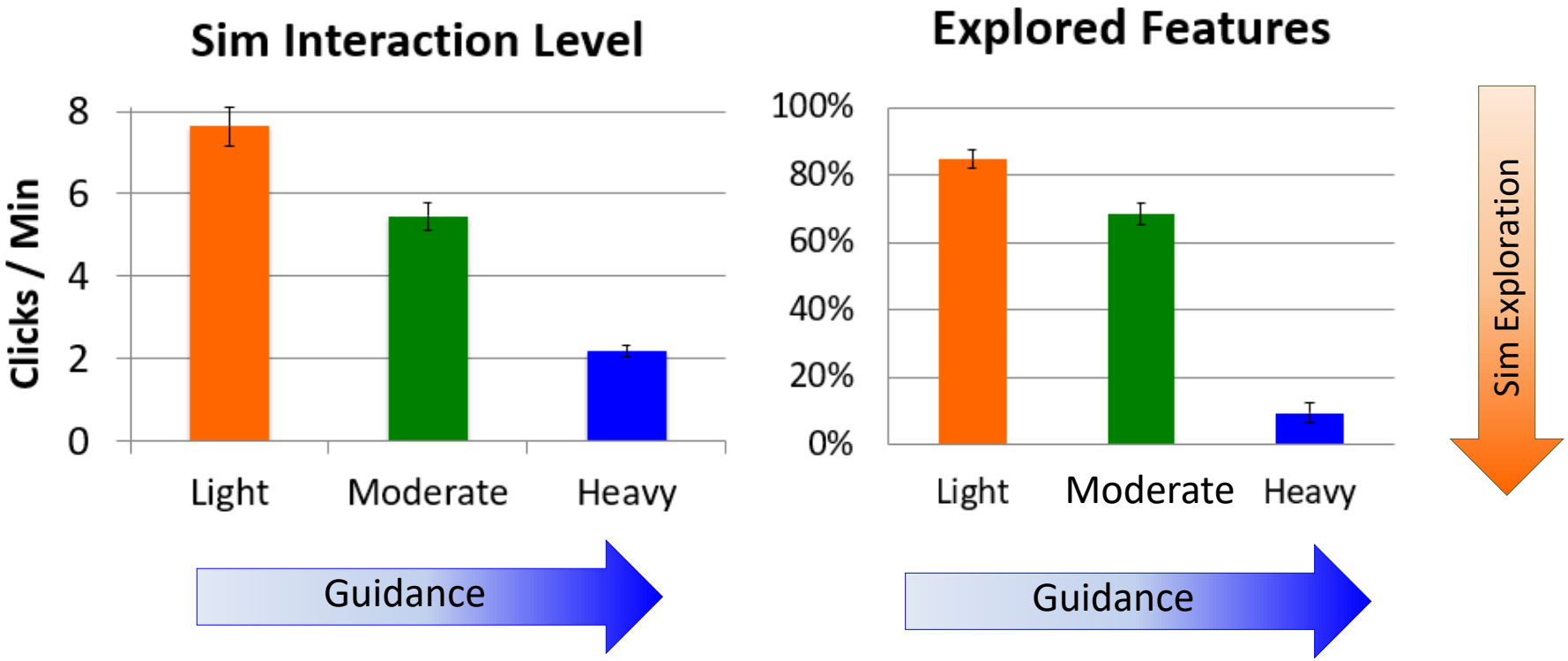
Light

Explore the sim. Make sure to investigate all of the factors that affect the pH of a solution.

Sim-based Learning

Julia Chamberlain

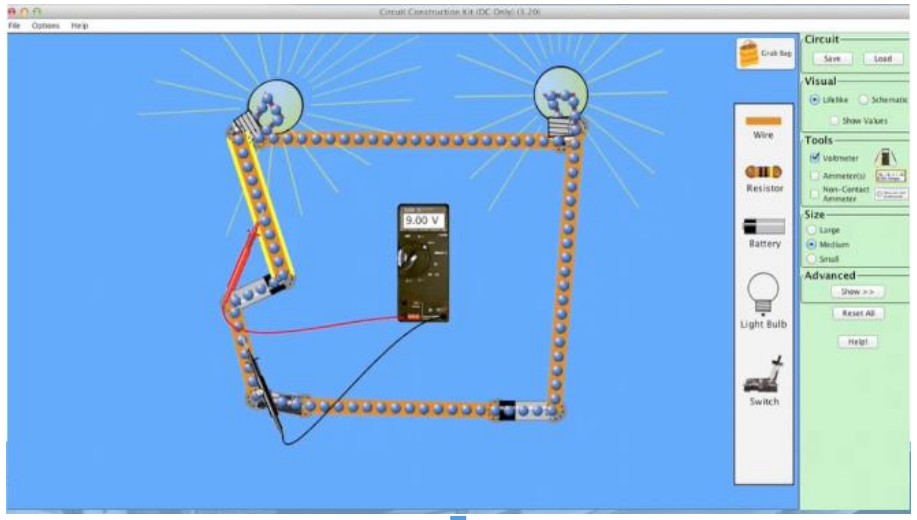
Activity Design: Impact of guidance



Learning Analytics

Ido Roll

Research on Guidance/Scaffolding & Learning



Context

100 1st year college students

Introductory Physics Courses

2 Conditions:

Different Levels of Scaffolding

Logged Event Stream of User Interactions

(100 hours of data, ~130,000 actions)

Roll, I. *et al.* Understanding the impact of guiding inquiry: The relationship between directive support, student attributes, and transfer of knowledge, attitudes, and behaviours in inquiry learning. *Instructional Science* **46,** 77–104 (2018).

Learning Analytics

Ido Roll

Procedure

Pre test → Unstructured / Directive → Unstructured → **Post test**

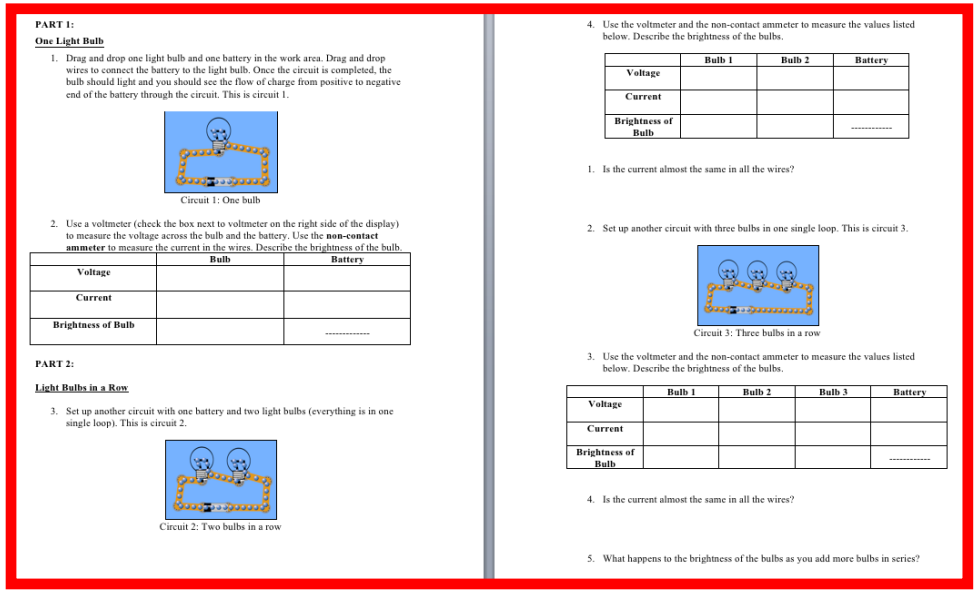
Activity 1

Activity 2

Unstructured

Use the DC Circuit PhET simulation to explore how voltage, current, and the brightness of light bulbs depend on the number and arrangement of light bulbs in a circuit.

Structured



PART 1:

One Light Bulb

1. Drag and drop one light bulb and one battery in the work area. Drag and drop wires to connect the battery to the light bulb. Once the circuit is completed, the bulb should light and you should see the flow of charge from positive to negative end of the battery through the circuit. This is circuit 1.

Circuit 1: One bulb

2. Use a voltmeter (check the box next to voltmeter on the right side of the display) to measure the voltage across the bulb and the battery. Use the **non-contact ammeter** to measure the current in the wires. Describe the brightness of the bulb.

	Bulb	Battery
Voltage		
Current		
Brightness of Bulb		----------

PART 2:

Light Bulbs in a Row

3. Set up another circuit with one battery and two light bulbs (everything is in one single loop). This is circuit 2.

Circuit 2: Two bulbs in a row

4. Use the voltmeter and the non-contact ammeter to measure the values listed below. Describe the brightness of the bulbs.

	Bulb 1	Bulb 2	Battery
Voltage			
Current			
Brightness of Bulb			----------

1. Is the current almost the same in all the wires?

2. Set up another circuit with three bulbs in one single loop. This is circuit 3.

Circuit 3: Three bulbs in a row

3. Use the voltmeter and the non-contact ammeter to measure the values listed below. Describe the brightness of the bulbs.

	Bulb 1	Bulb 2	Bulb 3	Battery
Voltage				
Current				
Brightness of Bulb				----------

4. Is the current almost the same in all the wires?

5. What happens to the brightness of the bulbs as you add more bulbs in series?

Learning Analytics

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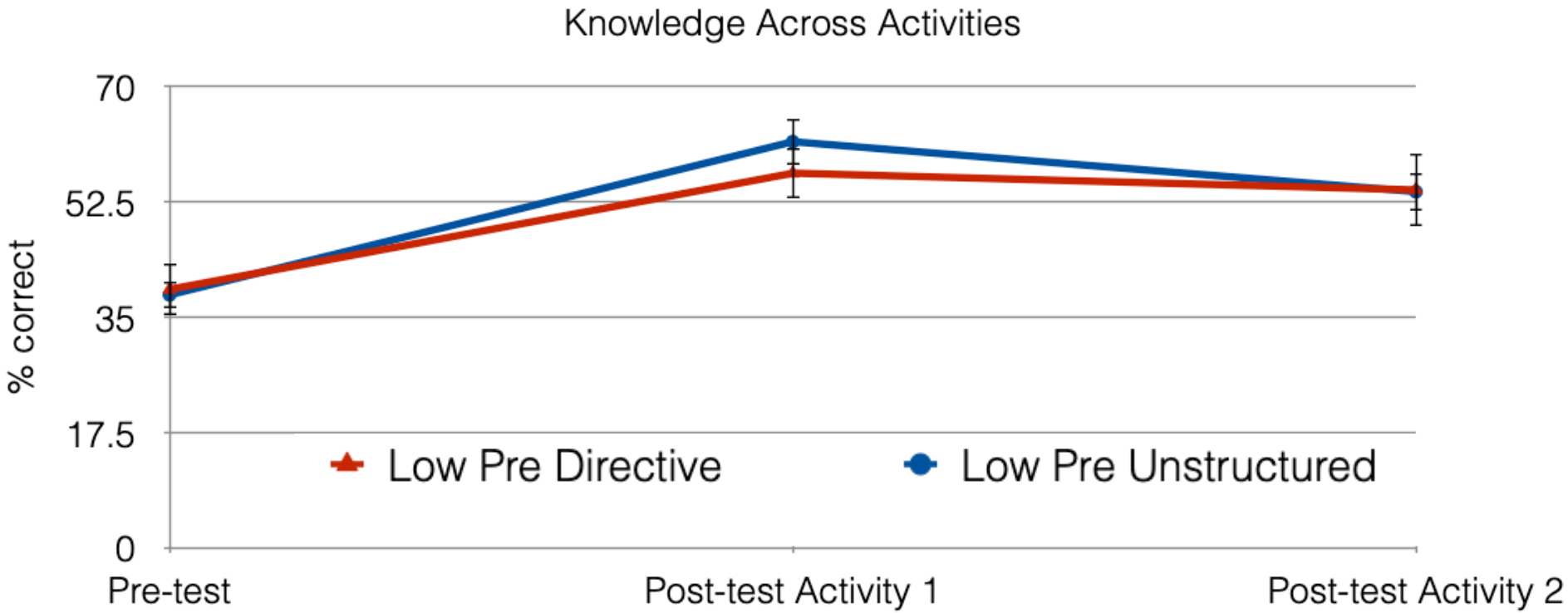
Impact on Learning (Low Pre-test Learners)

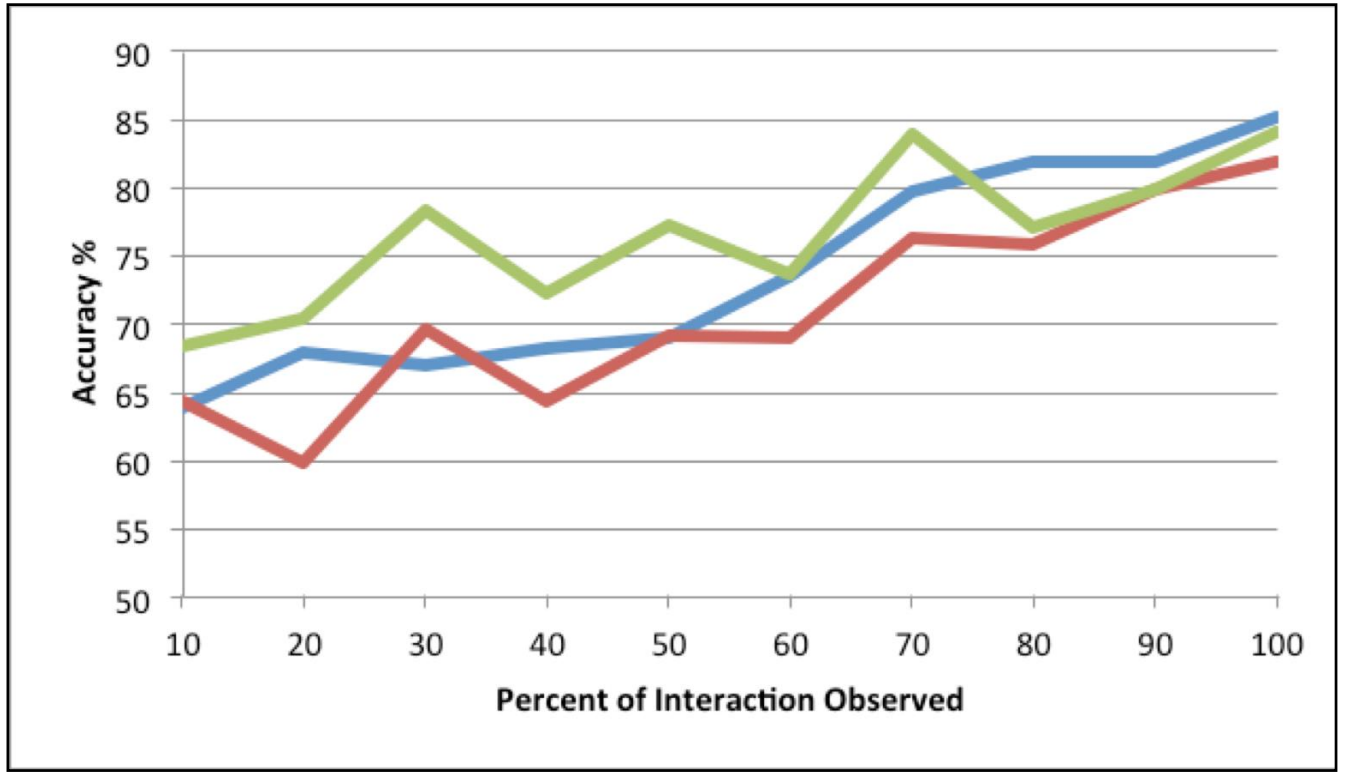


Learning Analytics

Ido Roll

Predicting Learning from Sim Interactions

Able to predict learning from log files after about 5 minutes (25% of the interaction).



3 different models of backend data signatures

Learning Analytics

Ido Roll

What did productive students do?

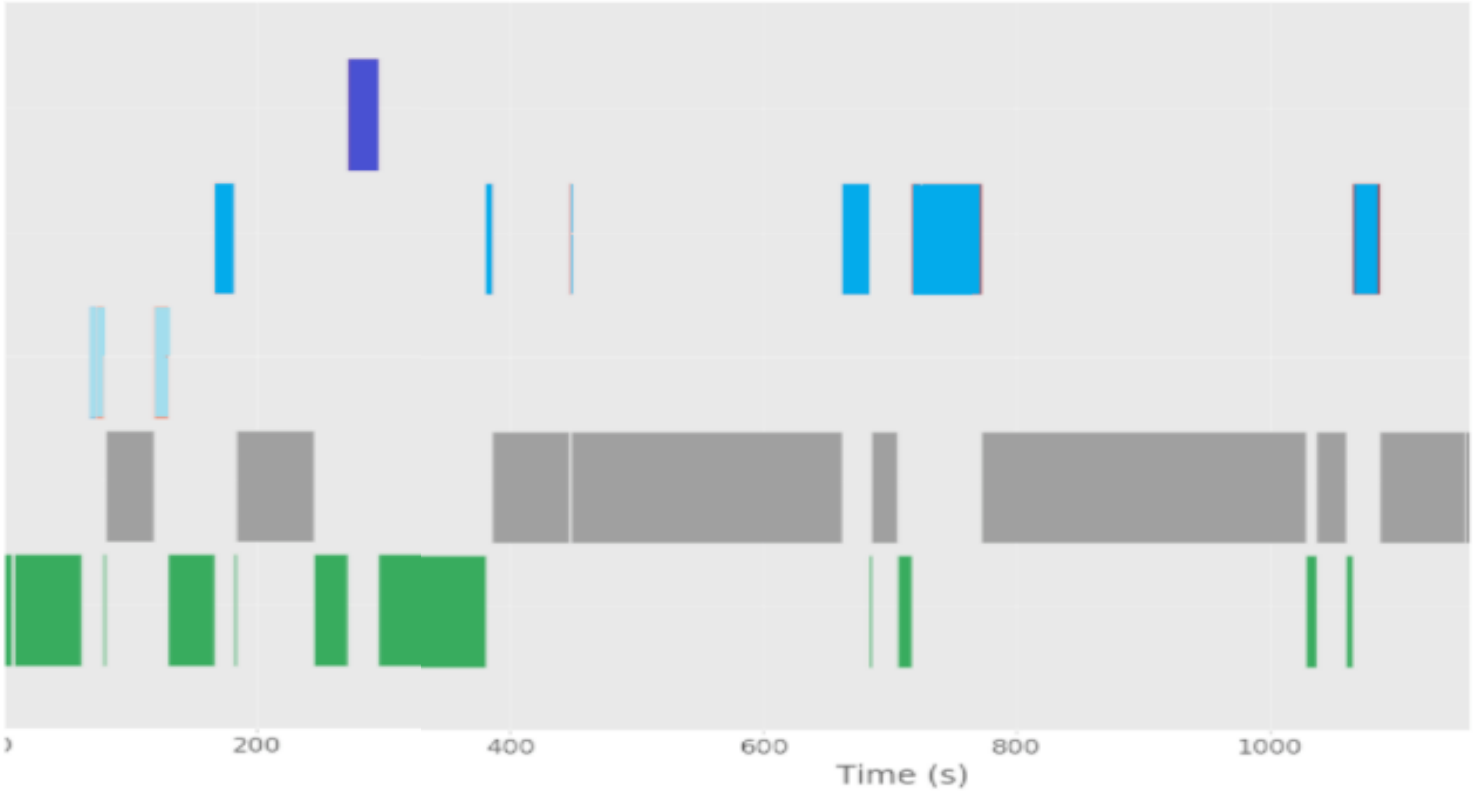
Test a circuit w/ many resistors (T_m)

Test a circuit w/ 2 resistors (T_2)

Test a circuit w/ 1 resistor

Pause

Construct



Learning Analytics

Ido Roll

What did productive students do?

Unproductive learners
P C T_m C T_m C
C P C T_2 C
P C P C T_m C
T_m C P C
T_2 C T_2 C

- T_m appears a lot.
- Pauses only before and after Construct.

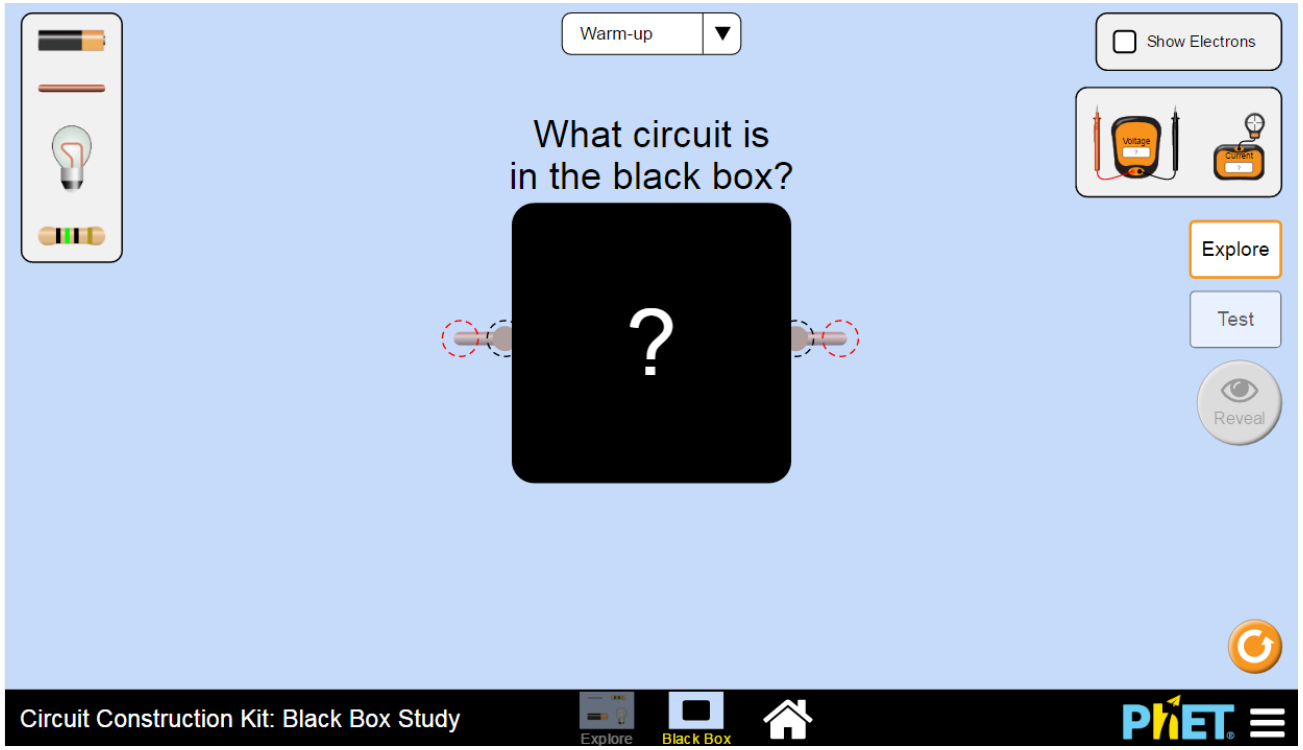
Productive learners
P T_2 P C
C T_2 P T_2 P
P T_2 P
T_2 P T_2 P C
C P T_2

- T_2 appears often, followed by a pause
- ...and iterate

Assessment

Assessing Knowledge and Practices

Shima Salehi
Wieman Group
Stanford



Assessment

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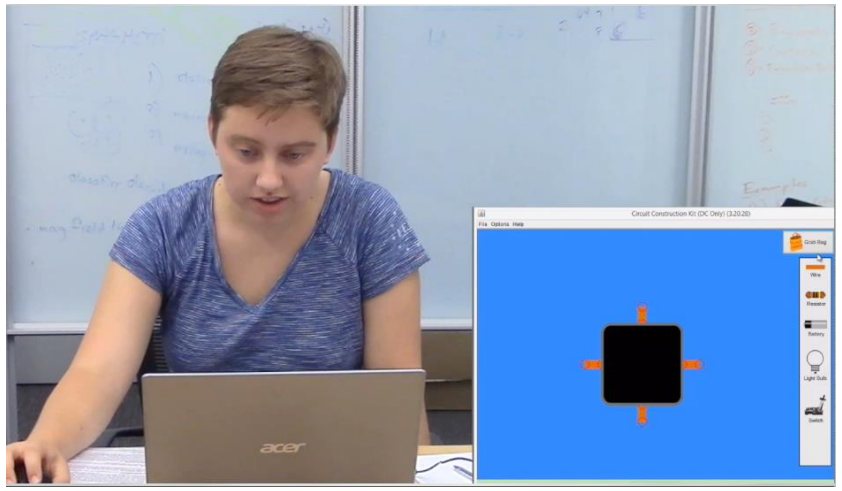
Wieman Group
Stanford

Interviews

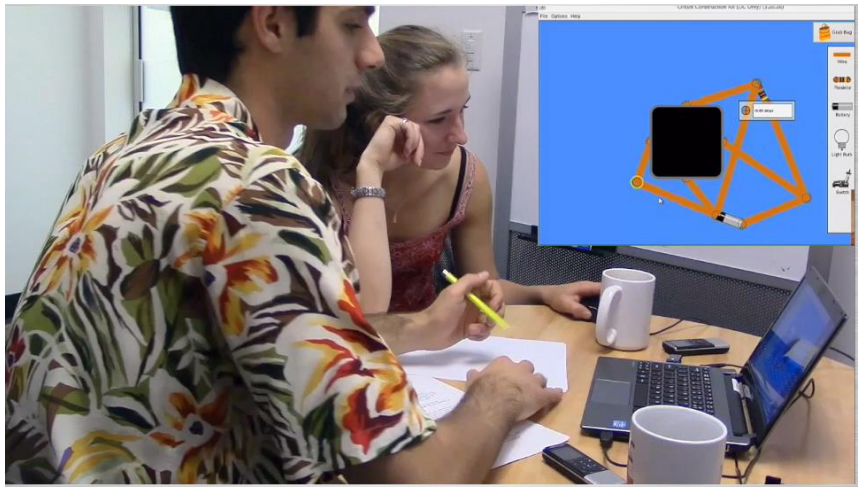
Ellen

An advanced undergraduate



Gail and Josh

Introductory E&M students



Assessment

Shima Salehi
Wieman Group
Stanford

Coding: Distinguishes Novices and Experts

Experimentation Practices	Reflective Practices
Problem Decomposition	Reflect on Assumptions
Data Collection	Reflect on Knowledge
Data Representation	Reflect on Strategy
Data Analysis	Verification

Assessment

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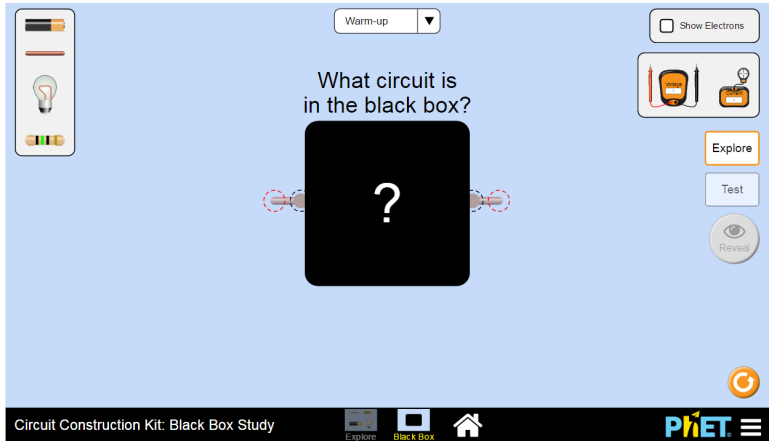
Wieman Group
Stanford

At Scale?



Backend Data

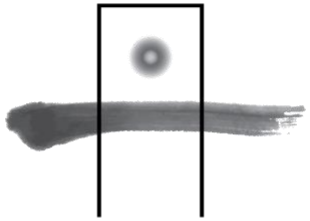
Learning Analytics Methods

Funders

Thank you!

THE WILLIAM AND FLORA
HEWLETT
FOUNDATION

GORDON AND BETTY
MOORE
FOUNDATION



Yidan Prize
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Google.org

Invitation

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