Engaging Students and Supporting STEM Learning with PhET Simulations

Amanda McGarry, MA
PhET Math Specialist
University of Colorado Boulder

Kathy Perkins, PhD
Director of PhET Interactive Simulations
University of Colorado Boulder

AMANDA McGARRY, MA
KATHY PERKINS, PhD
PhET Interactive Simulations
University of Colorado Boulder

Amanda McGarry, MA
• Holds a MA in Math Education and BA in Mathematics
• Former math teacher for 6 years, primarily in Brooklyn, NY
• Currently leads PhET math simulation design and teacher partnership initiative

Kathy Perkins, PhD
• Holds 3 degrees from Harvard University; physics BA, chemistry MA, atmospheric science PhD; Also has authored over 60 articles on STEM education
• Currently directs PhET Interactive Simulations at UC-Boulder; also a faculty member
• Many PhET international recognitions and over 200 million simulations/year worldwide
Who is here?

Respond to the poll

[link]

Responses

AGENDA

What is PhET
How to teach with PhET
Where to find more resources
How to stay in touch
Motivation

**STEM fields are active**

- Curiosity
- Evidence
- Patterns
- Data
- Limits
- Designing Experiments

- Experimentation
- Analysis
- Inquiry
- Test

- Interpretation
- Predict
- Uncertainty
- Assumptions
- Models

Motivation

**Challenge:** Make learning STEM more like doing STEM

- STEM Inquiry
- STEM Practices
- Problem Solving

Advance (their) understanding, knowledge, and ideas
What is PhET?

Overview

- 160 Interactive Simulations
- 2000+ Activities (170+ for remote)
- Physics, Chemistry, Math, Earth Science, Biology
- K-12 and College
- Open education resources
- Translated into 90+ languages
- Can run online or offline

https://phet.colorado.edu

What is PhET?

Research-based design

All PhET sims go through a rigorous research-based design process
What is PhET?

**Play with a sim!**

Choose a breakout room based on the content you are most interested in:
Room 1: Forces and Motion
Room 2: Gas Properties
Room 3: Natural Selection
Room 4: Equations

Share your observations in Jamboard!

What is PhET?

**Sim design principles**

- MULTIPLE, ACCURATE, DYNAMIC REPRESENTATIONS
- IMPLICIT SCAFFOLDING
- COLLECT AND INTERPRET DATA
- PEDAGOGICALLY POWERFUL ACTIONS
- INTUITIVE INTERFACE

McGarry/Perkins – Engaging Students with PhET Simulations
How to teach with PhET

Simulations are designed to be flexible

- Demonstration
- Predictive questions
- Guided inquiry

How to teach with PhET

Demonstration

- Great for classrooms with limited technology
- Provides a dynamic visual to complement a lesson
How to teach with PhET

**Interactive lecture**
- Can use color cards, clickers, or polling
- Use the sim to test predictions
- Ask concept questions

How to teach with PhET

**Guided inquiry**
- Students using the sim directly to explore and discover
- Students can take different paths toward the same learning goal
- Supports rich discussions
How to teach with PhET

Creating and finding sim-based lessons

- Create your own lesson - paper/pencil, google docs/excel, slides
- Find and adapt one of over 2,000 lessons on the PhET website
- Find lessons in your favorite platforms (STEMscopes, Nearpod, BrainPOP, etc...)

How to teach with PhET

Sample interactive lecture

- Grade 9 (or middle school or intro chem in college)
- Learning goal: Develop a model of an atom; Predict how addition or subtraction of a proton, neutron, or electron will change the element, the charge, and the mass.
- Simulation: Build an Atom
Lesson: Let’s Build an Atom

Last week

- Molecules are made up of different kinds of atoms

Today

- Dive inside the atom itself (notebook)

Discoveries about an atom

- (paste notes)
Apply and Predict

What will change if we remove an electron?

A) The name of the element  
B) The mass  
C) The net charge  
D) More than one of the above

Strategies for interactive lecture

Engage students in STEM practices during lecture/presentation!

- Whole class inquiry
- Concept Questions with Peer Instruction
  - Pose questions → neighbors discuss → students vote
    → students share reasoning → “do experiment” with the sim
  - Find resources and questions at the PhET website
How to teach with PhET

Sample guided inquiry lesson

- Grade 8
- Learning goal: Define a function as a rule that assigns exactly one output to each input.
- Simulation: Function Builder

Lesson: What is a function?

Play with Function Builder!

- Take a few minutes to just play
- Be prepared to share something you can do with the sim or a question you have

Share in the chat, or raise your hand:
What did you notice? What did you wonder?
Lesson: What is a function?

Answer the questions in the google doc

- Copy the google doc* linked in the chat and add your responses
- When indicated, discuss your answers with your breakout group

*If you don't have google, you can view the doc here

Discussion

- What would you call the cards on the left?
- What would you call the cards on the right?
- What happens if you put the same card through the function multiple times?
- What are the different ways a function can be represented?

Type your response in the chat and wait to hit enter
Lesson: What is a function?

Summary

What is a function?

Type your response in the chat and wait to hit enter

How to teach with PhET

Strategies for guided inquiry lessons

- Start with open play
- Use carefully designed challenge prompts
- Provide opportunities for students to share their thinking (in pairs, and with the whole class)
- Summarize, using the sim to illustrate thinking
How to teach with PhET

Open play

- Give students a chance to explore and take ownership over their learning
- Allow students to share their findings

Challenge prompts

- Find all the ways to... make a necklace with the same bead pattern.
- What's the largest... fraction you can make?
- Create... an atom with a net charge of zero.
- What are two ways to... turn on a light bulb?
- How can you make... the outputs... bigger?
- Develop a procedure for... solving equations with two variable terms.
- Name... the different parts of an atom.
- Build... two ratios that are equivalent.
How to teach with PhET

Support student-centered learning

- Provide opportunities for students to share with classmates
- Use student thinking to seed class discussions
- Always allow students to “drive” the sim when sharing their ideas

How to teach with PhET

Summarize

- Facilitate a discussion to wrap up the learning goals
- Use a poll, quiz, or open-ended prompt as a formative assessment
How to teach with PhET

Evidence of new classroom norms

- One teacher
- Comparison of sim lessons and non-sim lessons


Where to find more resources

Find sims you want

- Browse the newest sims
- Filter by subject, grade level, tech compatibility, accessibility features, and even translations
Where to find more resources

Using a specific sim

- Learning goals
- Teacher guides for every sim
- Teacher-submitted activities

Tips for using PhET

- Documentation about writing activities, facilitating lessons
- Video series
Where to find more resources

Virtual workshop

• Conduct PD with your colleagues

Stay connected

Follow PhET and learn about new sims

@PhETsims
facebook.com/PhETsims

Register for the website for email updates
Suggestions and questions: phethelp@colorado.edu
Thank You for Attending

We appreciate our talented presenters today.
We appreciate you teaching and taking care of children.

STEMposium.com