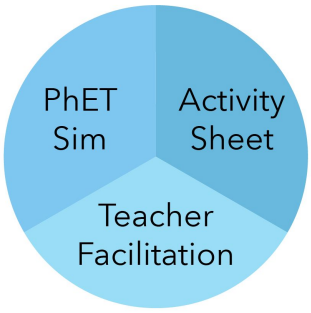
PhET Design Guidelines for Sim-Based Math Lessons

Overview

A sim-based math lesson includes the sim as a central learning tool, an activity sheet to guide student thinking, and teacher facilitation moves to create a student-centered environment.



Students work directly with a sim using individual or shared devices, record their thinking on an activity sheet, and engage in discussion within groups while the teacher facilitates and leads whole-class discussions.

Preparing to design a lesson

- Play with the sim!
- Consider the number of devices and desk arrangement
- Consider 2-3 learning objectives over 1-2 days
- Brainstorm challenge prompts
- Think about how you will measure/assess student learning
- Consider how to differentiate and provide multiple entry points for all students to be successful

Goals of the lesson

- Student-centered: fosters an environment that values student ideas and promotes student agency
- Responsive: adapts to emergent student ideas
- Goal-oriented: includes clear learning objectives and summary
- Guided: uses an activity sheet to guide student inquiry

Goals of the activity sheet

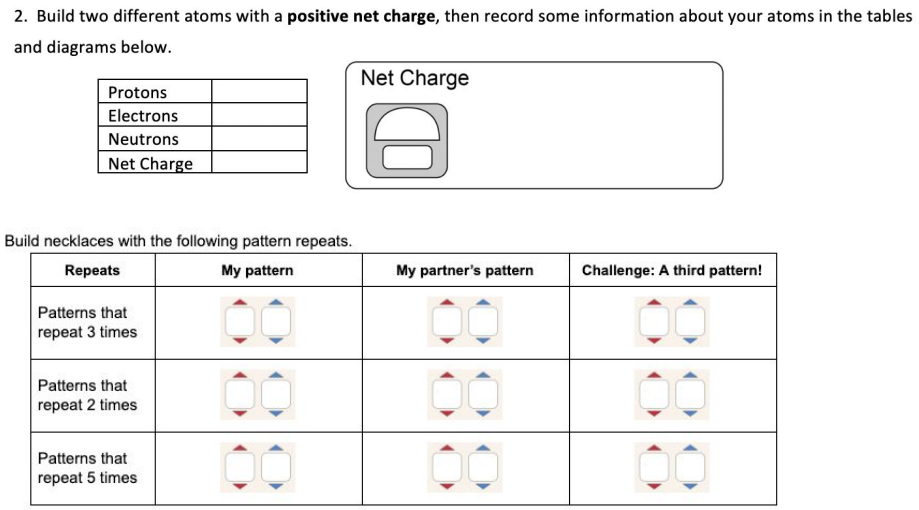
- Student-centered: a place to record thoughts and discoveries
- Sim-focused: positions the sim as the central learning tool
- Scaffolded: uses open-ended challenge prompts and tables to keep ideas organized, but keeps the length manageable and avoids explicit instruction on how to use the sim
- Modular: has places to pause for discussion

Sample lesson flow

Timing	Students…	Teacher…
5-8 mins	(Optional) Work through warm-up problem, such as introduction to topic, hook, or opportunity to activate relevant prior knowledge.	(Optional) Conducts typical daily routines
3-8 mins	Freely explore the sim (open play).	Circulates, listening to student conversations and probing students to experiment with the sim
5-8 mins	Share discoveries from open play.	Allows students to drive the sim in front of the class
10-20 mins	Work through activity sheet *part 1* in small groups (2-4 students), discussing ideas where indicated.	Circulates the room, helping students who might be stuck or need redirection. Listen for examples that students can share later in the discussion. Sample questions include: ● "How do you know?" ● "Can you share that later with the class?" ● "I wonder…" ● "What would happen if… " ● "Wow! What do you think is happening there?" ● "Does that tool help you answer this question?" Checks for understanding: look at answers to the questions you've identified as checkpoints. Has informal, small-group discussions where appropriate, but save student ideas for the whole-class discussion as well.
5-10 mins	Participate in whole-class discussion, engaging in argumentation and reasoning.	Facilitates whole-class discussion, calling on a variety of students to share ideas from part 1 of activity sheet. ● Use sim to test predictions or provide evidence for claims ● Highlight key ideas Uses the discussion as a checkpoint for the class.
10-20 mins	Work through activity sheet *part 2* in small groups (2-4 students), discussing ideas where indicated.	Circulates the room, helping students who might be stuck or need redirection. Listen for examples that students can share later in the discussion.
5-10 mins	Summarize key ideas from lesson,	Facilitates a whole-class discussion to address learning goals and summarize discoveries.
5 mins	Complete exit ticket (optional).	Provides an exit ticket to check for individual student understanding.

Activity sheet guidelines

- Keep it short so as not to overwhelm, with space for writing ideas (approximately 2 pages)
- Provide explicit stopping points for discussion(s) and prepare discussion questions
- Use sim-focused challenge prompts that generate discussion, support student autonomy, and encourage a variety of answers and approaches, allowing for peer comparison and discussion:
    - **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**... combine coins?
    - **How can you make**... the outputs... bigger?
    - **Develop a procedure for**... solving equations with two variable terms.
    - **Name**... the different parts of the function builder.
    - **Build**... two ratios that are equivalent.
    - **How do you know**... your two ratios are equivalent?
    - *Before & after example:* (learning goal is for students to discover GCF)
        - *Before*: Build a necklace with 6 red beads and 8 blue beads. What do you notice about the number of times the pattern repeats?
        - *After*: Build a necklace with a pattern that repeats 2 times. Compare with your partner. What do you notice about both ratios?
- Scaffold with tables to provide structure and reduce drawing load



2. Build two different atoms with a **positive net charge**, then record some information about your atoms in the tables and diagrams below.

Protons	
Electrons	
Neutrons	
Net Charge	

Net Charge

Build necklaces with the following pattern repeats.

Repeats	My pattern	My partner's pattern	Challenge: A third pattern!
Patterns that repeat 3 times			
Patterns that repeat 2 times			
Patterns that repeat 5 times			

- Allow extra time for unexpected learning opportunities

Reflection strategies

- Consider inviting a colleague to observe
- Consider using a reflection rubric
- Make tweaks for the future (and update your activity on the PhET website!)

For more information, see:
Activity sheet guidelines
Facilitation strategies