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Why You Should Include Simulations in Your STEM Lessons: A physics teacher discusses 6 reasons why simulations take STEM learning to the next level.

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During my first year of teaching, a mentor teacher showed me interactive PhET simulations, and it changed my curriculum forever. To be honest, I was blown away by their versatility.

Since then, I have implemented the use of many simulations in my Physics, Conceptual Physics, and Physical Science classes. Here are six different ways that I use simulations in my classroom:

1. Low Error Quantitative Analysis

Coming from a science background, I know that the more data points my students can collect, the better their analysis will be. I also know that the average 15-year-old can have short attention spans.

Sometimes using a simulation, like this Charges and Fields simulation, allows my students to take a large amount of data more accurately and in less time than a hands-on lab. They can change variables with a tap of their finger and get instant results. They can change more variables than we can control in a classroom setting and still quickly return to default settings. This allows them to gather enough data in one class period to make the data interpretations necessary to see how these values influence each other.

2. We Just Can't Do That…

When we study Astronomy and gravity beyond Earth and orbits, I'm limited on hands-on activities. Teachers do some heavy lifting, but I don't think any of us can move a planet. "I can't bring Jupiter in here kids," as I tell my students, so an interactive simulation is the next best thing. This Gravity and Orbits simulation allows students to model simple orbiting systems and see the results.

In my classroom, I could have one student pretend to be the moon and orbit, another pretending to be the Earth, and try not to let them trip over each other as they orbit the sun but…why? Such a model brings its own misconception of size, scale, and speed even if they can carry it out successfully. I want students to see the effects of changing the mass of the star and realize that this change in force has a direct effect on the planet's orbit. I want them to think about the height of a satellite above a planet and think about how that changes with the size of it.

In a nutshell, I want them to play with these adjustments to think critically about what they see and apply that to new problems that are presented to them. Students can play with this simulation and discover some amazing connections beyond the equations they are taught.

3. Can You See What I See?

Science, however constant, can be difficult to visualize. Some things are too small like atoms or microbes. Some are invisible to the human eye. While studying electric or magnetic fields, we have a lot of indicators of those fields, but no magic camera that allows us to see the fields. For example, Faraday's Law is something that can be demonstrated in the classroom, but only by comparing it to something similar, because we can't see magnetic field lines. Electric fields can't be seen either even though their effects might be.

The Charges & Fields simulation that I use allows students to see the fields around different charged particle arrangements. Students could create complex patterns and see the resulting field. They can measure its strength, determine the size of the force on another particle and more. I can set up a certain arrangement of particles ahead of time and ask students to describe the field that they would see. With a check of a box now students will be able to see this invisible electric field around the specific arrangement I wanted them to discuss.

4. Fun Applications and Extensions

"Okay students, turn off gravity," are instructions I can't expect students to follow. The Balancing Act simulation about balanced torque is another one that quickly evolves into a competition among students. There are quite a few ways to get a balanced see saw (the "right answer") and students often don't believe another has solved it until they can prove it. That means students are explaining their solutions to each other, debating their accuracy, and hopefully coming to an agreement.

5. Intuitive Proportions

There are many times when I don't need students to solve for a number, I just want them to be able to infer a change based on what they know. Many of my students would rather solve a calculation question than answer a conceptual one. Without a number backing it, they often don't understand the proportions in equations.
I use the Wave on a String simulation to show students how changes in frequency affect the wavelength of a wave. It only takes a few adjustments for them to see and understand the pattern they may have missed with calculations.

6. Simplify to Clarify

Over-simplification can cause problems, and can frustrate students. While studying motion, I must tell students to ignore wind, air resistance, shape and size of the object, etc. There are several simulations that offer simple yet highly visual examples of phenomenon that help make it clear to students.
The Friction simulation shows students what happens at the microscopic level when there is friction between two books. The Balloons and Static Electricity lets me show students what is happening with invisible charged particles when a balloon sticks to the wall.
Whether my students complete a prescribed lab, play them as a game, or see them briefly as part of a lecture, they love interactive simulations. The available depth and variety of simulations means that there is something for every unit and these simulations are embedded throughout my curriculum all year.