Using Inquiry Based Simulations in the Honors Science Classroom

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Introduction

The project known as PhET, originally stood for Physics Education Technology, but was quickly expanded into the other natural sciences. It is a project which, with a grant from the NSF and other sponsors, now provides free inquiry- based simulations in the natural sciences and mathematics. The project was founded by Nobel Prize winner Carl Wieman. The simulations are highly interactive, easy to use, and based on the latest educational research. The GMU Honors College teaches several science courses geared to high achieving liberal arts students. The courses cover a wide range of topics that include astrobiology, energy/environmental issues, and scientific thought and processes. Despite their high ability and motivation, these students often report a dislike of science and a reluctance to engage in scientific inquiry. PhET simulations were used as laboratory experiments to teach basic concepts in physics and chemistry. Students display high engagement and interest utilizing PhET simulations. Students also were able to demonstrate creativity in problem solving, and a reduced fear of making mistakes. The PhET computer simulations allowed students to quickly identify cause and effect relationships between simulation inputs and outputs.

Figure 1: Screen capture of the PhET website. Simulations are free. Registration gives teachers access to a broad selection of prepared labs and exercises utilizing the various simulations. Link: https://phet.colorado.edu/

Keywords

PHET; simulations; physics; chemistry; inquiry-based learning; liberal arts; creative problem solving; honors

PhET Design

PhET simulations have been created to foster student engagement, and inquiry based investigation in science and math. The following principles have guided PhET's design:

1) Encourage scientific inquiry.
2) Provide interactivity.
3) Make the invisible visible.
4) Show visual mental models.
5) Include multiple representations (e.g., object motion, graphs, numbers, etc.).
6) Use real-world connections.
7) Give users implicit guidance (e.g., by limiting controls) in productive exploration.
8) Create a simulation that can be flexibly used in many educational situations.

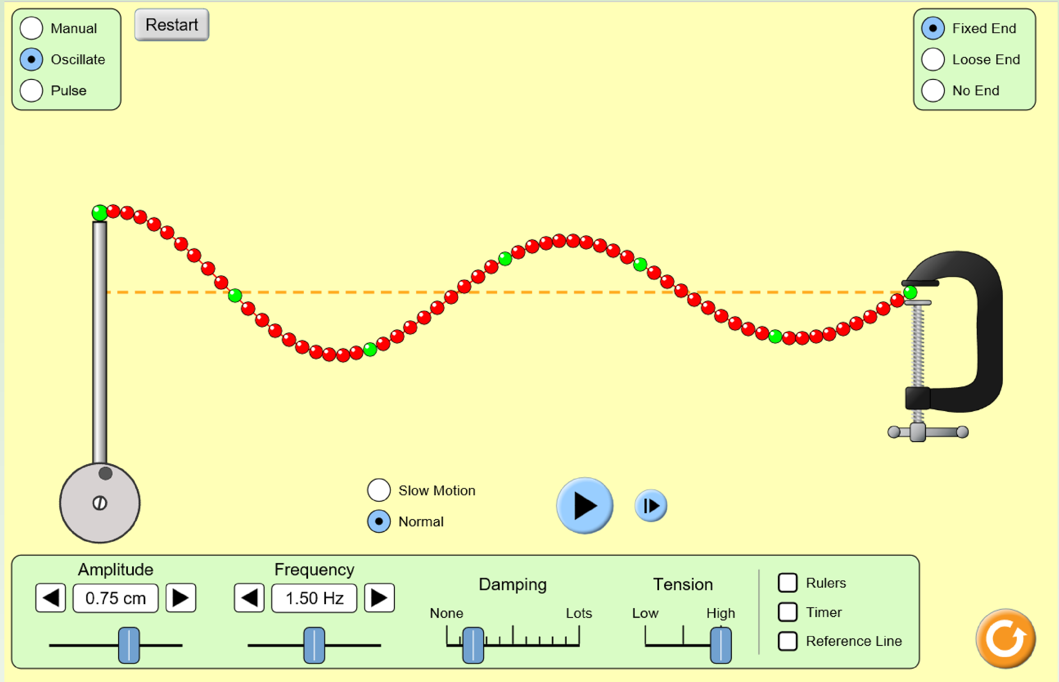

Figure 2: PhET simulation, "Waves on String," showing the visual model, and simple user controls. This simulation was used in Scientific Thought and Processes I lab. (1-8 copied from PhET website).

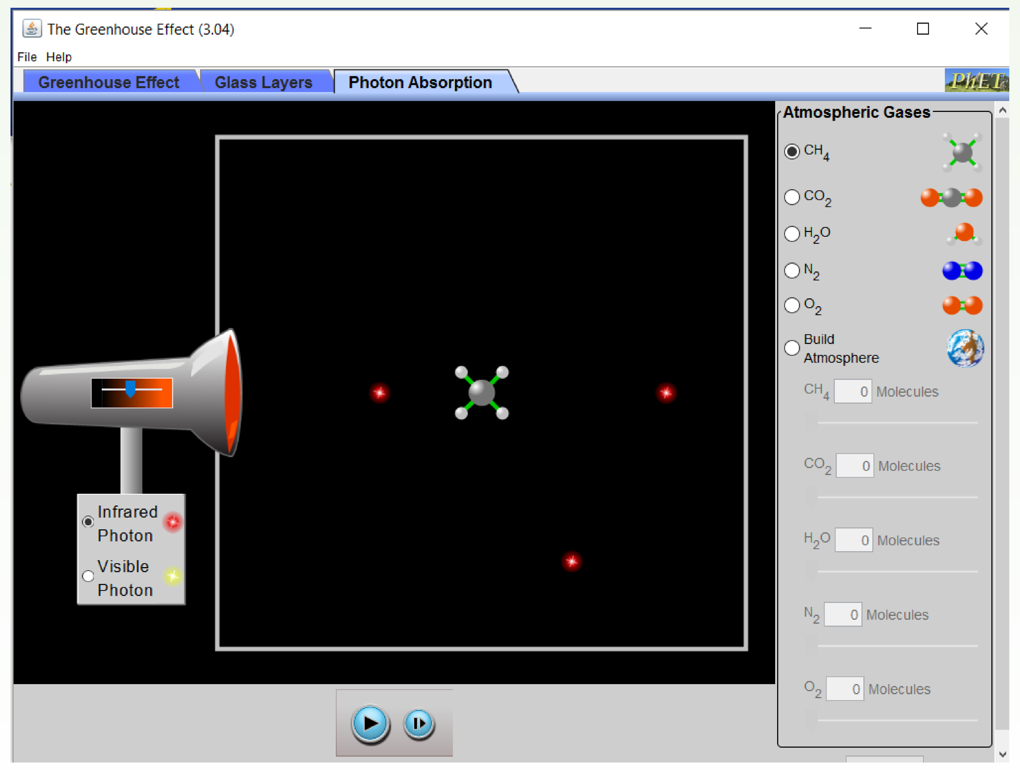

Figure 3: PhET simulation, "Greenhouse Effect," showing the absorption, transmission, and emission of infrared photons by Methane. This simulation was used in Energy and the Environment lab.

Methods and Setting

This research is qualitative in nature and based on observations made in the following Honors Science labs during the 2015-16 school year: Energy and the Environment, Scientific Thought and Processes I, and Astrobiology. Students were all members of GMU's Honors program, and the majority of students were majoring in subjects outside of the fields of science and mathematics. These students were highly motivated, and driven to perform well. Many of the these students did not like science and/or math. Also, most are easily frustrated when things don't run smoothly.

Students, in general, were given a short PowerPoint lecture covering the relevant scientific information. Lectures typically lasted 5-15 minutes. Inquiry based lab guides were provided on Blackboard. Students were usually asked to work in pairs, and were allowed to run the simulations on their own laptops. Initially, students were given a short demo on use of the simulations. This was discontinued after the first few labs, as students quickly mastered learning to use new simulations.

Results

One of the most notable results of using the PhET simulations was the **high level of engagement** that students showed. Students always focused intently on the simulations and often discussed results with their lab partners. Because the simulations are easy to reset and use, students could quickly run through many trials and find **cause and effect relationships**.

When possible, students were given a problem that required them to use the simulations to prove or verify a fact or relationship. This was a **very successful technique** that often resulted in students showing creativity in how they solved the problem. Students often gave explanations that were more in-depth than what was asked for.

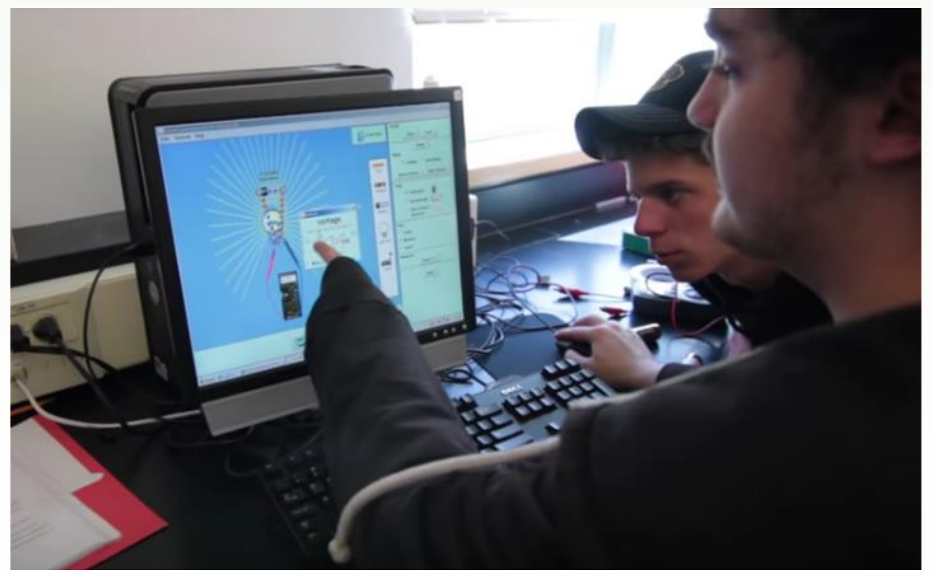

Figure 4: Representative picture showing the typical level of student engagement when using PhET. (Retrieved from a video on PhET's website).

Results, continued

Problem example: Galileo correctly predicted that an object projected horizontally will reach the ground in the same time as an object that is dropped from rest. Use the simulation to prove that the time it takes both objects to reach the ground is the same. What velocity should you use for the golf ball that is dropped straight down? What angle?

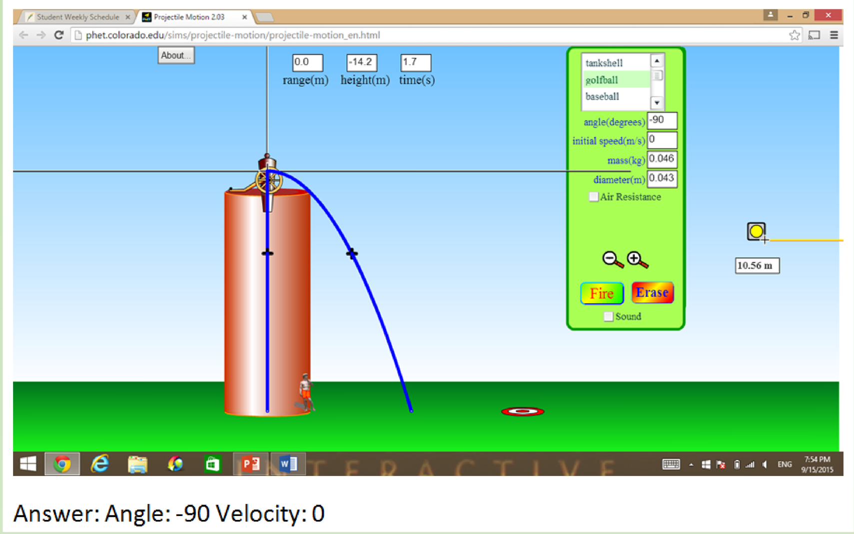

Figure 5: Student's solution to the above problem, using PhET's "Projectile Motion" Simulation.

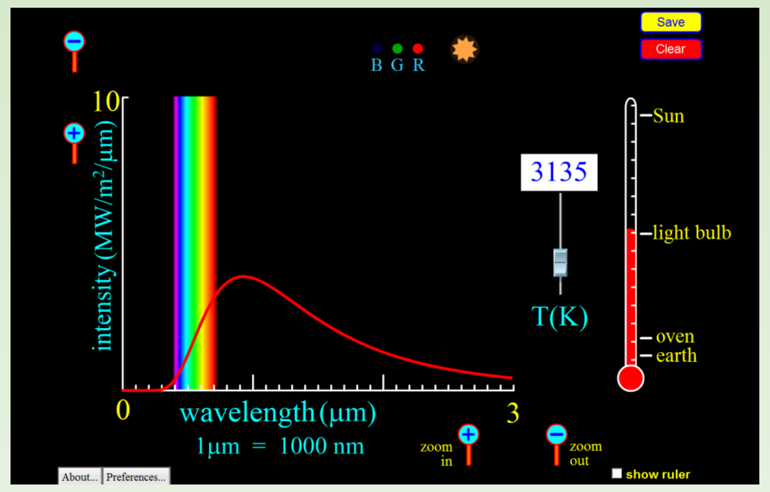

Figure 6: Using the "Blackbody" Simulation to determine if a light bulb is a better generator of heat or light.

Conclusions

Student engagement was high when using the simulations. Students stayed on task. They asked questions when needed, and sought to really understand the material.

Creativity in Problem Solving: students would use the simulations in different ways to arrive at the same answer.

Identifying Cause & Effect relationships: students were able to quickly correlate how simulation inputs are related to outputs.

Frustration levels were low as simulations are intuitive and very easy to work with.

References

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