Computational Modeling and Parameter Optimization – Alia Zander

Purpose

This lesson will introduce students to the process and importance of computational modeling. Exposure to the power of computational modeling will enhance students' computational thinking skills and demonstrate practical uses for modeling that relate back to different forms of energy and the environmental issues associated with this topic.

Overview

The lesson begins with students creating their own individual "happiness" models as an easy to comprehend starting point. They will determine the factors that contribute to their happiness either negatively or positively and give each one a coefficient to describe its weight on happiness for an individual. Having learned how to turn a simple concept into an equation/model, we will create a more realistic model using data from an experiment. Students will have a final goal of predicting the temperature of the ocean in 100 years by taking into account the number of icebergs and the amount of time in the sun. Students will determine the effect that time on a hot plate (representing time in the sun) and the number of ice cubes (representing icebergs) has on the temperature of water (representing the temperature of the ocean). They will use different conditions and record their data. The teacher will then collect all of the data in an excel spreadsheet (see materials and tools) and use the solver function to determine the exact coefficients for their equation. This equation can then be used to make predictions about the temperature of water under different conditions.

Student Outcomes

- SWBAT list 5 components that affect an emotion (such as happiness) and used weighted coefficients to create an equation for calculating a relative value for that emotion.
- SWBAT follow a protocol to measure the temperature of water after the water heating on a hot plate for different amounts of time using a different number of ice cubes to produce results useful for our computational model
- SWBAT understand how to optimize parameters in an equation to fit a set of data for computational modeling by changing coefficients until the difference between experimental data and computational data from our model is as small as possible
- SWBAT use a model to make predication for new conditions that have not been tested such as a longer time on the hot plate to represent a later time point for ocean temperatures
- SWBAT describe the process of computational modeling and appreciate the importance of models for predictions in different fields such as engineering, environmental studies, and finance.

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Time
This activity was completed in a 70-minute class period, but it could easily be extended for more repetition to give students more time to comprehend the main ideas.

Level
This lesson was taught in a 10th grade Chemistry class, but it could be used in different high school science classes and the type of model/experiment can be changed.

Materials and Tools
Handouts for the lesson are included as separate documents:

- Creating a computational model word document – handout for students to follow along with the computational modeling and fill out answers to questions during class and after class as homework for assessment. The completed answer key is also available.
- Solver for parameter estimation – Excel sheet for the teacher to use to demonstrate optimization of weighted coefficients. You must first add the solver function to Excel and then all you need to do is click the solver button to use it. First explain that the solver is minimizing the difference between predicted results from our model and the actual results from the experiment.

For the experiment students can work in groups of 4 and each group will need:

- Hot plate
- Beaker
- Water
- Cylinder
- Thermometer
- Ice cubes

Preparation
Teachers should have the supplies ready for students to carry out the experiment and also familiarize themselves with the Excel sheet so that things run smoothly during class.

Prerequisites
None.

Background
Today we will be going over how computational models are used and we will actually create one our selves. You'll learn about how models are used for environmental predictions and the types of data you need to collect in order have a good model. We will also perform our own experiment to collect data for our model. You will need to pay attention to protocols for our experiment and be following along with how the excel function is able to help us create our model.

Teaching Notes

1. Do now, outlined in handout – use the happiness example as a first activity so that all students can participate and understand the concept of creating equations to explain outcomes.
2. Intro to lesson - write out an example happiness equation, explain what the different numbers mean in an equation, have students write their own equation. An example equation is in the answer key.
3. Explain that we just made a computational model. We need to collect data to determine the right coefficients though because before we were only guessing the weight of each factor and it could be different from what we expect. To make our happiness equation a better model we would need to collect data on the time spent doing the different factors (example: happiness depends on time watching tv, eating cookies, doing homework, spending time with family, time in traffic – you need data on each of these factors and an overall happiness measurement at the end of the week for a few weeks). We will do this process of collecting data for a model to predict the temperature of our oceans in 100 years.
4. Intro to the experiment they are going to do and the equation they are going to be working with and show an example of people actually modeling this type of environmental change. http://www.nrmsc.usgs.gov/research/glacier_model.htm
5. Students work on experiment in groups.
6. I use solver to find coefficients, but first explain how it works. The excel sheet shows the equation we are using to predict final temperatures. It shows the predicted temperature with random coefficients before they have been fit to a data set. We also calculate the difference between our experimental results and the model's prediction. The computer will try to minimize this difference.
    Tip for future lessons: Before even using excel and showing the students the spreadsheet, have them calculate the difference between our predicted and observed temperatures. They can change the coefficients and try to find a good answer for a few minutes. Then introduce the solver function (not in detail, but the overall idea) and get the best coefficients.
7. Now use our equation to predict what the ocean temperature will be in 100 years – the worksheet has conversions for how many icebergs an ice cube is equal to, but if you have time to change these numbers based off of students data you should change them to get a more reasonable prediction.
8. How people use this process for computational modeling in different fields of study – science, engineering, environmental studies, business, etc.
    Tip for future lessons: Maybe go through this entire process again for a new example, but give students the data instead of them producing it themselves so that they can see the steps for producing models and a broader range of their use.

Assessment

Students will submit a homework assignment going over the main steps and concepts from the lesson (writing equations, gathering data, and minimizing error for optimization). Homework questions are at the end of the handout. Teachers can also observe students throughout the lesson and especially during their experiment time.