**Subject area/course**: Mathematics/Algebra I

**Grade level/band**: 9-12

**Task source**: Colorado Department of Education; Colorado Content Collaborative in Mathematics

**Power to the Variable**

**TEACHER'S GUIDE**

1. **Task overview**:

Students will model the data with both a linear function and an exponential function and use it to predict the CO2 concentration in the year 2050 and also when the CO2 concentration will be above 500 parts per million. Students will discuss and document which model makes a better prediction and the limitations of each model.

1. **Aligned standards:**
2. **Common Core State Standards**

CCSS.Math.Practice.MP4 Model with mathematics.

CCSS.Math.Practice.MP5 Use appropriate tools strategically.

CCSS.Math.Content.HSF.LE.A.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.

CCSS.Math.Content.HSF.LE.A.1.A Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

CCSS.Math.Content.HSF.LE.A.1.B Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

CCSS.Math.Content.HSF.LE.A.1.C Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

CCSS.Math.Content.HSF.LE.A.2 Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

1. **Critical Abilities**

Analysis of Information:Integrate and synthesize multiple sources of information (e.g., texts, experiments, simulations) presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to address a question, make informed decisions, understand a process, phenomenon, or concept, and solve problems while evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

Communication in Many Forms:Use oral and written communication skills to learn, evaluate, and express ideas for a range of tasks, purposes, and audiences. Develop and strengthen writing as needed by planning, revising, editing, and rewriting while considering the audience.

1. **Colorado Academic Standards**

* MA10-GR.HS-S.1-GLE.2
* MA10-GR.HS-S.2-GLE.2
* MA10-GR.HS-S.2-GLE.3
* MA10-GR.HS-S.2-GLE.4

1. **Time/schedule requirements:**

This task will require approximately 2-3 class sessions.

1. **Materials/resources:**

* Students will need access to the Internet for data, specifically: <http://www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_full>
* Students will also need a graphing program such as Excel or a graphing calculator that can fit linear and exponential models to data.

1. **Prior knowledge:**

This task assumes students are familiar with linear and exponential models. Students will need to know how to copy data from a website into a computer or calculator.

1. **Connection to curriculum:**

This task is the culminating activity in an algebra unit (full unit available here: http://www.cde.state.co.us/standardsandinstruction/mahs-powertothevariable-pdf).

This unit, [Power to the Variable](http://www.cde.state.co.us/standardsandinstruction/mahs-powertothevariable-pdf), focuses on a formal introduction to exponential functions. The students start with exploring exponential growth through geometric sequences that either grow or decay. As the students learn about geometric sequences, they continually compare them to arithmetic sequences, building to linear and exponential functions. Student fluency with these functions improves through multiple experiences with tables, graphs, equations and contexts. Then students examine the differences in the growth rates of linear, exponential, and polynomial functions leading to a formal proof of how linear functions grow by constant differences and exponential functions grow by common factors.

1. **Teacher instructions:**

Students will work with real-life data from the NOAA to construct a function modeling the growth of CO2 in the atmosphere. This project involves making sense of real life data, using tools such as a graphing calculator or a spreadsheet to model the data, selecting the best model, and presenting the results of the analysis.

This project will likely require time for the students to make sense of the data and put it into usable form. Once the data are correctly entered into a computer or calculator, the core computations can be done very quickly using a calculator or spreadsheet (especially if the students use the regression tools to fit a function to the data). However, it is important to remember that the core skills in this activity are interpreting and modeling with real life data. It is worth highlighting that the process of preparing data for interpretation and selecting and evaluating models are some of the key everyday practices of scientists.

Suggested outline:

Day 1: Introduce the activity. Review the objective, the expected products, and the rubric.

Give students time to explore the website. Answer questions (including, yes, this is actual data gathered from the observatory on Mauna Loa). Students will likely want to know whether they need to model the wavy oscillation of CO2. Rather than answer this directly, challenge students to choose whether it is best to focus on the annual or monthly data based on the question we are asking.

Day 2: Allow students time to work on fitting functions to the data. It is likely students may need guidance entering the data into a spreadsheet or transferring it to a calculator. Students should compare predictions resulting from the linear and exponential models, as well as goodness of fit when choosing a model.

Day 3: Allow students time to build their digital story explaining the model and their predictions. Students might consider recording a presentation or making a video.

1. **Student support:**

For differentiation, students can write their report using a template showing each step of the modeling process and sentence starters to scaffold their writing. See:

* <http://www.mathsisfun.com/algebra/mathematical-models.html>
* <http://caccssm.cmpso.org/high-school-modeling-task-force>

1. **Extensions or variations:**

None provided.

1. **Scoring:**

Student work can be scored using the Power to the Variable Rubric. The written report and the digital video should be collected and scored.