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

**Grade level/band:** 9-­‐12

**Task source**: Stanford Center for Assessment, Learning, and Equity (SCALE)

**TEACHER'S GUIDE**

**A. Task overview**:

**Heating Degree Days**

In this task, students are given a simulation about a family concerned with saving money and energy by better insulating their house. Students are given a set of information regarding heating bill costs over time, costs of insulation investments, and additional constraints, and are asked to determine the cost-­‐effectiveness of the family’s insulation and window sealing investments and provide evidence for their decision.

**B. Aligned standards:**

**1. Primary Common Core State Standards**

CCSS.Math.Content.HSN-­‐Q.A.1 Use units as a way to understand problems and to guide the solution of multi-­‐step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. CCSS.Math.Content.HSA-­‐CED.A.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

CCSS.Math.Content.HSN-­‐Q.A.2 Define appropriate quantities for the purpose of

descriptive modeling

CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of

others.

CCSS.Math.Practice.MP4 Model with mathematics.

**2. Secondary Common Core State Standards**

CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them. CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.

**3. 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.

Modeling, Design, and Problem Solving: Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

**C. Time/schedule requirements:**

The suggested time for the task is 5 days total:

• 1 day for the pre-­‐lesson and to preview the task as a class

• 2-­‐3 days to continue work and discuss with partners or in groups

• 1 day for students to write individual reports or present sections of their reports in groups

**D. Materials/resources:**

• Calculator

• Access to the Internet

• Heating and Cooling Degree Days -­‐ Definitions and Data Sources:

o Definition and discussion -­‐<http://en.wikipedia.org/wiki/Heating_degree_day>

o Standard for HDDs and CDDs -­‐

<http://www.weather2000.com/dd_glossary.html>

o National Climatic Data Center -­‐

<http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html>

**E. Prior knowledge:**

This task draws heavily on proportional reasoning typically developed in the middle grades.

However, many students may need additional support in this area of mathematics. Students should have an understanding of the knowledge and skills articulated in the following CCSS math content standards:

CCSS.Math.Content.7.RP.A.2c Represent proportional relationships by equations. *For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as t = pn*.

CCSS.Math.Content.7.RP.A.3 Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error

**F. Connection to curriculum:**

*Linear modeling*

Using heating degree days as the measure of energy use relies on a linear model of energy use because it assumes energy use changes at a constant rate relative to temperature.

*Constructing and comparing rates and ratios*

There are several ways to set up ratios and rates for comparison in this task. One is to start with the ratio between the number of heating degree days for January in 2008 and January

2007, which indicates that January 2008 was 10.8% colder than January 2007. Some students may skip the conversion from percent increase in heating degree days into units of heat used, and jump directly to the ratio of units used in each month. Another approach is to begin with the rate of energy use per heating degree day for each month.

*Understanding cost-­‐effectiveness*

The task also requires an understanding of what is meant by ”cost-­‐effective” and an ability to determine what would count as cost-­‐effective.

**G. Teacher instructions:**

A pre-­‐lesson is provided for teachers to use (see attached). These are suggestions for

teachers, and modifications might be needed in your classroom. The purpose of the pre-­‐

lesson is to help students have a common understanding of “heating degree days.”

**H. Student support:**

Students may not be familiar with the concept of heating degree days. A discussion focused

around these questions should provide the foundation for using this unit of measure in the task.

• Why does it require more gas to heat your home when the average outdoor temperature is 15°F than it does when the average temperature is 40°F?

• If the comfortable outdoor temperature is defined as 65°F, what is the number of degrees below comfortable for 15°F and for 40°F?

• Heating degree days are used to provide a common way to express the heating requirements over a period of time. The number of heating degree days for any particular day is the difference between 65°F and the average temperature for that day. What was the number of heating degree days for a day when the average temperatures of 15°F? What was the number of heating degree days for a day when the average temperature was 45°F? What is the total number of heating degree days for these two days?

• What is the average outside temperature on a day with 45 heating degree days?

What is the average outside temperature on a day with 15 heating degree days? How do you think the amount of gas needed for a day with 45 heating degree days compares to a day with 15 heating degree days?

**I. Extensions or variations:**

• Students could investigate the heating/cooling degree days in the local area, using online resources. Investigate a local construction company to find out about how insulation choices and anticipated savings are estimated.

• City-­‐specific data heating/cooling degree days [http://www.degreedays.net](http://www.degreedays.net/) (use local weather station in database)

• Natural Gas Usage and Natural Gas Prices U.S. Dept. of Energy: <http://www.eia.doe.gov/neic/brochure/oil_gas/rngp/index.html>

**J. Scoring:**

Student work can be scored using the Mathematics Performance Assessment Rubric,

Grades 9-­‐12.

**Heating Degree Days – Solutions**

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| 1. Equating a rate between 2007 and 2008 or visa-versa.   Converting the amount of heating units used in 2008 by the rate used in 2007 (heating units to heating degree days):  188/1108 = 0.1696  0.1696 • 1000 **= 169.6** heating units (by 2007 standards)  or  Converting the amount of heating units used in 2007 by the rate used in 2008:  (200/1000) = 0.2  0.2 • 1108 **= 221.6** heating units (by 2008 standards) |
| 1. Determines cost of usage in one year compared to the other year.   Cost in 2007 rate of 2008 energy usage 169.6•$1.20 = **$203.52**  or  Cost in 2008 rate of 2007 energy usage 221.6•$1.25 = **$277.00** |
| 1. Determines the percent of savings from one year to next.   Based on year 2007:  $240.00-$203.52 = $36.48 (savings)  $36.48/$240.00 = 15.2%  or  Based on year 2008:  277.00-235.00 = $42.00 (savings)  $42.00/$277.00 = 15.2%  *Partial Credit*  If the savings was calculated using the wrong difference and/or divisor to determine the percent savings is an incorrect then partial credit. |
| *Special Case (short cut solution)*  (0.2 – 0.17)/0.20 = 15% savings |
| 1. Concludes that the savings are cost-effective to make the investments. (Based on correct work) |
| 1. Determines how long it will take to pay-off the investment such as:   $600 investment divided by $42 (per winter month) = 14.2 (winter months). If there are 5 winter months per year, it would take three years to make up her investments. |