Is It Sustainable? Renewable Fuels for the Future

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Overview

Issues of sustainability and the effect of nonrenewable and renewable fuels are experienced in this unit using hands-on exercises and problem solving. Students create and analyze algebraic models using automotive data to understand the dynamics associated with the merits of cars which run on fossil fuels and green cars (non-fossil fuels). The unit also contains a lesson which simulates the use and depletion of nonrenewable energy and the effect of replacement with renewable energy. Lastly students are engaged in creating motion graphs which match supplied graphs and determining the equation of the linear models using a motion detector. This curriculum unit is written for high school mathematics students in grades 9 through 11 who are studying Algebra 1 or Algebra 2. This curriculum unit could also be used in science courses such as physical science, environmental science or physics since it provides experiences creating real data and determining the mathematical model for the data for sustainability.

Rationale

The environment is of national and international concern. United States government agencies and private concerns have as their mission finding solutions to environmental issues, particularly our ability to lower greenhouse gases by lowering pollution, securing our energy future by lowering energy consumption and finding new renewable energy. The uses of natural resources, energy consumption, global warming and fuel are hotly debated in many circles. Frequently the debate centers around energy sources, their effects on the environment and the implications for future generations.

Is it Sustainable? This is a question asked frequently among those who debate the environment and our ability as humans to chart a course which will allow us to inhabit the earth for generations to come. There are many issues: global warning, pollution, fossil fuel depletion - to name a few. Understanding the issues and making the changes necessary to solve the problems is the challenge before us. In this case, “it” refers to the use of fossil fuels. As a country we depend almost exclusively on a mixture of coal, oil, and natural gas for energy. Fossil fuels are nonrenewable, so their availability is finite - that is, they will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve.

By comparison, there are many types of renewable energy resources-such as wind, solar energy and hydrogen fuels-that can be constantly replenished and will never run out. This dilemma also creates an educational opportunity: to raise awareness of the problem and use that awareness to create authentic learning in US classrooms. High school students frequently live in their own world devoid of real time issues and solutions. While they are unaware of many issues, when teenagers are given the resources and educational tools to understand and tackle problems they become powerful advocates and leaders. The high school students, for whom this unit is written, will study sustainability in environmental science and will study data modeling in algebra 1 and 2. The curriculum unit will provide lessons which relate the energy issues and offer an opportunity to apply environmental related exercise to math modeling.

The objective of the seminar, Penn Laboratory on Energy, Sustainability and Environment was "to integrate mathematics and science in order to develop an understanding of quantities, rates of change of quantities, and their relationships to everyday situations, physical systems, and public policy decisions". To meet these objectives the seminar used technology that captured data from physical situations and students developed and built mathematical models for the data and made predictions. The subjects of energy and sustainability were the platforms for our learning. This curriculum unit will introduce students to issues concerning sustainability as it relates to fuel. The unit will use data for fuels and the environment to provide hands- on/experiential mathematical learning. The issue of sustainable energy is important for our future and is therefore one in which the next generation can get involved.

This year the United States Congress is debating plans for clean power. These plans will set standards to reduce carbon dioxide emissions based on 2005 levels and achieve the levels by 2030. President Obama has proposed lowering carbon dioxide emission by 32 percent by 2030 and believes that this standard if adopted and passed to states for implementation will put us on a track for sustainability (EPA, 2015). The opposition believes that the plan is "a "draconian" and "job-killing" assault on the coal industry that will jack up America's utility bills." (Whitehouse, 2015) So why all the fuss? The answer lies in the history of American fossil fuel energy usage and its effect on the environment.

Fossil fuels have been a source of energy since humans discovered and began using coal along with burning wood for energy. It may be said that the fossil fuel era began when fire was discovered in prehistoric times. More often, it is said that the fossil fuel era began with the advent of the Industrial Revolution in the 1700s. Although wood was the first combustible fuel for thermal energy after fire was discovered and remained in use for many thousands of years, the use of a higher-specific-fuel became desirable by the thirteenth century for production of charcoal. The use of coal, the first fossil fuel employed in quantity, increased steadily over the next 400 years. As the use of fossil fuels increased the use of biomass (renewable fuels decreased. (Kruger, 2009).

From Neolithic times through the eighteenth century technology changed very little. Then the steam engine began using energy in the 1700s, cities in Europe began using natural gas and the combustion engine and steam ships used fossil fuels in the 1800's (Ebsco Host Science). These nonrenewable fossil fuels: coal, oil, natural gas will eventually be depleted and thus conservation efforts are underway. United State dependency on foreign sources of oil and gasoline was accentuated during the oil crisis of the early 1970's and so a focus on automobile fuel efficiency began.

Use of fossil fuels also harms the environment. The energy released when fossil fuels are burned was captured by plants millions of years ago and compressed in the earth. As fossil fuels are burned the by-product, carbon monoxide, a pollutant, is released into the air. Usage of fossil fuels has increased over time as more people populate the earth and more cars, houses, industry and power plants need them for power.

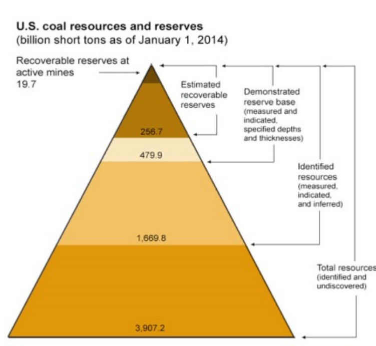
Regional energy use (kWh/capita & TWh) and growth 1990–2008 (%)[25][26]						
	Population Growth 1990-2008			Energy use (1,000 TWh)		
Region	**1990**	**2008**	**Growth**	**1990**	**2008**	**Growth**
USA	250	305	22%	22.3	26.6	20%
EU-27	473	499	5%	19.0	20.4	7%
Middle East	132	199	51%	2.6	6.9	170%
China	1,141	1,333	17%	10.1	24.8	146%
Latin America	355	462	30%	4.0	6.7	66%
Africa	634	984	55%	4.5	7.7	70%
India	850	1,140	34%	3.8	7.2	91%
Others*	1,430	1,766	23%	36.1	42.2	17%
The World	**5,265**	**6,688**	**27%**	**102.3**	**142.3**	**39%**

Source: IEA/OECD, Population OECD/World Bank

- Energy use = kWh/capita* Mrd. capita (population) = 1000 TWh

Others: Mathematically calculated, includes e.g. countries in Asia and Australia. The use of energy varies between the "other countries": E.g. in Australia, Japan, or Canada energy is used more per capita than in Bangladesh or Burma.

Fossil fuels also cause environmental issues. The atmosphere surrounding the earth traps heat from the sun around the earth so that it is warm enough for human habitation. Too little heat and it is cold and too much heat and it is too hot. Carbon dioxide, other gases and pollutants trap more heat in the atmosphere causing the greenhouse effect and global warming. In some states, like Texas, 96% of the energy used makes greenhouse gases. (Infinite Power, 2014). In addition, coal drives the production of electricity so a key factor in lowering greenhouse gases involves finding alternate energy sources for electricity production.



In addition to energy production for industry, energy production contributes heavily to state economies. For instance, Pennsylvania is the leading East Coast provider of coal, natural gas, nuclear power and refined petroleum products. Just behind Texas, Pennsylvania is the nation's second largest natural gas producer – producing 15 times 2009 levels since the development of the Marcellus Shale. It is the fourth largest coal producing state. One of the top three electricity-generating states in the nation, Pennsylvania exports electricity to the Mid-Atlantic region making electricity important to state revenue. (Eia, 2015). Hard industry is heavily affected by clean air regulations as new rules can be costly to implement. Both these nonrenewable energy sources are important to Pennsylvania. How long will they last?

The US Energy Information Administration estimates that the total recoverable domestic coal resources are 256.7 billion short tons. Based on US coal production in 2013 at 984.8 million short tons coal reserves would last for 261 years. As demand continues to increase particularly in China, anticipated coal supply reserves are expected to drop. (Eia, 2015).

New, renewable energy sources which don't rely on natural nonrenewable resources and can be replaced at a rate comparable to their use are needed. These renewable sources such as solar, wind, water (wave), hydro, geothermal and biomass (plant) will be important for sustainability. The United States currently obtains 4% of its energy from renewable sources. In Pennsylvania, where renewable energy historically came from hydroelectric and biomass power plants, wind power has grown to provide two-fifths of renewable electricity. (Eia, 2015).

Electric power is also being used to lower US dependency on automobile fossil fuel usage. In 1976, Congress authorized a committee to examine the potential for the development of electric vehicles to reduce US dependency on fossil fuels. Hybrid automobiles, cars having engine systems that are both gas and electricity power, have proliferated over the last decade. This year the 2015/2016 model cars include more electric cars than any other year (Edmondson Report, 2015). High in fuel mileage, electric cars provide an economic alternative for short distances. Electric cars are expected to become more affordable once electric filling stations make longer travel possible and increased demand for the vehicles helps to lower the sticker price.

Objectives

While primarily focused on high school mathematics, the objective of this curriculum unit is to enable students to experience the connections between math and science and gain a perspective on past issues and future implications involving sustainability. This unit will study the environmental issues around alternative fuels and provide lessons for students to engage in mathematics investigations within the environmental theme.

The objectives of the unit are:

- To create and analyze algebraic models using data in order to understand the dynamics of green cars and sustainable energy
- To develop mathematical data for student analysis to bring the issues to light and create student understanding

- Provide an opportunity for students to personalize their interaction with the environment through project based learning.

The lesson plans are designed for students studying Algebra 1 and Algebra 2. This unit could also be used in science courses studying sustainable energy.

PA Common Core Standards are incorporated into the curriculum unit. Students will accomplish math standards by analyzing data and using the results to draw conclusions. They will interpret data and develop the equation of the line and slope of the line to establish relationships and graphs. Science standards will also be accomplished as students use multi-step processes and use technology to solve complex problems.

Strategies

This curriculum unit will meet the objectives discussed above through problem based, hands on lessons. The Mathematics Pennsylvania Common Core Standards will be addressed by students identifying and using the rate of change to solve real life problems; by calculating and interpreting the equation of a line as well as translating data from table to graph. Given a set of data students will analyze the data and determine the best algebraic or graph representation.

Classroom Activities

The classroom activities consider several different issues regarding sustainability. In lesson one, students will analyze and compare the costs and create algebraic models using sets of cost and fuel efficiency for automobiles. The Pennsylvania Common Core Standards in mathematics of modeling relationships between quantities and graphing and analyzing the functions are also required in lesson two. In this lesson, a simulation of depleting natural resources while replenishing resources using different proportions of two colors of bingo chips increases student learning about renewable and nonrenewable energy. It also models constructing linear models to solve problems. Lesson three allows students to make data using a motion detector, technology and graphing calculators. This lesson provides a vehicle for students to not only graph functions but to use the analysis to make connections between the different graphs and experience being the maker of the data.

Lesson Plan 1 Evaluating Green Cars and Fuel Efficiency through Algebraic Modeling

Title: Is it Worth It?

Goals: To create and analyze algebraic models using automobile data in order to understand the dynamics of green cars and sustainable energy.

Materials: Graph paper, prices and fuel economy for traditional and energy-efficient cars (sample car data is provided below), graphing calculator to model graphs after pencil paper; internet access for research.

Introduction: In an effort to reduce the carbon monoxide released into the atmosphere due to fossil fuels used in cars, automobile manufacturers have developed new cars with more energy efficient and/or sustainable energy features. This exercise uses algebra to analyze several green energy car options.

Car Option information:

Make	**Model**	**Engine Type**	**Price ($)**	**Fuel Economy** Miles/gallon	
				City	Hwy
Toyota	Prius Hatchback	Hybrid	$24,200	51	48
Toyota	Prius Hatchback	Plug-in	$29,990	95	(95)
Toyota	Camry Sedan	Gasoline	$22,970	25	35
Toyota	Camry Sedan	Hybrid	$27,840	43	39
Ford	Fusion Sedan	Gasoline	$34,645	22	34
Ford	Fusion	Hybrid	$39,075	44	41

Source: www.edmunds.com; www.bluebook.com; www.toyota.com

Modeling:

1. Divide the class into groups where each group has a pair of cars of the same make and model but different engine type. Each group will develop the cost equation for their cars in slope intercept form y = mx+b. The variables are: y= the total operating cost of the car (dollars); x = the miles driven (miles); m = the car's city fuel economy (miles per gallon); f= gas cost at the pump (cost/gallon); b = the car price. Each group should graph both cars on individual graphs for the following mileage: 1000, 1500, 3000, 6000, 9000, 12000 and 15000 miles. How do the graphs compare? When developing your equation check that the units cancel out so that dollars on the left hand side of the equation (cost) equal dollars on the right hand side of the equation.
2. Now the students should graph the two cars on the same graph in multiples of 50000 miles ending with 300,000 miles. Do the two graphs cross? If not, can you estimate when the graphs will cross? What does the point of intersection represent?
3. Repeat the exercise in 1 and 2 above using the fuel economy for highway miles per gallon instead of city mpg (assume that the electric/plug in car has no restrictions for driving long distances. How does the graph change?
4. Businesses use the term payback period to describe the time period needed to make up for a cost difference between two alternatives. Using $2.65 per gallon, 15,000 miles (yearly miles driven) and the city fuel economy determine the cost to drive the car over 1 years' time. How many years will it take for the fuel economy savings to equal the difference in cost? Is it worth it? Why? Or Why not?

Challenge: Conservationists would factor in more than the payback period to determine the value of a “green car”. Use the internet to research what other factors should be considered? What data would you use and where would you find it? Factor your new information into the analysis. Is a Green car worth it?

Lesson Plan 2

Adapted from Renew-a-Bean: A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms. © Revised and updated 2003 by the Union of Concerned Scientists, All rights reserved www.ucsusa.org/sites. Used with permission. Original activity adapted from Conserve and Renew: An Energy Education Package for Grades 4–6, Sonoma State University, 1990.

Title: Renewables to the Rescue

Goal: To demonstrate the use and depletion of nonrenewable resources over time in order to highlight the importance of energy sustainability. Through the activity, students experience the eventual depletion of fossil fuel resources and the existence of renewable resources changes the rate of energy use.

Materials: Brown paper bags (1 for each group) containing 100 x ¾ inch bingo chips: 94 of one color (amazon.com), six of another color, extra chips of both colors: 10 of first color, 40 of second color, five copies of the student handout (copies in the appendix); extra graph paper.

Introduction: This activity demonstrates use and depletion of nonrenewable sources over time and emphasizes the difference between renewable and nonrenewable resources. It shows students that nonrenewable sources will be exhausted over time. Moreover, it shows that conservation measures—ways of using less energy—along with increased use of renewables can slow the depletion of fossil fuels. The intent is to simulate depletion of nonrenewable resources but may not model the proportions based on real energy data. The difficulty of this activity can be adjusted for different grade levels.

Time: Two 45-minute class periods

Procedure:

1. Fill each bag with 94 chips of one color, six chips of another. This represents the ratio of nonrenewable to renewable energy in use. Mix the chips well.
2. Divide students into groups of five. Each group will need a bag of chips, the student handout and graph paper: Make certain to note on the bag which color is renewable and which one is nonrenewable.
3. Explain to the students that the chips in the paper bag represent nonrenewable and renewable energy resources. They will draw chips from the paper bag in order to simulate energy use over time. The students will use the first bag of chips twice recording their results each time on the student handout.
4. Students in each group will take turns drawing a designated number of chips from chips from the bag. They should record the result of the chips drawn on the student handout. When a “nonrenewable” chip is drawn, it should be set aside—it is “used up.” When a “renewable”

chip is drawn, it should be returned to the bag to be "used again" Each drawing of a group of chips from the bag represents one decade.

5. For the first round students are drawing 10 chips per decade out of the bag and recording the number of renewable and nonrenewable chips they drew on their student data sheet. Groups should stop picking chips when all the nonrenewable chips are "used up."
6. Students should graph energy use over time on the graph paper (time is on eth x axis). Ask groups how many decades it took to "run out" of nonrenewable energy. When the nonrenewable energy ran out, was there enough energy to meet the next decade's energy needs (10 chips)? Ask students how they could make the energy supply last longer. They should come up with two answers—use less energy (conservation) and use more renewables.
7. Students should determine the equation of the line for different portions of the graph.
8. In round three each group will have a different variation to simulate (see chart in appendix).

Class discussion:

1. When did each group run out of energy? How did this relate to how quickly they used energy? Which groups ran out of energy first?
2. Have students look at their graphs. During which decade did each group start using more renewable than nonrenewable energy? How is this represented on the graph? Does the equation for each part of the graph support the data? Explain.
3. Will energy use keep increasing indefinitely? Why or why not? (Discuss limits on the growth of renewable sources of energy (e.g., available land for biomass crops and wind turbines, water sources for hydro).
4. Research the ratio of renewable to nonrenewable energy use in the United States in the current year. Is our current use of energy sustainable?

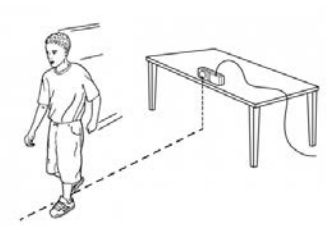
Lesson Plan 3:

Title: Making Models from Real-Life Data

Goals: Mathematical models of events in the real world are created from data related to every day events and situations. In this lesson, students will create and use data to develop a real world model using simple motion.

Introduction

When one quantity changes at a constant rate with respect to another, we say they are *linearly related*. Mathematically, we describe this relationship by defining a linear equation. In real-world applications, some quantities are linearly related and can be represented by using a straight-line graph.



In this activity, students will create straight-line, or constant-speed, position versus time plot using a Motion Detector, and then develop linear equations to describe these plots mathematically.

Objectives:

- To create data by recording distance versus time data for a person walking at different rates
- Analyze the data to calculate slope and y-intercept information
- Graph the data for each scenario
- Interpret the slope and intercept information for physical meaning

Materials: TI-84 Plus graphing calculator, CBR 2 or GoMotion motion detector, TI-CBL2 (Calculator Based Laboratory), graphing paper, student handout.

Procedure:

1. Follow the Texas Instruments instructions for setting up and using the CBR 2 and CBL2 with a TI-84 calculator.
2. Position the Motion Detector on a table or chair so that the head is pointing horizontally out into an open area where you can walk. There should be no chairs or tables nearby. Students will begin walking one foot from the motion detector.
3. Divide the students into groups of two. One group member will serve as the walker and another as the operator (the operator will let the walker know when to start walking). Group members will change tasks so that each student will perform each task.
4. Each group will receive a student handout. The walker will attempt to walk a path that makes the calculator show a graph similar to the handout.
5. The operator should turn the calculator on, then press PRGM and use the down arrow key to highlight the line showing the HIKER program name. Press enter, enter. The calculator screen should list the Hiker Experiment and prompt the operator with directions.
6. At the "press enter to start graph" screen the operator should press enter three more times.
7. When the operator says start, the walker should begin at the starting position based on the group's analysis of the graph and the operator should press enter. The walker should begin walking moving at the pace the group believes will produce the graph. Once the motion detector stops clicking data collection has stopped and the operator should say stop.

The group should examine the graph produced and compare it to the sample graph. If the two graphs are very different, the group should repeat the experiment until they are satisfied with the results. Groups may want to establish a "walking strategy" based in what they see on the graph before they start each experiment (e.g. Look at the graph, consider how fast or slow the graph appears to be rising or falling). The x-axis represents time and the experiment starts at time =0; the y-axis represents distance from the sensor. The walker begins 1.0 feet from the sensor. Additional graphs and other information can be found in the appendix.

Annotated Bibliography/Resources

"Clean Power Plan for Existing Power Plants." *Regulatory Actions*. US Department Environmental Protection Agency, 3 Aug. 2015. Web. 4 Aug. 2015. <http://www2.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants>.
This website includes articles, reports, charts, tables and multiple energy related articles

Connection.ebscohost.com. N.p., n.d. Web. <http://connection.ebscohost.com%2Fscience%2Falternative-energy-exploration/history-alternative-and-renewable-energy>.
An informed discussion of the history of energy and renewable energy

Kruger, Paul. *Alternative Energy Resources: The Quest for Sustainable Energy*. Hoboken, NJ: John Wiley & Sons, 2006. Print.
This book not only provides a detailed history of energy it also links energy topics with math and math models.

"Pennsylvania State Energy Profile." *Pennsylvania Profile*. US Energy Information Administration, n.d. Web. 8 Aug. 2015. <http://www.eia.gov/state/print.cfm?sid=PA>.
The energy information specific to Pennsylvania from the US government.

"President Obama's Plan to Fight Climate Change." *The White House*. The White House, 7 Aug. 2015. Web. 8 Aug. 2015. <https://www.whitehouse.gov/climate-change>.
Website provides details of President Obama's plan for climate change.

Watts, Robert G. *Innovative Energy Systems for CO_2 Stabilization*. Cambridge, UK: Cambridge UP, 2002. Print.
This book provides a lot of information on the issues of CO_2 and the importance of lowering emission.

Other Teacher Resources

Chu, Steven, and Arun Majumdar. "Opportunities and Challenges for a Sustainable Energy Future." *Nature* 488.7411 (2012): 294-303. Web. 15 May 2015.
Article explaining the issues and challenges of sustainable energy

Explorations. N.p.: Texas Instruments Incoporated, n.d. Print.
Easy in class labs using the Texas Instruments TI-84 series calculators

Gastineau, John E., Chris Brueningsen, Bill Bower, Linda Antinone, and Elisa Kerner. *Real-world Math with Vernier: Connecting Math and Science*. N.p.: n.p., n.d. Print.
Lessons and hands-on experiments using probes. This book and Vernier offer excellent learning opportunities for students.

Randolph, John, and Gilbert M. Masters. *Energy for Sustainability: Technology, Planning, Policy*. Washington, D.C.: Island, 2008. Print.
Energy issues with policy and practice

Renewables Are Ready: A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms. Cambridge, MA: Union of Concerned Scientists (Two Brattle Square, Cambridge 00238-9105), 2003. Print.
A textbook on renewable energy

"Temperature - Precipitation - Sunshine - Snowfall." *Climate Philadelphia*. N.p., n.d. Web. 22 July 2015. <http://www.usclimatedata.com/climate/philadelphia/pennsylvania/united-states/uspa1276/2015/6>.
This website provides both national and regional climate information

Student Reading List

Energy Kids (www.eia.gov/kids) is a student-friendly website hosted by the U.S. Department of Energy, Energy Information Administration (EIA). The site includes a variety of information and activities about energy organized in several main categories: What is Energy?, Sources of Energy, Using & Saving Energy, History of Energy, Games and Activities, for Teachers, Related Links, Energy Calculators, and a Glossary.

Appendix - Pennsylvania Core Academic Standards

MATHEMATICS

Anchor Descriptor	Core Standard
A1.1.2.1 Write, solve and /or graph linear equations using various methods	**CC.2.1.HS.F3** Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs and data displays CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi-step problems. CC.2.2.8.B.3 Analyze and solve linear equations CC.2.2.8.C.1 Define, evaluate, and compare functions. CC.2.2.8.C.2 Use concepts of functions to model relationships between quantities. CC.2.2.HS.C.3 Write functions or sequences that model relationships between two quantities. CC.2.2.HS.D.7 Create and graph equations …to describe numbers or relationships.
A1.2.1.1 Analyze and/or use patterns or relations.	CC.2.2.8.C.1 Define, evaluate, and compare functions. CC.2.2.8.C.2 Use concepts of functions to model relationships between quantities. CC.2.2.HS.C.2 Graph and analyze functions and use their properties to make connections between the different representations. CC.2.2.HS.C.3 Write functions or sequences that model relationships between two quantities.
A1.2.1.2 Interpret and/or use linear functions and their equations, graphs, or tables	CC.2.1.HS.F.3 Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data displays CC.2.1.HS.F.4 Use units as a way to understand problems and to guide the solution of multi -step problems. CC.2.2.8.B.2 Understand the connections between proportional relationships, lines, and linear equations. CC.2.2.8.C.1 Define, evaluate, and compare functions. CC.2.2.8.C.2 Use concepts of functions to model relationships between quantities. CC.2.2.HS.C.2 Graph and analyze functions and use their properties to make connections between the different representations. CC.2.2.HS.C.3 Write functions or sequences that model relationships between two quantities.

Anchor Descriptor	Core Standard
	CC.2.2.HS.C.6 Interpret functions in terms of the situations they model.
A1.2.2.1 Describe, compute, and/or use the rate of change (slope) of a line.	CC.2.2.HS.C.2 Graph and analyze functions and use their properties to make connections between the different representations. CC.2.2.HS.C.3 Write functions or sequences that model relationships between two quantities. CC.2.2.HS.C.5 Construct and compare linear, quadratic, and exponential models to solve problems. CC.2.2.HS.C.6 Interpret functions in terms of the situations they model. CC.2.4.HS.B.1 Summarize, represent, and interpret data on a single count or measurement variable.

SCIENCE

Anchor Descriptor	Core Standard
Science & Technology	Conduct multiple step experiments
	Apply appropriate tools, materials and processes to solve complex problems

Student Handout – Chip Record Sheet

Group Member Names:

Directions:

Students in each group should take turns drawing chips from the bag until the total number indicated for the decade have been drawn. Record the number of renewable and the number of nonrenewable chips drawn on the chart. Return any renewable chips drawn to the bag after recording on the chart they can be used again. Set all nonrenewable chips aside, they are used up. Draw chips from the bag again, this is decade 2. Record your results on the chart. Each chip represents energy usage. Draw chips until there are no more nonrenewable chips in the bag.

Round 1					Round 2			
Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips		Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips
1	10				1	10		
2	10				2	10		
3	10				3	10		
4	10				4	10		
5	10				5	10		
6	10				6	10		
7	10				7	10		
8	10				8	10		
9	10				9	10		
10	10				10	10		

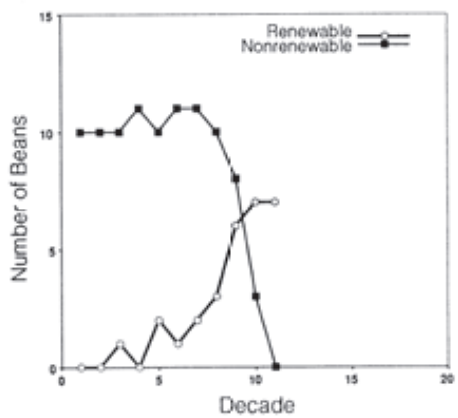
Variations for Round 3	
Variation	Simulation
1	Energy usage increases by four percent per decade (round to the nearest whole number); Graph results
2	Energy usage decreases by two percent per decade (round to the nearest whole number); Graph results
3	Energy usage decreases by four percent per decade (round to the nearest whole number); Graph results
4	Availability of renewable energy increases by six percent per decade (round to the nearest whole number); Graph results
5	Availability of renewable energy increases by ten percent per decade (round to the nearest whole number); Graph results

Chips to be Drawn for Group Bags in Round 3							
	Variation 1	Variation 2	Variation 3	Variation 4	Variation 4 Add renewables	Variation 5	Variation 6 Add renewables
Decade	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn
1	10	10	10	10	0	10	0
2	10	10	10	10	0	10	1
3	11	10	10	10	1	10	0
4	11	10	9	10	0	10	1
5	12	9	9	10	1	10	1
6	12	9	8	10	0	10	1
7	13	9	8	10	1	10	1
8	13	9	8	10	1	10	2
9	14	9	7	10	0	10	1
10	14	8	7	10	1	10	1
11	15	8	7	10	1	10	2
12	16	8	7	10	1	10	2
13	-	8	6	10	0	10	2
14	-	8	6	10	1	10	2
15	-	-	6	10	1	10	3
16	-	-	6	10	1	10	2
17	-	-	6	10	1	10	3

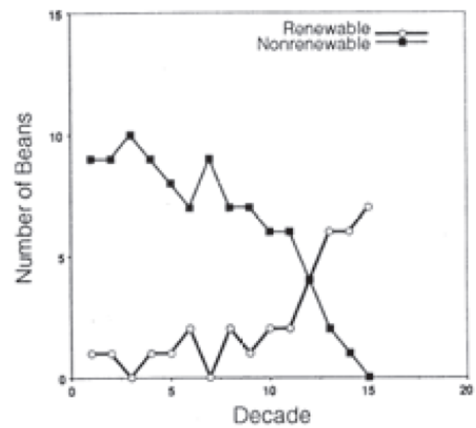
Chips to be Drawn for Group Bags in Round 3							
	Variation 1	Variation 2	Variation 3	Variation 4	Variation 4 Add renewables	Variation 5	Variation 6 Add renewables
Decade	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn	Total # Chips Drawn
18	-	-	-	10	1	10	3
19	-	-	-	10	1	10	4
20	-	-	-	-	-	10	4
21	-	-	-	-	-	10	4
22	-	-	-		-	10	5

Example graphs for the variations in round 3

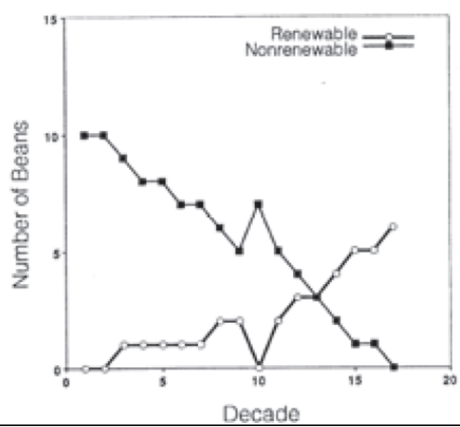
Variation 1



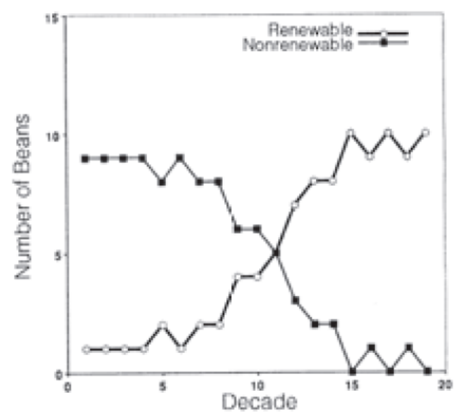
Variation 2



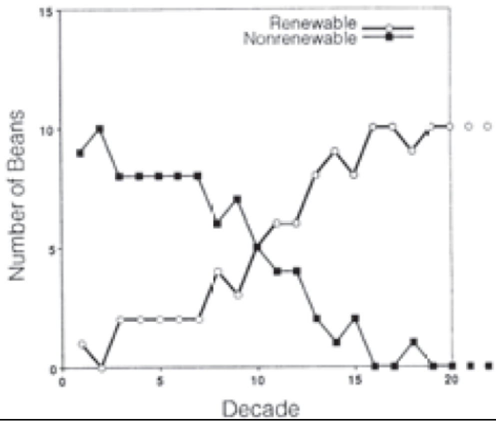
Variation 3



Variation 4



Variation 5



Student Handout – Chip Record Sheet - Round 3

Group Member Names:

Directions:

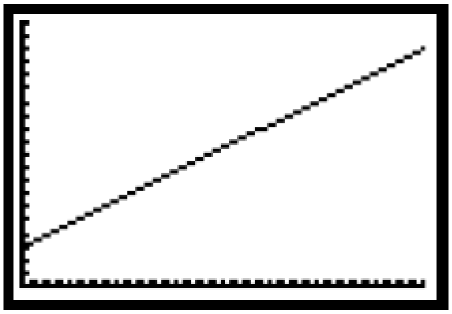
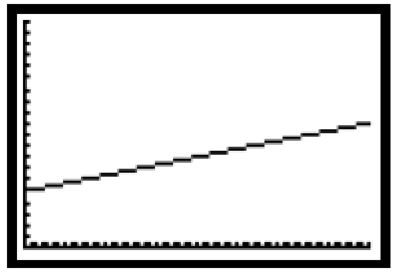
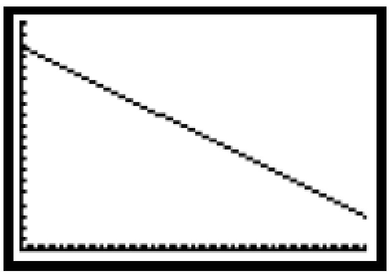
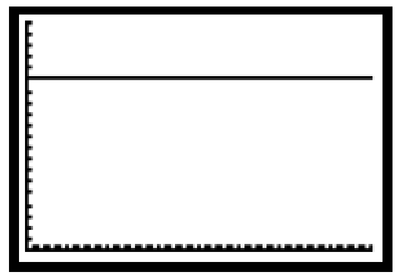
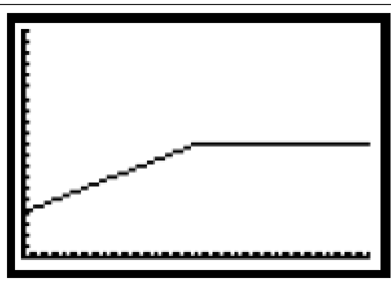
Students in each group should take turns drawing chips from the bag until the total number indicated for the decade have been drawn. Record the number of renewable and the number of nonrenewable chips drawn on the chart. Return any renewable chips drawn to the bag after recording on the chart they can be used again. Set all nonrenewable chips aside, they are used up. Draw chips from the bag again, this is decade 2. Record your results on the chart. Each chip represents energy usage. Draw chips until there are no more nonrenewable chips in the bag.

Round 3	Variation		
Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips
1			
2			
3			
4			
5			
6			

Round 3	Variation		
Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips
1			
2			
3			
4			
5			
6			

Round 3	Variation		
Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			

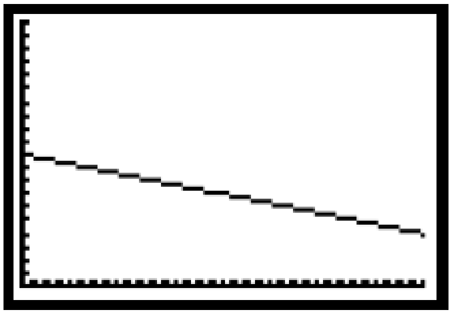
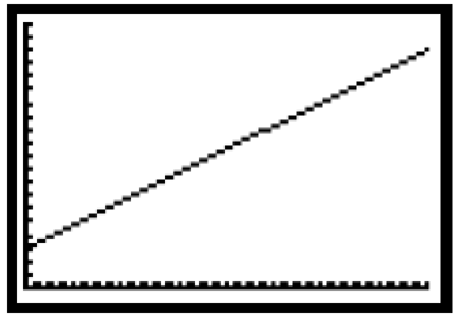
Round 3	Variation		
Decade	Total # Chips Drawn	Renewable Chips	Non renewable Chips
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			

Graphs for Experiments			
1.		2.	
3.		4.	
5.			

Questions:

1. For each experiment, use the data collected by the calculator to plot your graph and determine the slope and the equation of the line. Explain the differences in the walking, to produce each graph. What similarities and differences are there in the equations?
2. Create two new graphs of your own determine how you will walk to create each graph. Find the slope and equation of the line for each graph.

Problems for Additional Exploration	

Walker A	Walker B
	

The graphs shown above represent two different walkers, A and B, moving in front of the motion sensor.

a. Which walker started walking closest to the sensor? Explain.

b. Which walker moved at a faster rate of speed? Explain. Estimate the rate each person was walking.

c. Which graph was created by the walker moving toward the sensor?

Some extensions of the lesson:

Students can consider not linear graphs as dictated by course content and student knowledge of exponential, quadratic, and trigonometric functions (See graphs below).