



GREEN BUILD 2
in Whyville

CAREER FOCUS

Home Energy Engineer

ACADEMIC FOCUS

Understanding the mathematical concept of base vs. recurring costs, and reinforcing the terms and meaning of energy measures.

Contents of this lesson plan

1. Teacher Preparation	
2. Part One	EXPLORE (directed inquiry)
3. Part Two	REFLECT (group discussion)
4. Part Three	ACCOMPLISH (the assigned task)
5. Part Four	CONNECT (to standards and real life)
6. Standards covered	

In Green Build 1, student learned about the materials and appliances that largely determine the energy efficiency of a home. We introduced terms used to measure energy, and described their meanings. In Green Build 2, we will build on that experience to show students how benefits accumulate over time, and help them understand that decisions change depending on the time horizon over which they are made.

Considering long term impact is often a characteristic that distinguishes technical from professional jobs. Our career focus will be on a professional job, the Home Energy Engineer. Students will perform the same selection of building materials and appliances, and manage total building and energy costs as in the prior lesson; however, they must plan for 20 years, rather than a one-year time span.





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TEACHER PREPARATION

Review this prior to class!

Instructional Approach

This lesson plan uses directed inquiry to lead students to discover the questions they should ask about building and running a green home, and the answers to those questions.

Teacher's Role

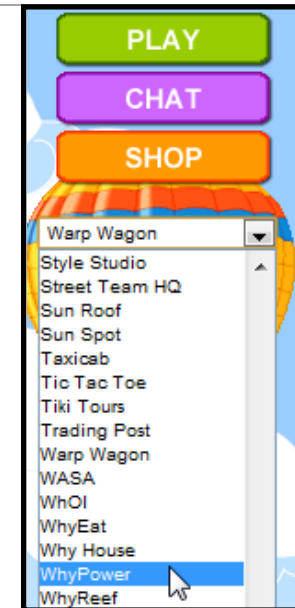
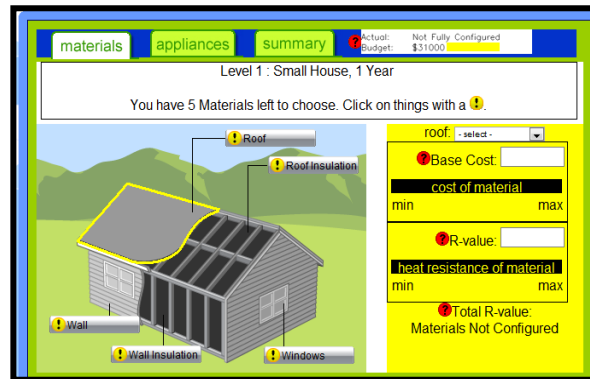
The teacher's role is classroom facilitator and expert consultant. You will lead students to explore and help them when they have problems. Many students will learn much more than is formally included in this lesson plan, and they will also be able to help other students.

Materials

1. Computers with Internet access and confirmed access to Whyville
2. CONNECT worksheet, included in this lesson plan
3. Calculator (optional)

Follow these instructions to prepare to facilitate your class.

1. Log into Whyville and select *WhyPower* from the Bus menu (see picture →).
2. Click the link *WhyPower Station*.
3. Click the link *Green Build*, and then click the button under *Engineer 20 Year* for the smaller house.



4. Note that you can get information by doing a mouse-over on the red question marks.



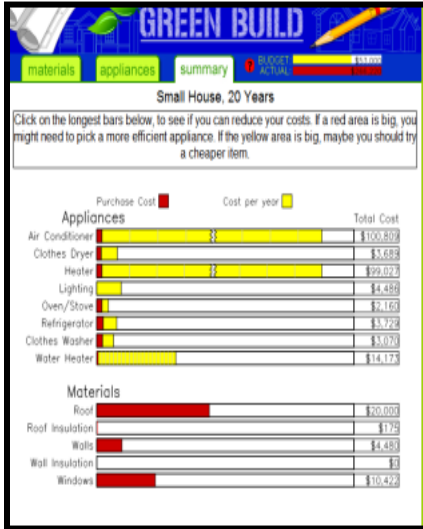
5. Choose materials for the roof, roof insulation, wall, wall insulation and windows.
6. NOTE: Students will discover that no wall insulation has an R-Value of 1. Why does no insulation still hold an R-Value? Because air has a slight R-Value!
7. Click on the *Appliances* tab and select your appliances.



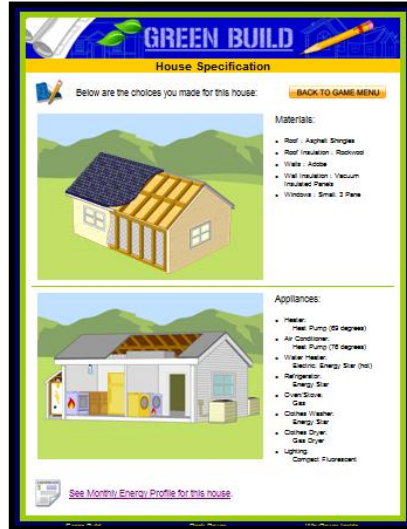
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TEACHER PREPARATION Review this prior to class!

- Click on the Summary tab to see if you stayed within budget. Go back and change settings if you are over budget
- When you are within the budget, click done, and examine your house specifications and the monthly energy profile.



(8) Summary Tab



(9) House Specification

Appliance	Item	Power/Month	Cost/Month
Heater	Heat Pump (69 degrees)	162.29 kW-H	\$ 21.10
Air Conditioner	Heat Pump (76 degrees)	206.56 kW-H	\$ 26.85
Water Heater	Electric Energy Star (hot)	353.85 kW-H	\$ 46.00
Refrigerator	Energy Star	63.62 kW-H	\$ 8.27
Oven/Stove	Gas	333 kBtu	\$ 4.00
Clothes Washer	Energy Star	60.92 kW-H	\$ 7.92
Clothes Dryer	Gas Dryer	667 kBtu	\$ 8.00
Lighting	Compact Fluorescent	13.85 kW-H	\$ 1.80
Total energy used per month:		861.08 kW-H 999 kBtu	\$ 123.94

(9) Energy Profile

It is possible to transfer the data from the Monthly Energy Profile to a Microsoft Excel Spreadsheet, by copying and pasting the information if using the Microsoft Internet Explorer Browser.

- Repeat these steps for 20 Years for the larger house.

Note the differences in Materials costs and the impact different materials make to the R-Value (thermal resistance) of the house. Also examine the differences between Purchase Cost and Operating Costs for appliances over the 20 year period. There are 2,880 possible combinations for housing materials and over 93,000 options available for appliances. Obviously not all combinations will provide a workable solution.

- Go to <http://www.energystar.gov/> to familiarize yourself with information about Energy Star.





ENERGY MEASUREMENTS

While there are more fundamental units of measure for energy that we will study in future lessons plans, the most practical measures of energy are **kilowatts, kilowatt-hours** and **BTUs**. These measures can be difficult to understand because the kilowatt is actually a *rate* of energy usage, even though that’s not obvious from the name. Kilowatts are like miles-per-hour (MPH). MPH indicates how fast a car is going at moment in time; kilowatts indicate how much energy-per-second is being used at a moment in time. Kilowatt-hours indicate how much *total energy* is used, just like “miles” indicates total distance traveled. The thing to understand about kilowatt-hours is that it is measures energy use over *any time period*, not over one hour!

Term	Definition	Is this a Rate of use, or Total use?	It’s analogous to ...
Kilowatts	The rate of usage of energy in some process (like running an A/C unit)	Rate of use	Miles per hour
Kilowatt-hours	Total energy use over some amount of time	Total use	Total miles traveled

BTU stands for British Thermal Units. BTU is a total energy measurement, like kilowatt-hours (and miles). By tradition, it used in measuring energy produced with propane and natural gas.

Term	Definition	Is this a Rate of use, or Total use?	It’s analogous to ...
BTU	Total energy use over some amount of time – about 4,000 kW-H* (kilowatt-hours).	Total use	Total mile traveled

* You will see these units of measure on the Monthly Energy Profile.





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TEACHER PREPARATION
Review this prior to class!

R-VALUE

The R-Value is the thermal resistance of an object. This is a measure of how easily the object will transfer heat energy. The higher the R-Value, the greater the insulating effectiveness. The R-Value of insulation depends on the type of material, its thickness, and density. Insulation must be properly installed to derive the full insulation benefit.

MATH

There is much basic arithmetic in this lesson as numbers are added to determine energy usage. The key new concept is the idea of base costs vs. recurring costs. Unlike Green Build One, this lesson will examine energy use over 20 years instead of one year. The lesson will ask the student to write (on paper) a formula like this one:

$$\text{Total Cost} = \text{Base Cost} + (\text{Years} * \text{Recurring Yearly Cost})$$

This will exercise algebraic concepts. In addition, students will complete a worksheet to examine energy usage over 20 years, to reinforce the recurring cost concept.

The combination of choices available for both the building materials and the appliance selection are an opportunity to discuss the concept of combinations. There are 5 options for roofing, 3 choices for roof insulation, 8 selections for windows, six options for wall materials, and four choices for wall insulation. A possible 2,880 combinations: $5 \times 3 \times 8 \times 4 \times 6 = 2,880$. The possible combinations for the appliance selection are even larger. While there were only five categories of building materials, there are eight different appliances, and three of those (water heater, heater, and air conditioner) have temperature settings for each appliance selection; three choices for lights, two ovens, two refrigerators, two washers, two dryers, six water heaters, and three temperature options, two heater options, and six degree settings, and while there are three choices for the air conditioner, and six temperature settings, selection of the heat pump as either furnace or air conditioner results in heat pump automatically selected for the other.



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PART 1 – EXPLORE

Do this for the first 20 minutes of class

Starter Question 3 minutes

If you were going to live in a home for a long time, what kinds of things would be important to you?

Perform these *Teacher Actions*

Do these in the order indicated

Expect this *Student Experience*

You should see your students experience the following

1. ENGAGE (3 minutes)

Ask students the Starter Question. Facilitate a class discussion for three minutes and help the students take ownership of the lesson.

ENGAGEMENT

Students take ownership while they are discussing a question that matters to them.

2. DIRECT (2 minutes)

Direct students to log into Whyville, go to *WhyPower*, and then to *WhyPower Station*, and then to *Green Build*. Direct them to play the games that require running a house for 20 years.

NOTE: Avoid giving further directions. Let them explore individually in teams and figure out for themselves what is going on, and how to be successful in the activities.

EXPLORATION

Within three minutes of the start of the lesson, students are logged into Whyville and in the Green Build activity, exploring the activities that require running a home for 20 years, and learning what is important and how to be successful.

3. COACH (15 minutes)

Wander around the room, encourage students to help each other, and help students if they cannot work through problems. Ask students what the activity is, what is important to succeed, and where they have additional questions.





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PART 1 – EXPLORE

Do this for the first 20 minutes of class

WHERE DO THE LESSONS APPEAR? Recognize the Core Content

Roof: Glass

Base Cost: \$20000

cost of material

min max

R-value: 0.91

efficiency of insulation

min max

Total R-value: 2.99

Oven/Stove: Gas

Base Cost: \$960

retail cost of appliances

min max

Energy Usage: 333333 BTU

Monthly Cost: \$4

cost to run per month

min max

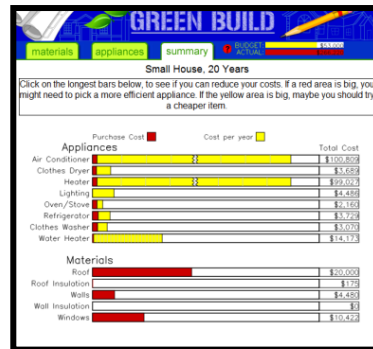
Lighting

Base Cost: \$15

Energy: beeswax

Yearly Cost: \$3000

Click to edit



GREEN BUILD Monthly Energy Profile

Estimated monthly usage and cost for your appliances. [BACK TO GAME MENU](#)

Appliance	Item	Power/Month	Cost/Month
Heater	Heat Pump (69 degrees)	162.29 kW-H	\$ 21.10
Air Conditioner	Heat Pump (76 degrees)	206.56 kW-H	\$ 26.85
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Total energy cost per month:			\$ 123.94

[See House Specifications](#)

On the materials selection page is the R-Value of the material and total R-Value of the building once all materials have been selected

Appliance base cost is on the appliance selection tool. The Summary Tab provides information on the appliance purchase cost and on the operational cost. Hovering over any line on the Summary Page will display a pop-up box which shows the yearly cost, and a link to edit that selection.

A **Done** button will appear to display the Energy Profile. It is only available once the building and appliances have been selected and are within the budget.





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PART 2 – REFLECT

Do this for the next 10 minutes of class

	Perform these <i>Teacher Actions</i> <i>Do these in the order indicated</i>	Expect this <i>Student Experience</i> <i>You should see your students experience the following</i>
1.	<u>GATHER</u> Give students a one-minute warning that exploration time is almost over. Then, have the students turn off their screens quickly when you direct them to stop.	<u>GATHERING</u> Students wrap-up their self-guided exploration and turn their full attention to the discussion.
2.	<u>FACILITATE</u> Lead students to discuss the questions below. Resist any urge to give them the answers.	<u>REFLECTING (group)</u> Students share their ideas and refine their ideas in large group discussion.

Questions

	Question	Expected Answer
1.	What are the Green Build 20-year activities about?	Saving money and being sustainable over the long term.
2.	What is success in the activity?	Building green homes that stay under budget for 20 years; earning Home Energy Engineer badges.
3.	What do you need to know to succeed?	Which building material and appliance choices result in costs that keep the house below the given budget over 20 years.
4.	What questions do you still have?	
5.	Beyond getting graded, do you care about this? How does selection of green building materials and appliances affect your life?	
6.	Name a real world job that is like this job.	





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PART 3 – ACCOMPLISH
Do this for the next 15 minutes of class

	<p align="center">Perform these <i>Teacher Actions</i> <i>Do these in the order indicated</i></p>	<p align="center">Expect this <i>Student Experience</i> <i>You should see your students experience the following</i></p>
1.	<p><u>DIRECT</u> Tell the students that their goal is to earn their Home Energy Engineer badge. Direct them to Green Build to either earn the badge or show you that they already earned the badge. <u>NOTE:</u> Many will have earned the badges during the prior class period, or between WhyCareers class periods.</p>	<p><u>ACCOMPLISHING</u> Students work independently to earn their badges. Those that already earned their badge help those who have not. They receive help from the teacher as needed.</p>
2.	<p>Transition to <u>CONNECT</u> As students finish and have no other students to help, direct them to complete the CONNECT worksheet.</p>	





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PART 4 – CONNECT
Five Minute Student Analysis

Name and Date		
Class Period and Whyville ID		
To save money, which is more important: the building, or the appliances? Why?		
Will green building skills be more or less important in the future? Why?		
If H is the cost to build a house, and A the cost to run appliances each year, what does it cost to own the house for 10 years?		
Why is the R-Value of building materials important?		
Identify a real world career that is related to what you learned today.		
Why should you care about what you learned? Is it relevant to your life? Why or why not?		
What uses more energy — heating, cooling, lighting, or powering appliances like the refrigerator, washer, and dryer, computers, and MP3 players?		





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STANDARDS MET
Texas Essential Knowledge and Skills (TEKS)
8th Grade

All TEKS listed are impacted by this lesson plan. **Boldfaced** TEKS represent the focus of the lesson plan.

TEKS: Career Investigation

- (2) The student knows how to locate, analyze, and apply career information. The student is expected to:
 - (A) access career information using print and on-line resources to complete an educational and/or training plan for a career pathway;
 - (C) complete career critiques gained through a variety of experiences (for example, shadowing, career study tours, guest speakers, career fairs, videos, CD-ROM, Internet, and simulated work activities); and
- (3) The student knows that many skills are common to a variety of careers and that these skills can be transferred from one career opportunity to another. The student is expected to:
 - (A) compile a list of multiple career options matching interests and aptitudes; and
 - (E) role-play appropriate interviewing techniques for an employment opportunity in the student's interest area.
- (6) The student knows the process of career planning. The student is expected to:
 - (A) list and explain the steps in the decision-making process;
- (8) The student knows the effect change has on society and career opportunities. The student is expected to:
 - (A) cite examples of change in our society;
 - (B) compose a report explaining positive and negative aspects of one of the examples of societal change;

TEKS: Exploring Careers

- 1) The student explores personal interests and aptitudes as they relate to education and career planning. The student is expected to:
 - (D) research current and emerging fields related to personal interest areas;
 - (G) research educational options and requirements using appropriate technology.
- (2) The student analyzes personal interests and aptitudes regarding education and career planning. The student is expected to:



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Texas Essential Knowledge and Skills (TEKS)
8th Grade

- (C) develop and analyze tables, charts, and graphs related to career interests;
- (D) determine the impact of technology on careers of personal interest; and
- (E) identify entrepreneurial opportunities within a field of personal interest.
- (4) The student evaluates skills for personal success. The student is expected to:
 - (A) implement effective study skills for academic success;
 - (B) use interpersonal skills to facilitate effective teamwork;
 - (C) use a problem-solving model and critical-thinking skills to make informed decisions;**
 - (D) use effective time-management and goal-setting strategies;
 - (E) effectively use information and communication technology tools; and
 - (F) identify skills that can be transferable among a variety of careers.
- (5) The student recognizes the impact of career choice on personal lifestyle. The student is expected to:
 - (A) prepare a personal budget reflecting the student's desired lifestyle;
 - (B) use appropriate resources to compare and contrast salaries and educational requirements of at least three careers in the student's interest area; and
- (6) The student demonstrates an understanding of personal financial management. The student is expected to:
 - (A) compare the advantages and disadvantages of different types of banking services;
 - (B) simulate opening and maintaining different types of bank accounts;
 - (C) simulate different methods of withdrawals and deposits; and
 - (D) reconcile bank statements, including fees and services.
- (7) The student develops skills for professional success. The student is expected to:
 - (A) demonstrate effective verbal, nonverbal, written, and electronic communication skills;
 - (B) evaluate the impact of positive and negative personal choices, including use of electronic communications such as social networking sites;
 - (C) model characteristics of effective leadership, teamwork, and conflict management;
 - (E) explore and model characteristics necessary for professional success such as work ethics, integrity, dedication, perseverance, and the ability to interact with a diverse population; and
 - (F) complete activities using project- and time-management techniques.
- (8) The student identifies and explores technical skills essential to careers in multiple occupations, including those that are high skill, high wage, or high demand. The student is expected to:



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- (A) complete actual or virtual labs to simulate the technical skills required in various occupations; and
- (B) analyze the relationship between various occupations such as the relationship between interior design, architectural design, manufacturing, and construction on the industry of home building or the multiple occupations required for hospital administration.

TEKS: Career Portals

- (1) The student explores one or more career clusters of interest. The student is expected to:
 - (A) identify the various career opportunities within one or more career clusters; and
 - (B) identify the pathways within one or more career clusters.
- (3) The student explores programs of study. The student is expected to:
 - (A) compare levels of education for careers of personal interest;
 - (B) identify the academic and technical skills needed; and
- (5) The student understands personal financial management and recognizes the value of personal fiscal responsibility. The student is expected to:
 - (A) compare and contrast different types of banking services;
 - (B) open and maintain different types of simulated bank accounts;
 - (C) practice different methods of withdrawing and depositing funds;
 - (E) compare and contrast forms of credit, including credit cards and debit cards;

TEKS: Mathematics

- (1) **Number, operation, and quantitative reasoning.** The student understands that different forms of numbers are appropriate for different situations. The student is expected to:
 - (A) compare and order rational numbers in various forms including integers, percents, and positive and negative fractions and decimals;



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- (B) select and use appropriate forms of rational numbers to solve real life problems including those involving proportional relationships;
 - (C) approximate (mentally and with calculators) the value of irrational numbers as they arise from problem situations (such as $\sqrt{2}$, $\sqrt[3]{2}$);
 - (E) compare and order real numbers with a calculator.
- (2) **Number, operation, and quantitative reasoning.** The student selects and uses appropriate operations to solve problems and justify solutions. The student is expected to:
- (A) select appropriate operations to solve problems involving rational numbers and justify the selections;
 - (B) use appropriate operations to solve problems involving rational numbers in problem situations;
 - (C) evaluate a solution for reasonableness; and
 - (D) use multiplication by a given constant factor (including unit rate) to represent and solve problems involving proportional relationships including conversions between measurement systems.
- (3) **Patterns, relationships, and algebraic thinking.** The student identifies proportional or non-proportional linear relationships in problem situations and solves problems. The student is expected to:
- (A) compare and contrast proportional and non-proportional linear relationships; and
 - (B) estimate and find solutions to application problems involving percents and other proportional relationships such as similarity and rates.
- (4) **Patterns, relationships, and algebraic thinking.** The student makes connections among various representations of a numerical relationship. The student is expected to generate a different representation of data given another representation of data (such as a table, graph, equation, or verbal description).
- (5) **Patterns, relationships, and algebraic thinking.** The student uses graphs, tables, and algebraic representations to make predictions and solve problems. The student is expected to:
- (A) predict, find, and justify solutions to application problems using appropriate tables, graphs, and algebraic equations; and
 - (B) find and evaluate an algebraic expression to determine any term in an arithmetic sequence (with a constant rate of change).
- (14) **Underlying processes and mathematical tools.** The student applies Grade 8 mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to:
- (A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;



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- (B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;
 - (C) select or develop an appropriate problem-solving strategy from a variety of different types, including drawing a picture, looking for a pattern, systematic guessing and checking, acting it out, making a table, working a simpler problem, or working backwards to solve a problem; and
 - (D) select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.
- (15) Underlying processes and mathematical tools. The student communicates about Grade 8 mathematics through informal and mathematical language, representations, and models. The student is expected to:
- (A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models; and
 - (B) evaluate the effectiveness of different representations to communicate ideas.
- (16) Underlying processes and mathematical tools. The student uses logical reasoning to make conjectures and verify conclusions. The student is expected to:
- (A) make conjectures from patterns or sets of examples and nonexamples; and
 - (B) validate his/her conclusions using mathematical properties and relationships.

TEKS: Science

- (2) Scientific investigation and reasoning. The student uses scientific inquiry methods during laboratory and field investigations. The student is expected to:**
- (A) plan and implement comparative and descriptive investigations by making observations, asking well-defined questions, and using appropriate equipment and technology;
 - (B) design and implement comparative and experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology;
 - (C) collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers;
 - (D) construct tables and graphs, using repeated trials and means, to organize data and identify patterns; and



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(E) analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

(3) Scientific investigation and reasoning. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions and knows the contributions of relevant scientists. The student is expected to:

(B) use models to represent aspects of the natural world such as an atom, a molecule, space, or a geologic feature;

Blooms (Taxonomy):

X	Knowledge: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state.
X	Comprehension: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate
X	Application: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.
X	Analysis: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
X	Synthesis: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.
X	Evaluation: appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support,

Instructional Strategies:

X	Identifying similarities and differences
X	Summarizing and note taking
X	Reinforcing effort and providing recognition
	Homework and practice
X	Nonlinguistic representations
X	Cooperative learning
X	Setting objectives and providing feedback
X	Generating and testing hypotheses
X	Cues, questions, and advanced organizers





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STANDARDS MET
Common Core Math, Grades 6 to 8

All standards listed are impacted by this lesson plan. **Boldfaced** standards represent the focus of the lesson plan.

Sixth Grade

<i>Subcategory</i>	<i>Standard ID</i>	<i>Standard Description</i>
Expressions and Equations	6.EE.6	Use variables to represent numbers and write expressions when solving a real world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.
Expressions and Equations	6.EE.7	Solve real world and mathematical problems by writing and solving equations of the form $x + p = q$ and $px = q$ for cases in which p, q and x are all nonnegative rational numbers.

Seventh Grade

<i>Subcategory</i>	<i>Standard ID</i>	<i>Standard Description</i>
Expressions and Equations	7.EE.4.A	Use variables to represent quantities in a real world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. a. Solve word problems leading to equations of the form $px + q = r$ and $p(x + q) = r$, where p, q, and r are specific rational numbers. Solve equations of these forms fluently. Compare an algebraic solution to an arithmetic solution, identifying the sequence of the operations used in each approach. For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width?



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STANDARDS MET
Common Core Math, Grades 6 to 8

<i>Subcategory</i>	<i>Standard ID</i>	<i>Standard Description</i>
Expressions and Equations	7.EE.4.B	Use variables to represent quantities in a real world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. b. Solve word problems leading to inequalities of the form $px + q > r$ or $px + q < r$, where p , q , and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem. For example: As a salesperson, you are paid \$50 per week plus \$3 per sale. This week you want your pay to be at least \$100. Write an inequality for the number of sales you need to make, and describe the solutions.