CAREER FOCUS

Power Plant Engineer

ACADEMIC FOCUS

Discover the basic parameters of power plants and the environmental impact of each.

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.	Student Worksheets	

In the Peak Power 2 activity, students will participate in an inquiry-driven open discussion on the operational cost, amount of CO_2 emissions, and the amount of land used by various energy sources. The students will then navigate to the Peak Power Game and complete levels four through six within allowable class time.

In addition to the topics covered in the Peak Power 1 activity, students will understand factors such as the cost of plant operation, plant emissions and pollutants, and the degree of land use of each energy source. Students earn their Power Plant Engineer badges by completing the activity. Finally, students will connect their experiences in the activity to aligned academic standards and to real world experiences.

Grant funding from the Texas Workforce Commission and U.S. Department of Labor. Grant funding from Next Generation Learning Challenges.

PEAK POWER 2 in Whyville

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

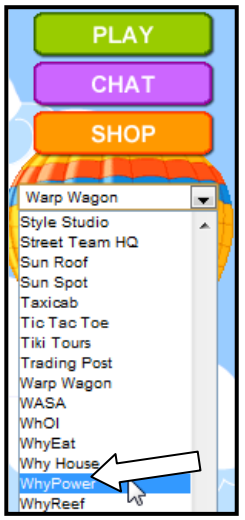
The teacher's role is classroom facilitator and expert consultant. You will lead students to explore and help them when they have difficulties. Many students will learn much more than is formally included in this lesson plan, and they will also be able to help other students.

Materials

1. Computers with Internet access and confirmed access to Whyville
2. CONNECT worksheet, included in this lesson plan

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 *Peak Power,* and then click the button *Cost* for the fourth level.
4. Continue clicking on the "Next" button and read all the instructions for level 4, then click on "Play".



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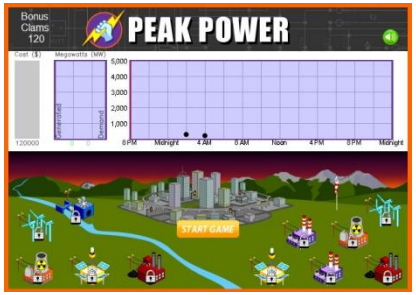
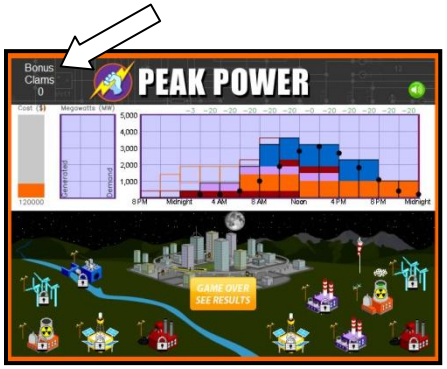
5. Play through the activity and make sure to stay under your cost constraint, which is displayed in the upper left-hand corner.

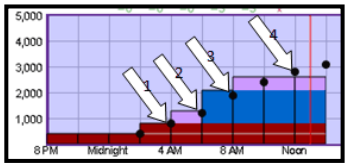


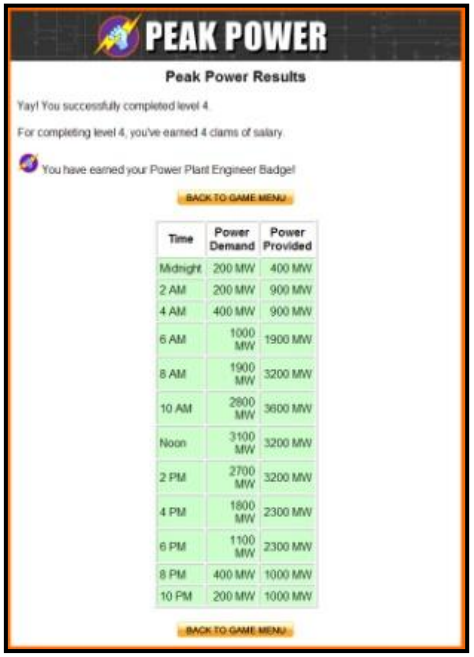
6. Click on the "See Results" button to see how you closely you followed the power curve over 24 hours.
   You may go back to improve your skill to increase the bonus clams award.



7. Repeat these steps for the Emissions and Land Use levels earning your Power Plant Engineer Badge. The success screen awards clams to the students' salary, varying amounts of extra clams for following the power curve as closely as possible, and a badge at levels 1 and 4.

8. Students meet demand at a given time interval (arrows one and two), not exceed demand (arrow 3) or fall short of demand (arrow 4), which causes a "brownout" condition.





Time	Power Demand	Power Provided
Midnight	200 MW	400 MW
2 AM	200 MW	900 MW
4 AM	400 MW	900 MW
6 AM	1000 MW	1900 MW
8 AM	1900 MW	3200 MW
10 AM	2800 MW	3600 MW
Noon	3100 MW	3200 MW
2 PM	2700 MW	3200 MW
4 PM	1800 MW	2300 MW
6 PM	1100 MW	2300 MW
8 PM	400 MW	1000 MW
10 PM	200 MW	1000 MW

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	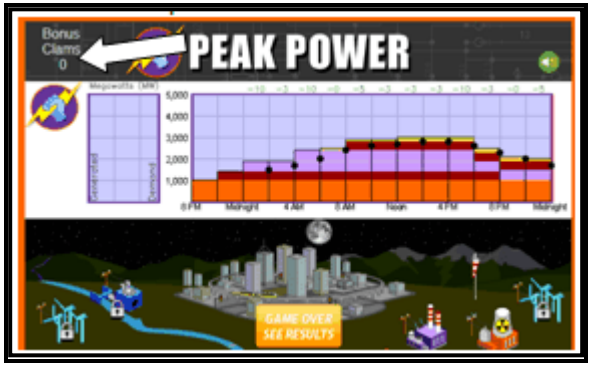	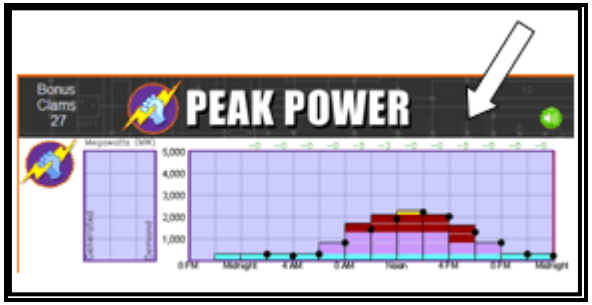
RESULT 1 Brownout Zero Clams Brownout conditions immediately end the game and students must start over from the beginning.	**RESULT 2** Exceeding Demand Zero Bonus Clams out of possible 40 In this case, the student met the demand of the city, but exceeded the energy needed. The student receives their Power Plant Operator Badge and 1 clam is added to their salary.	**RESULT 3** Mostly Meeting Demand 27 Bonus Clams out of possible 120 Here the student precisely meets the demands of the city at almost every time interval. However, they exceeded demand in some cases. As can be seen at the top of the time chart, clams are deducted for exceeding demand at a particular interval. In this case, the student receives 40 - 5 - 3 - 5 = 27 clam bonus, 1 clam added to their salary, and their Power Plant Engineer Badge.

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ENERGY MEASUREMENTS

In prior lessons, we exposed the students to kilowatts and kilowatt-hours. In this lesson, students utilize measurements in megawatts and megawatt-hours to calculate the cost of operation and land use in acres, and utilize kilowatt-hours to calculate grams of CO2 emissions for each type of power plant. In level four, the students must consider how much money it costs to generate power using each type of power plant in dollars per MW-h in addition to meeting all of the conditions of the first three levels. In level five, the students have to consider the carbon dioxide (CO2) levels that their set of active power plants emit, in grams per kW-h, in addition to meeting the criteria of all the earlier levels. And finally, the students have to consider the amount of land that their set of active power plants utilize in acres per MW while considering the criteria set forth in the previous levels.

MATH

Students will exercise graph interpretation skills, since the game display and "bonus" graph tracks energy demand vs. supply as they turn on and off power plants. In addition, students may exercise estimation skills as they make educated selections about which power plants to enable and disable. Also, students may exercise mental arithmetic skills to help them determine in advance the power plants to enable. Students will see measurement units, reinforcing prior lessons about the meaning of joules, watts, watt-hours, and the meaning of mega and kilo. Students will also see graph results displayed in a table, exercising their ability to conceptually understand that underlying data can be displayed in multiple formats.

Also in this lesson the students are actively engaging rates and ratios mentally. Students compare dollars to MW-h, grams to kW-h, and acres to megawatts. The students are utilizing these rates and ratios informally in the context of other mitigating factors such as time of day, startup times, etc. which increases the complexity of each succeeding activity.

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Starter Question 3 minutes

You are the Mayor of a city and plan to build a power plant. What will you have to spend money on to build the plant? (Valid answers include: land, equipment, staff, plant design, and regulatory expenses including emissions studies / permits.)

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 *Peak Power*. Direct them to explore the activities inside Peak Power. NOTE: Avoid giving further directions. Let them explore individually in teams and figure the activity out for themselves.	**EXPLORATION** Within three minutes of the start of the lesson, students are logged into Whyville and in the Peak Power activity, exploring the activity 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 individual students if they cannot work through problems. Ask students what is important to succeed in the activity, and assist them where they have additional questions.	

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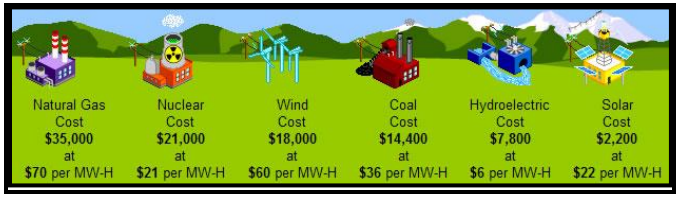
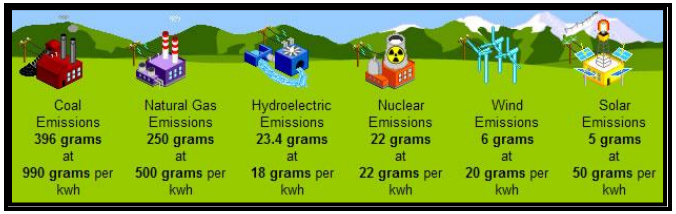
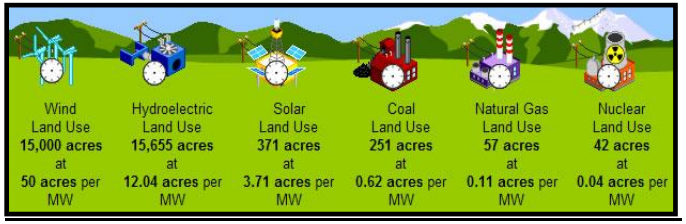
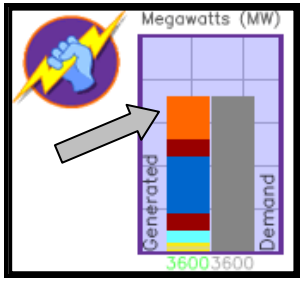
WHERE DO THE LESSONS APPEAR? Recognize where the core content shows up.



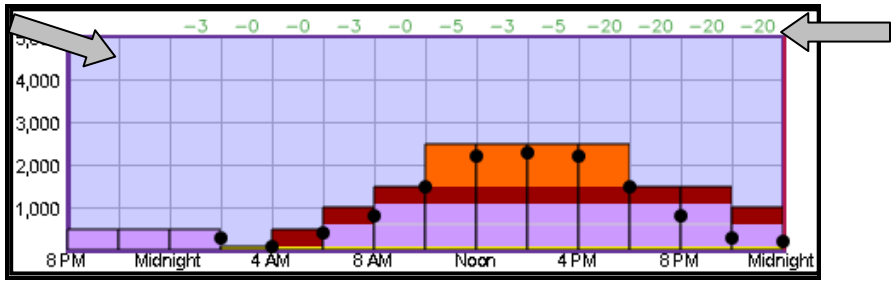




Students must recognize that the various plants cost more or less (in dollars, land, and emissions) to generate different amounts of electricity in megawatts.



Using the bar graph to the left of the game, students will be shown the demand (right side) at a given time and are required to mentally add or subtract the number of megawatts to meet that demand (left side).



Using the time lapse chart, the students must fulfill the demand of the city as closely as possible without creating "brownout" conditions or exceeding the demand at a given time interval. The students will quickly learn that the amount of clams they earn for each level is dependent upon how closely the city's needs are met as indicated by the green numbers above the graph.

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PART 2 – REFLECT

Do this for the next 10 minutes of class

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

Questions

	Question	Expected Answer
1.	What is Level 4 about?	To prevent brownout, cost of producing power must not exceed $120,000.
2.	What is Level 5 about?	To prevent brownout, power plants cannot exceed emitting 900 grams of CO_2.
3.	What is Level 6 about?	To keep a city from experiencing a brownout, you are not allowed to activate a set of power plants that take up more than 17,000 acres of land.
4.	What is success in the activity?	Effectively keeping a city supplied with cost effective energy while being aware of the environmental impact and startup times of various forms of power plants in order to earn clams and badges.
5.	What questions do you still have?	
6.	Beyond being graded, do you care about this? Does this topic affect your life?	
7.	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

	Perform these *Teacher Actions* ***Do these in the order indicated***	Expect this *Student Experience* ***You should see your students experience the following***
1.	**DIRECT** Tell the students that their goal is to earn the Power Plant Engineer career badge. Direct them to Peak Power to either earn the badge or show you that they already earned the badge. NOTE: Many will have earned the badges during the prior class period, or between WhyCareers class periods.	**ACCOMPLISHING** Students work independently to earn their badges. Those that have already earned their badge help those who have not. They receive help from the teacher as needed.
2.	*Transition to* **CONNECT** As students finish and have no others to help, direct them to complete the CONNECT worksheet as directed.	

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PART 4 – CONNECT

Five Minute Student Analysis

Name and Date		
Class Period and Whyville ID		
What was this activity about?		
What did you need to know to succeed?		
What new questions did you think of while playing?		
How many acres per megawatt are needed to generate power using solar as compared to using hydroelectric?		
How many grams of emissions per kilowatt-hour are needed to generate power using wind as compared to using coal?		
How much money per megawatt-hour is needed to generate power using nuclear as compared to using natural gas?		
Name a real world career that is related to what you learned today.		
Do you care about what you learned? Is it relevant to your life? Why or why not?		

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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;
(B) access career information using interviews with business and industry representatives to create a career resource file;
(6) The student knows the process of career planning. The student is expected to:
(B) prepare an oral or written plan describing the specific factors considered in the decision-making process used to solve a simulated career problem;
(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;

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;
(F) explore how career choices impact the balance between personal and professional responsibilities; and
(2) The student analyzes personal interests and aptitudes regarding education and career planning. The student is expected to:
(C) develop and analyze tables, charts, and graphs related to career interests;
(D) determine the impact of technology on careers of personal interest; and
(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;
(F) identify skills that can be transferable among a variety of careers.
(7) The student develops skills for professional success. The student is expected to:
(C) model characteristics of effective leadership, teamwork, and conflict management;
(D) recognize the importance of a healthy lifestyle, including the ability to manage stress;

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(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:

(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.

(2) The student explores pathways of interest within one or more career clusters. The student is expected to:

(A) investigate career opportunities within the pathways;

(B) explore careers of personal interest;

(4) The student explores the professional skills needed for college and career success. The student is expected to:

(E) identify professional associations affiliated with a specified program of study;

(F) employ effective leadership, teamwork, and conflict management;

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:

(B) select and use appropriate forms of rational numbers to solve real life problems including those involving proportional relationships;

(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

(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).

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(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;
(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;
(B) use a problem-solving model that incorporates understanding the problem, making a plan, carrying out the plan, and evaluating the solution for reasonableness;
(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

(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:
(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;
(B) use models to represent aspects of the natural world such as an atom, a molecule, space, or a geologic feature;
(C) identify advantages and limitations of models such as size, scale, properties, and materials;

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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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Sixth Grade

Subcategory	Standard ID	Standard Description
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.**

Subcategory	Standard ID	Standard Description
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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Subcategory	Standard ID	Standard Description
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.**

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