Saving the Environment with Economic Ideas

FEDERAL RESERVE BANK of ST. LOUIS

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Introduction

The lessons in this module cover a range of topics in environmental economics and can be done as a unit or individually. The following provides a brief description of each lesson and explains the concepts covered.

Lesson 1: Water Rights: Managing the Colorado Water System

Lesson 1 addresses an important question: Why is a price system the best way to allocate natural resources? The lesson sets the stage by describing the competing demands for Colorado River water. The students then simulate a river by passing a pitcher of water down a line of students. Each student must decide how much water to take. They are given a number of scenarios that change their incentives to take water from the river. The remaining students act as economists and calculate the water usage's total value to society. The students discover that when something is appropriately priced, its total value is maximized under a price system. The lesson ends with a section on what might impact the choice of an appropriate price.

Lesson 2: Property Rights

Lesson 2 provides a quick illustration of the Coase Theorem using a lake-pollution activity. The theorem explains that externalities like pollution in a lake can be resolved through two parties (the polluter and the user of the lake) bargaining with each other. The results of the bargaining will be what is best for society. The lesson highlights two points. First, the fate of the lake (whether it will be clean or polluted) does not depend on who owns the lake. If the user owns the lake and the polluter values a polluted lake more than the user values a clean lake, the polluter will pay the user to compensate for polluting the lake. If the polluter owns the lake and the user does not value a clean lake enough to pay the polluter to not pollute the lake, then the lake will be polluted. Second, while the fate of the lake does not depend on who owns the lake, ownership of the lake is important in one very important way: The lake has value, so whoever has rights to the lake will be wealthier.

Lesson 3: Marginal Analysis: How Clean Is Clean Enough?

Lesson 3 starts with a simulation in which the students clean up rugs dirtied with paper towels, beans, and paper bits/glitter. The students realize that in order to get the rugs cleaner, the marginal costs of doing so increase. In the simulation, three cups of pollution are placed on each rug. The first cup of balled-up paper towels is easily cleaned up. However, the second cup of beans takes longer to clean up. Finally, the third cup of paper bits and glitter, all remaining pollution, takes a long time to clean up. The students then use the data from the simulation to construct a demand for pollution. In other words, they understand that firms are willing to pay to dispose of pollution into the environment instead of paying to clean their waste. The students observe that if the price for polluting is high, then firms will clean their waste and emit less into the environment. If the price is low or free, then firms will do little to reduce the waste they dispose of into the environment. The students end the lesson with an activity that illustrates when it's a good idea to clean up a lot of pollution and when it's OK to let some pollution into the environment.

Lesson 4: Supply and Demand of Pollution

While it can be done independently, Lesson 4 builds on the demand for pollution disposal illustrated in Lesson 3. The students begin by understanding that if a price is charged to dispose of pollution into the environment, then the result is a demand for pollution disposal. At high prices, a firm will clean more of its waste and release less pollution into the environment. At low prices, a firm will clean less of its waste and release more into the environment. Students are then introduced to two ways to regulate pollution through market-based systems: In a cap-and-trade system, the supply of pollution is illustrated with a vertical (perfectly inelastic) supply curve. In a permit system, the supply of pollution is illustrated with a horizontal (perfectly elastic) supply curve. The lesson concludes by examining what happens when the supply or demand of pollution disposal changes.

Lesson 5: The Emissions Simulation

The emissions simulation in Lesson 5 puts students in the roles of firms. Each firm must decide how much pollution to release into the environment. The simulation goes through a number of rounds: The firms can pollute without any charges; the firms are not allowed to pollute at all; the firms pay an emissions tax to pollute; the firms receive a non-tradeable permit to pollute; and the firms receive a tradeable permit to pollute. The students should learn that (a) no pollution control or no pollution allowed at all are generally costly solutions, (b) trading pollution permits allows firms to find the lowest costs, and (c) both an emissions tax system and a tradeable permit system minimize the costs to society of cleaning up pollution. The simulation reinforces the idea that using a price system (whether a tax or a permit) results in the lowest-cost method of controlling pollution among a large number of firms.

Lesson 6: Green Is the New Gold

The fun simulation in Lesson 6 challenges students to figure out the best way to create a product from resources with the least amount of waste. The lesson emphasizes that being green is not just something businesses do to adhere to regulations, but it's something that can be profitable as well.

These lessons build on past work of other economic educators. Curt L. Anderson's 1996 book *Economics and the Environment* provided the building blocks for many of the lessons presented here. However, these new lessons include innovations that should help in conducting the activities and hopefully make it easier to implement in the high school classroom.

The ultimate goal of the module is to help students understand how providing incentives through price systems, taxes, and permits are important tools in effectively addressing pollution and natural resource issues. Students should also realize that being green is good business: The resilience industry is growing and will offer more jobs in the future. It is hoped that once students understand these concepts they will be better-educated citizens who can more effectively deal with future environmental challenges.

Acknowledgments

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Lesson 1:
Water Rights: Managing the Colorado River System

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Standards and Benchmarks (see page 1.18)

Lesson Description

The class will participate in an activity simulating the Colorado River's trek to the sea. The goal is to try to sustain the river long enough for some water to exit into the Gulf of California. The challenge is to align the individual needs of consumers with the health of the river while an ever-changing set of conditions influences both supply and demand. If students have an understanding of supply and demand, conduct the fifth round of the simulation and an extension activity, which will allow them to illustrate their skills in shifting market curves for the Colorado River water as conditions change.

Grade Level

High school

Concepts

Allocation

Scarcity

Value

***Optional concepts*:** Changes in market price and quantity, shifts in demand, shifts in supply

Objectives

Students will be able to

- define allocation, scarce, and value;
- describe the water crisis affecting the western United States;
- describe the multiple parties using the Colorado River System;

- compare the results of different water allocation schemes; and
- (optional) express their understanding of market shifts as river conditions change.

Compelling Question

How should we allocate scarce resources?

Time Required

90-120 minutes

Materials

- PowerPoint Slides 1.1-1.14
- Handout 1-1A, one copy for all but 14 students
- Handout 1-1B, one copy, cut into strips
- Handout 1-2, one copy for each student (optional)
- Handout 1-3, one copy for each student
- Twelve 16-oz. clear plastic cups
- Two pitchers or containers (reservoirs) that will hold seven cups of water each
- One gallon of water
- A funnel (if the jug's opening is narrow)
- Blue painter's tape
- One permanent marker
- Two 1-c. measuring cups

Preparation

- Label the plastic cups using the blue painter's tape and permanent marker.
- Two cups should say "Power Plant," two should say "Fracking," two should say "Agriculture," two should say "Residential," two should say "Data Storage," and two should say "Marsh: Bay of California."
- Use a 1-c. measuring cup to pour eight ounces of water into one of the plastic cups. Tear off a small piece of blue tape and adhere it to the back of the cup (the side not labeled) at the water line. Do this for each of the consumer cups so that students will know where to stop pouring during the simulation. In the end, each cup should have the blue tape at the halfway mark.

- The two pitchers (reservoirs) should each be filled with seven cups (56 ounces) of water. Use the blue tape to mark the water level.
- Preview the following documentary: https://e360.yale.edu/features/video_colorado_river_running_near_empty.
- For additional background and depth of understanding, view the following series: https://e360.yale.edu/series/crisis-on-the-colorado.

Introduction

The Colorado River provides water for one out of every eight Americans for residential, industrial, mining, agricultural, and recreational needs. The river serves seven western U.S. states and Mexico, and water appropriation was established by an agreement forged in 1922. Senior water rights were given to the earliest (white) settlers and tended to be in the agriculture, ranching, and mining interests. Senior rights were also awarded to California after a series of Supreme Court cases throughout the twentieth century. Having senior water rights mandates that the same amount of water be allotted each year regardless of river totals. All others have junior rights and have to share the remainder. Ultimately, the federal government controls the water and has the final say in appropriation. The region was divided in half: the Upper Basin and Lower Basin. The boundary between the basins is at Lee's Ferry just below Glen Canyon Dam at the Utah/Arizona border. Each basin was apportioned 7.5 million acre-feet per year, but that agreement came on the heels of one of the wettest periods in western U.S. history. Though the river has been reliable, it has fallen victim in recent years to severe drought and growing demand. During the past 50 years, according to figures from the Reclamation Bureau, the population served by the river has grown from 12 million to 40 million. During that period, the average flow of the river has fallen from 15.5 million acre-feet to as low as 12 million acre-feet. (An acre-foot serves a family of five for a year.) As a result, the Colorado River has reached its historical rendezvous with the Gulf of California only once in nearly two decades (the result of an artificial surge of water orchestrated by environmentalists). Consequently, the marsh at the doorstep of the Gulf has been dramatically compromised with significant salt intrusion and the loss of ecosystems.

Procedure

1. If desired, introduce the Colorado River crisis to the students by showing the following short documentary before opening the PowerPoint slideshow: https://e360.yale.edu/features/video_colorado_river_running_near_empty.

2. Use the PowerPoint slides to indicate the numerous "straws" that draw water from the Colorado River. This will introduce the students to their roles in the subsequent simulation.

3. Display Slides 1.2-1.5 to introduce the students to the agreement made in 1922 among the states fed by the Colorado River.

4. Display Slide 1.6 and explain that there is an early draw on the supply of water to satisfy a thirsty eastern Colorado.

5. Display Slides 1.7-1.12 and review descriptions of the consumers depicted in this lesson's simulation.

6. Display Slide 1.13 that illustrates the anomalous pricing system in many rain-starved western cities.

7. Display Slide 1.14 and discuss the ecological impact that occurs because the river doesn't reach its natural terminus.

8. Explain that water is a **scarce** natural resource. It is scarce because many people want to use/consume it but there is a limited amount. Societies develop different **allocation** strategies—that is, ways in which to distribute the water.

9. Tell the students they are going to simulate the movement of the Colorado River water through the Lower Basin of the system from Glen Canyon Dam to the Gulf of Colorado. Ask for 14 student volunteers to participate in the simulation. Once selected, tell the rest of the class they will be economists who will monitor and **value** the use of the river's water in the simulation. Distribute a copy of *Handout 1-1A: The Valuation of Water in the Colorado River Simulation* to each economist.

10. Instruct the volunteers to create two lines of seven. Assign each student a role by giving them a reservoir or pre-labeled plastic cup. The two students representing the reservoirs will each stand at the heads of the lines with the pitchers of water. Arrange students in each line as follows:
    - Reservoir
    - Power Plant
    - Fracking
    - Agriculture
    - Residential
    - Data Storage
    - Marsh: Bay of California

11. Tell the students they will simulate the flow of the river by passing the reservoirs down the lines. Explain that during the simulation they represent the people described by their roles: Based on either the information in the PowerPoint slideshow or their own assumptions, they should make decisions as if they were the people described by the roles. For example, as someone in agriculture, that student should try to obtain water for their crops. Have each student in line suggest reasons they need water. (*Answers will vary.*) To simulate the flow of the river during the simulation, each student will take some water and then hand the pitcher

to the next student in line. (Alternatively, the reservoir student can fill the cups as requested by each person on the river as he or she moves down the river.) Tell the students the simulation will be repeated a number of times with different scenarios.

12. Instruct half the economists to observe one of the rivers and the other half the other river. (This simulation uses two rivers to get more students involved. If desired, only one river can be used with the rest of the class as economists. However, with two rivers, a wider variety of results—or errors—may occur, giving the class more information to discuss.)

13. Meet quietly with the economists to ensure that they understand how to use the table to record information and value the river based on the example provided on Handout 1-1A. (NOTE: The first round requires that the volunteers in the river lines not know the values, so clear up any questions without revealing the values to the volunteers.)

Round 1

14. Tell the volunteers that in this first round, they should take as much water as they would like because the price of the water is so low it is practically free. But to keep it simple, they should take either no water, half a plastic cup of water (to the blue tape), or a full plastic cup of water. Explain the following:
    - As the reservoirs are passed down the line, take all the water you think your designated consumer will need. Each student may shield the drawdown of the river—that is, hide from others how much water he or she is taking—before passing the reservoir to the next consumer.
    - Once a reservoir is passed to the next student, no more water can be acquired.
    - If there is spillage, that water is irretrievable as either evaporation or leakage.
    - A reservoir will be passed until either all the water is gone or the marsh, the river terminus, is reached.
    - Results will be determined by the individual choices made at each stop.

15. Instruct the students to begin the round. When each pitcher has reached the last student in a line, or reservoirs have been emptied, have the water consumers show the amount of water they drew by raising their cups or calling out the amount. Instruct the economists to record the amounts used by each consumer and value the water usage. Discuss the following:
    - In either line, did water reach the marsh at the end of the river? (*Answers will vary.*)
    - If the answer to the first question was "No," what were the obstacles that kept water from reaching the marsh? (*Answers may include that the individual consumers took more water than they actually needed, placing more value on their needs than the needs of those further down the river. There could have been a degree of spillage [evaporation,*

leakage] that wasted a great deal of water. The individual consumers had no idea how their drawdown would impact other consumers.)

- In this round, water was allocated on a first-come, first-served basis.

Round 2

16. Return the distributed water to the reservoirs so that they are back to prescribed levels. (Have the students representing the reservoirs use extra water to replenish if some was spilled.)

17. Explain to the volunteers that in the previous round, they had little guidance on how much water to take. Tell them you will now give them a slip, from *Handout 1-1B: Value Slips for River Simulation*, that tells them the water's value. Explain that this slip lists the value amount for the first eight ounces of water and another value amount for the second eight ounces; this is the marginal benefit for their use of water.

18. Explain to the volunteers that their goal is to maximize the total value for themselves. Note that the water is still provided at a cost that is so low they can consider it free.

19. Instruct the students to begin passing the reservoirs down the line, allowing students to take all the water they think their designated consumers will need. The same rules about spillage, etc., apply in this round. Students should continue passing their reservoir until either all the water is gone or the marsh, the river terminus, is reached.

20. Have the water consumers show or call out the amount they drew. Instruct the economists to record the amounts used by each consumer and value the water usage. Discuss the following:
    - In either line, did water reach the marsh at the end of the river? (*No, it is likely that all the water would have been gone by the time it reached data storage.*)
    - Ask the students representing data storage or the marsh if they are unhappy with this allocation. (*Yes, since they did not receive any water, they are likely to be unhappy.*)
    - On what basis was water allocated in this round? (*In this round, water was used as though it were a free resource—on a first-come, first-served basis.*)
    - Why was water allocated in this way? (*No one had an understanding of the cost; early consumers saw nothing but benefit and took as much as they could. This meant that residents would have no more than eight ounces available and data storage would have none.*)

21. Explain that in this round, consumers received varying levels of water values as they consumed second cups of water. This might be because the marginal or additional satisfaction from a second cup of water varied among consumers. In a residence, there are limits to how much water a family can consume. Over-production by a fracking or agricultural operation could

reduce the price of the commodity (oil, corn, wheat, or beef). Data storage provides a unique service that seems to have limitless demand, and power plants can sell excess product to utilities in other parts of the hemisphere.

Round 3

22. Return the distributed water to the reservoirs so that they are back to prescribed levels (using extra water to replenish if some was spilled).

23. Tell the students that some consumers have senior water rights. This means they have a claim to the water before anyone else can use the water. Explain that because some consumers—the power plant, agriculture, and residential consumers—have been here the longest, they have a right to a full 16-oz. cup of water.

24. Instruct the students to begin passing the reservoirs down the line, allowing students to take all the water they think their designated consumers will need. The same rules about spillage, etc., apply in this round.

25. As the reservoirs reach the fracking consumers, note that based on senior rights, they can only take eight ounces because there must be enough for agriculture and residents to have a full 16-oz. cup. Students should continue passing their reservoir until either all the water is gone or the marsh, the river terminus, is reached.

26. Have each water consumer show or call out the amount they drew. Ask the economists to record the amount used by each consumer and value the water usage. Discuss the following:
    - In either line, did water reach the marsh at the end of the river? (*No*)
    - What were the differences in distribution with these rights compared with the distribution in the previous round? (*The fracking consumers received only eight ounces and the residents received a full 16-oz. cup instead of only the eight ounces allotted them in the previous round.*)
    - On what basis was water allocated in this round? (*In this round, water was allocated based on arbitrarily assigned rights.*)

Round 4

27. Point out that up until this point, the price of water has been so low that price didn't influence consumption decisions.

28. Return the distributed water to the reservoirs so that they are back to prescribed levels (using extra water to replenish if some was spilled).

29. Set the price of water at $65 for each eight ounces. Tell the volunteers to think about how much water they should take by comparing the price of the water with the marginal benefit of the water—based on the slips of paper you gave them in Round 2. Tell the students representing the marsh that they do not have any money to purchase water, so they will only get any water that filters down to the end.

30. Instruct the students to begin passing the reservoirs down the line, allowing them to take all the water they think their designated consumers will need. The same rules about spillage, etc., apply in this round. Students should continue passing their reservoir until either all the water is gone or the marsh, the river terminus, is reached. Discuss the following:

    - Did the water reach the marsh at the end of the river? (*Yes, if the volunteers took the correct amount of water.*)
    - What were the differences in distribution with these rights compared with the distribution in the previous round? (*All the volunteers took only eight ounces of water—except for data storage—because the second eight ounces is worth less to them than the $65. Data storage values the second eight ounces highly, so they took a full 16-oz. cup of water.*)
    - On what basis was water allocated in this round? (*In this round, water was allocated based on price.*)
    - Do you like that the water was priced? (*No, because in previous rounds it was free. Consumers are not as well off as they were when the water was free.*)
    - Why might pricing water be a good idea? (*Answers will vary, but hopefully some students will note that only people who value the water highly will buy the water.*)

31. Ask the economists to report the total values of the water usage. Record their answers on the board. (*Round 1: will vary depending on how the students elected to distribute the water; Round 2: $550; Round 3: $500; Round 4: $750*) Discuss the following:

    - Which round resulted in the least value and which round resulted in the most value? (*The round with least value will be either Round 3, the rights round, or Round 1, in which students chose the allocation. The round with most value will be Round 4, in which a pricing system was used.*)
    - Which system should be used to allocate water? (*Most students will choose the pricing system because it provides the most value to society. However, some students will point out that in a water rights system, residents get more water and so may choose that system because of what they believe is fair. Some students may think more water should reach the marsh to preserve nature. Point out that other issues besides value may be used to allocate water.*)

    NOTE: If a shorter activity is desired, skip to the Closure section. If time permits, you may conduct the optional Round 5 and then the Closure. (Economics classes that have covered supply and demand concepts can do the optional Round 5 and subsequent supply and demand activity.)

Round 5 (optional)

32. Return the distributed water to the reservoirs so that they are back to prescribed levels (using extra water to replenish if some was spilled).

33. Explain that if using a pricing system, economists must be careful about pricing the water. If the price is too high or too low, it can result in low-value outcomes.

34. Tell the students that in this final round, there will be different prices for the two river lines. For one river, the price of water will be $55. For the other river, the price will be $80. (If there is only one river, then conduct two rounds.)

35. Instruct the students to begin passing the reservoirs down the line, allowing them to take all the water they think their designated consumers will need. The same rules about spillage, etc., apply in this round. Students should continue passing their reservoir until either all the water is gone or the marsh, the river terminus, is reached.

    NOTE: For the river with high-priced water, the marsh students will have a reservoir with 24 ounces of water and a cup that holds only 16 ounces. You can either instruct the student to keep pouring—creating eight ounces of spillage waste and a small mess—or just note to the class that some water is not used and is wasted.

36. Ask the economists to report the total value of water usage for each river. (*$710 for the price of $55; $625 for the price of $80*)

37. Discuss the following with the economists:

    - Why did the value for the high-priced water result in a lower value than that in Round 4? (*Too much water flowed through to the marsh, creating waste.*)
    - Why did the value for the low-priced water also result in a lower value? (*No water reached the marsh, which provides value to society—even if the marsh can't "pay" for water.*)

38. Tell the students that economists prefer pricing resources such as water for two reasons: One, as was shown in the first four rounds, pricing results in the highest-value usage for a resource, as opposed to a first-come, first-served basis or arbitrarily assigned rights. Two, a correctly determined price produces the best results for society.

39. Explain that one way the water could be allocated is to auction off the water to determine the price. Ask the students if they see a problem with this idea. (*Answers will vary. The marsh has no ability to pay, so the water will be bought by someone who values having the water less than society would value having the water in the marsh.*)

40. Ultimately, economists must try to value water based on the idea of supply and demand. Distribute a copy of *Handout 1-2: Pricing the Colorado River System* to each student. Tell the students to read the scenarios and decide what will happen to the equilibrium price and quantity when the change described in each scenario occurs. Tell the students that in the simulation the amount of water was fixed, but in reality the Colorado River system has reservoirs to store water; more water can be released if the price rises, or less water can be released if the price falls. The following are suggested answers for the handout:
    1. *Demand up; price up; quantity up*
    2. *Demand down; price down; quantity down*
    3. *Supply down; price up; quantity down*
    4. *Demand up; price up; quantity up*
    5. *Supply down; price up; quantity down*
    6. *Supply down; price up; quantity down*
    7. *Demand down; price down; quantity down*
    8. *Supply down; price up; quantity down*
    9. *Demand up; price up; quantity up*
    10. *Supply up; price down; quantity up*

41. Review the answers and note that when more water is demanded, the price of water should increase. When more water is supplied (by nature), the price should decrease.

Closure

42. Discuss the following to review the key content from the lesson:
    - Describe the water crisis affecting the western United States. (*Water is a scarce natural resource. Many people want to use water, but there is a limited amount of water available.*)
    - Give examples of consumers who use water from the Colorado River. (*Examples include agriculture, residents, power plants, data storage centers, fracking operations, and golf courses.*)
    - What is the current allocation strategy for the Colorado River? (*The current strategy is based on a 1922 agreement involving seven western U.S. states and Mexico. The region is divided in half; each half is allotted an equal amount of water, and some consumers have first right of usage, while others receive what remains.*)
    - Did the rivers always reach the marshes in the simulations? (*No*)

- What were the results of the different allocation schemes demonstrated in the simulation? (*In Round 1, water was allocated on a first-come, first-served basis and was randomly consumed; water likely didn't reach the marsh. In Round 2, each consumer understood the marginal benefit received from water consumption but had no information about cost, so again water was drawn on a first-come, first-served basis; water likely didn't reach the marsh. In Round 3, senior and junior rights were assigned to consumers, giving power plants, agriculture, and residents freedom to consume a full allotment of water, with fracking and data storage having to accept what was left. In Round 4, the consumers became aware of the marginal cost of each eight ounces of water and had to weigh that against the marginal benefit; if each consumer gauged that relationship accurately, water reached the marsh. In the optional Round 5, the water in the rivers was priced differently—one river above equilibrium and one river below. The results were that for the low-priced river, no water reached the marsh, and for the high-priced river, too much water reached the marsh.*)
- What happened to cause a river to fall short of the marsh? (*Answers may include that there was too much demand, not enough water in the reservoir, or too many consumers looking after themselves before considering others who use the river.*)
- If a river's water did reach the marsh, what factor(s) allowed for that to happen? (*Answers may include that the introduction of a meaningful price for the water made consumers more cautious about how much water they consumed.*)
- In which round was the most value generated for society? Why? (*Round 4, with the pricing of water: Consumers used water after comparing how much they valued it with what the cost was. This reduced waste.*)
- Why do economists recommend pricing as a means of allocating scarce natural resources? (*Pricing provides a uniform basis for consumers to measure costs versus benefits received from a resource. This allows for each consumer to accurately gauge the value he or she receives from each unit. It also establishes parameters on marginal utility received.*)
- What factors were behind the varying benefits consumers received from the purchase of water? (*Answers may include diminishing marginal utility existed after a certain amount of water was consumed, as was the case for residents; excessive fracking produced a surplus of product, reducing its profitability; data storage and power plants offered unique products and had sustained utility at higher output levels; or agriculture increased its revenue by producing less thirsty crops.*)
- What additional changes could consumers of the Colorado River water implement if they wanted to sustain its flow into the sea? Why might they decide do so? (*Answers may include homeowners could eliminate their lawns; data storage centers could turn to air cooling systems; or fracking could be changed to more renewable energy sources to eliminate its viability. Under a pricing system, these steps might be taken to avoid using precious and costly water.*)

Assessment

43. Distribute a copy of *Handout 1-3: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice

1. When consumers of river water are unaware of the price demanded for the commodity, which system of allocation is used to distribute water?
   a. Need
   b. Achievement based
   c. First come, first served
   d. Rationing
2. Why does putting a price on water drawn from the Colorado River result in a more conducive allocation of the commodity?
   a. It provides for a reliable supply of water each year.
   b. It aligns self-interest with efficiency when satisfying consumer demand.
   c. It allows for each consumer to always take as much water as they want.
   d. It validates the 1922 agreement as the best system for distributing water in the western United States.
3. How could the water crisis in the western United States be best described?
   a. The 1922 agreement is regularly violated, creating unpredictable shortages of water for consumers.
   b. The federal government is consuming most of the water to maintain federal lands.
   c. The problem is temporary and will be solved when normal quantities of rain return.
   d. Not enough value is placed on the water, and it is increasingly over-subscribed by the growing number of consumers.

Short Answer

4. In times when gasoline is in short supply (for instance, in periods before and after a hurricane), is it best policy for a government to cap the price of gasoline to make it affordable for every consumer? Why or why not?

   No, because people will likely hoard gasoline and take more than they will actually use, making it difficult for late-arriving consumers to acquire any. By allowing the price to reflect the shortage, people will make better decisions about how much they consume, making it possible for more people to have access.

Handout 1-1A: The Valuation of Water in the Colorado River Simulation

As an economist, you are to estimate the total value generated by the water that flows down the Colorado River. You will observe the water usage in each round of the simulation. You will record the usage in 8-oz. units, which is equal to half the 16-oz. cups used in the simulation. For example, if the power plant fills its cup halfway, it is one unit. If it fills it to the top, it is two units. Circle the appropriate number. Do not circle any numbers if water is not used. You will then calculate the total value of the water usage with the values listed below. For example, if the power plant fills its cup to the top and the rest of the entities fill their cups halfway, then the total value, with the power plant in parenthesis, would be:

($150 + $50) + $115 + $75 + $75 + $135 + $100 = $700

	Value of first 8 oz.	Value of second 8 oz.	Round 1 quantity	Round 2 quantity	Round 3 quantity	Round 4 quantity	Round 5 quantity
Power plant	$150	$50	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Fracking	$115	$60	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Agriculture	$75	$25	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Residential	$75	$10	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Data storage	$135	$100	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2
Marsh	$100	$25	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2

Round 1 total value: _____

Round 2 total value: _____

Round 3 total value: _____

Round 4 total value: _____

Round 5 total value: _____

Handout 1-1B: Value Slips for River Simulation

POWER PLANT	Value of first 8 oz.	Value of second 8 oz.
	$150	$50
FRACKING	Value of first 8 oz.	Value of second 8 oz.
	$115	$60
AGRICULTURE	Value of first 8 oz.	Value of second 8 oz.
	$75	$25
RESIDENTIAL	Value of first 8 oz.	Value of second 8 oz.
	$75	$10
DATA STORAGE	Value of first 8 oz.	Value of second 8 oz.
	$135	$100
POWER PLANT	Value of first 8 oz.	Value of second 8 oz.
	$150	$50
FRACKING	Value of first 8 oz.	Value of second 8 oz.
	$115	$60
AGRICULTURE	Value of first 8 oz.	Value of second 8 oz.
	$75	$25
RESIDENTIAL	Value of first 8 oz.	Value of second 8 oz.
	$75	$10
DATA STORAGE	Value of first 8 oz.	Value of second 8 oz.
	$135	$100

Handout 1-2: Pricing the Colorado River System (page 1 of 2)

There are 10 market changes listed below. Each one will result in the shift of a curve and the formation of a new equilibrium price and quantity.

The following page has 10 supply and demand diagrams with numbers that correspond to the 10 market changes.

After reading each market change, illustrate its consequences on the accompanying diagram by shifting the appropriate curve (using up or down arrows) to describe the changes to market price and quantity.

1. Residential development expands rapidly in Las Vegas as the economy strengthens.

2. Data storage centers begin experiments with air cooling systems to relieve their mega-server complexes.

3. A dry winter translates to a disappointing snow melt in the spring.

4. The world price of oil spikes, leading to a number of new fracking operations opening.

5. The U.S. Forest Service fences off several water sources to protect endangered thistle.

6. The lining of a diversion canal in central Arizona has been compromised, and significant quantities of water have been lost.

7. Homeowners in southern California are responding eagerly to a lawn buyback program.

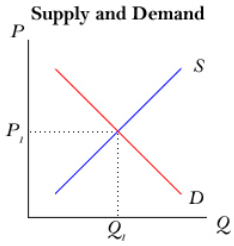
8. The federal government orders a reallocation of river water to both basins, reducing the annual drawdown from 7.5 million acre-feet to 7.05 million acre-feet.

9. New hotels are constructed at an unprecedented rate on the Las Vegas Strip.

10. A 16-year drought officially ends after two very extensive monsoon seasons.

Handout 1-2: Pricing the Colorado River System (page 2 of 2)

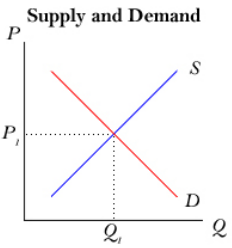
1. Las Vegas



Price _____

Quantity _____

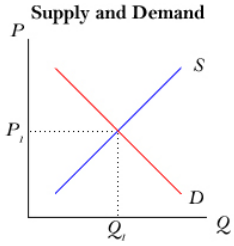
6. Diverson canal



Price _____

Quantity _____

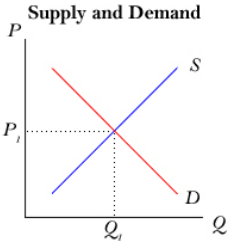
2. Data storage centers



Price _____

Quantity _____

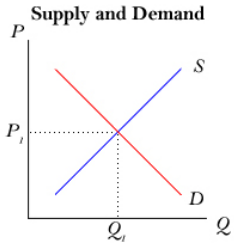
7. Lawn buyback



Price _____

Quantity _____

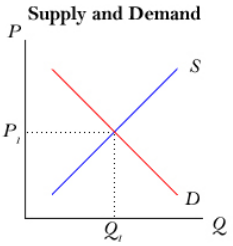
3. Dry winter



Price _____

Quantity _____

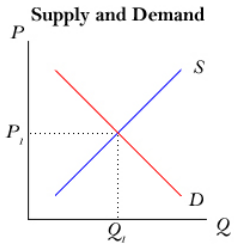
8. Reallocation



Price _____

Quantity _____

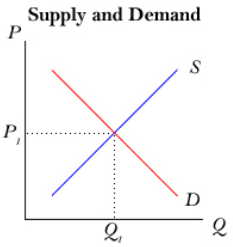
4. Price of oil



Price _____

Quantity _____

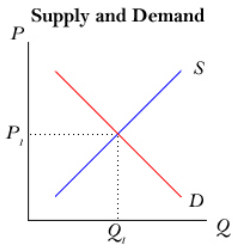
9. New hotels



Price _____

Quantity _____

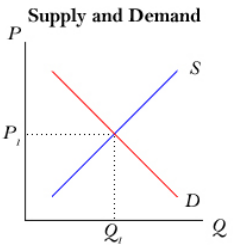
5. Endangered thistle



Price _____

Quantity _____

10. Monsoon season



Price _____

Quantity _____

Handout 1-3: Assessment

Multiple Choice

Select the best answer for each of the following questions.

1. When consumers of river water are unaware of the price demanded for the commodity, which system of allocation is used to distribute water?
   a. Need
   b. Achievement based
   c. First come, first served
   d. Rationing
2. Why does putting a price on water drawn from the Colorado River result in a more conducive allocation of the commodity?
   a. It provides for a reliable supply of water each year.
   b. It aligns self-interest with efficiency when satisfying consumer demand.
   c. It allows for each consumer to always take as much water as they want.
   d. It validates the 1922 agreement as the best system for distributing water in the western United States.
3. How could the water crisis in the western United States be best described?
   a. The 1922 agreement is regularly violated, creating unpredictable shortages of water for consumers.
   b. The federal government is consuming most of the water to maintain federal lands.
   c. The problem is temporary and will be solved when normal quantities of rain return.
   d. Not enough value is placed on the water, and it is increasingly over-subscribed by the growing number of consumers.

Short Answer

Write a response to the following prompt using complete sentences and correct grammar and punctuation.

4. In times when gasoline is in short supply (for instance, in periods before and after a hurricane), is it best policy for a government to cap the price of gasoline to make it affordable for every consumer? Why or why not?

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 3: Allocation

Different methods can be used to allocate goods and services. People acting individually or collectively must choose which methods to use to allocate different kinds of goods and services.

- **Benchmark: Grade 12**

    1. Comparing the benefits and costs of different allocation methods in order to choose the method that is most appropriate for some specific problem can result in more effective allocations and a more effective overall allocation system.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

- **Benchmark: Grade 12**

    1. Acting as consumers, producers, workers, savers, investors, and citizens, people respond to incentives in order to allocate their scarce resources in ways that provide them the highest possible net benefits.

Standard 8: Role of Prices

Prices send signals and provide incentives to buyers and sellers. When supply or demand changes, market prices adjust, affecting incentives.

- **Benchmark: Grade 12**

    3. Changes in supply or demand cause relative prices to change; in turn, buyers and sellers adjust their purchase and sales decisions.

Lesson 2:
Property Rights

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Standards and Benchmarks (see page 2.14)

Lesson Description

This lesson demonstrates the Coase theorem, which suggests that if bargaining can be done with low costs, then resources will be allocated in an efficient manner. In the activity, a household and a business sit on a shared lake. The two must decide whether the business will be able to pollute the lake, which imposes an external cost on the household. The lesson shows that ownership of the lake has no impact on whether the lake gets polluted, although ownership of the lake means potential gains for the owner.

Grade Level

High School

Concepts

Coase theorem

Negative externality

Property rights

Objectives

Students will be able to

- define Coase theorem, negative externality, and property rights;
- describe the effects of a change in ownership of environmental resources; and
- explain why environmental solutions are often difficult to negotiate.

Compelling Question

Does it matter who owns resources?

Time Required

45 minutes

Materials

- PowerPoint Slides 2.1-2.3
- Handout 2-1, one copy folded in half for each pair of students
- Handout 2-2, one copy cut in half for each pair of students
- Handout 2-3A, one copy cut in half for each pair of students in half of the class
- Handout 2-3B, one copy cut in half for each pair of students in the other half of the class
- Handout 2-4, one copy for each student

Introduction

Economists advocate for the use of market-based incentives to decide whether businesses can use a natural resource like a lake or the air to dispose of waste. The Coase theorem suggests that if a business can negotiate with people, such as those who live on a lake, then the parties can fix the problem of externalities in an efficient way. In other words, if the benefits of using a lake for waste disposal exceed the costs of doing so, the business will be allowed to pollute the lake. In addition, it should not matter who controls (or owns) the lake. If the business owns the lake, it can do as it likes with the lake. It will use the lake for disposal unless households pay the business to refrain from doing so. But if households control the lake, then the business can still use the lake for waste disposal by paying the households for the right to do so. The point is that with bargaining, the lake will be used to do whatever is valued most by society. The only difference that occurs when the property is assigned to one group or another is with the income; the owner of the property is wealthier because of the ownership. The lesson can be generalized to other market-based systems. For example, in a tradeable permit system used to control pollution, the ultimate result—how much pollution and by whom—is not in doubt; differences in allocation only impact the wealth of the businesses who receive permits, not the amount of pollution.

Procedure

1. Display Slide 2.2. Ask the students to speculate on why an environmental group would sell its land to a logging company. (*Answers will vary.*)

2. Tell the students you will conduct a short simulation to demonstrate the effects of property ownership on the use of a resource. Group the students into pairs. Put a folded copy of

Handout 2-1: Clean or Dirty between each pair. Tell the students they will determine if the lake should be clean or dirty. Demonstrate the difference by flipping the sheet from one side to the other. Tell the students that the lake will begin each round as clean—so flip Handout 2-1 so that the clean side faces up.

3. Display Slide 2.3. Explain that the student in each pair who is seated to the left will represent the business. The other student will represent the household. Both the business and the household are located next to the same lake. No one in the household works for the business.

4. Distribute a cut-apart copy of *Handout 2-2: Transaction Sheets* to each pair of students. The business sheets should be handed to the students representing the business. The household sheets should be handed to the students representing the household. Tell the students they will be using the transaction sheets to keep track of the finances for their business or household. Explain that they start with a certain level of wealth or assets and that that level will be affected by any payments made or received, as well as by whether the lake is clean or dirty.

5. Distribute a cut-apart copy of *Handout 2-3A: Business and Household* to each pair of students in half of the class. Distribute a cut-apart copy of *Handout 2-3B: Business and Household* to each pair of students in the other half of the class. (NOTE: Versions A and B are different. To keep easy track of the two versions, distribute version A to one side of the class and version B to the other side.) The business sheets should be handed to the students representing the business. The household sheets should be handed to the students representing the household. Tell the students to review their information without immediately sharing their information with their partner. Discuss the following to remind them of the incentives for each role:

    - Ask the business students why they would like to pollute the lake. (*They would save money by doing so.*)
    - Ask the household students why they would like the lake to remain clean. (*Their homes would have more value.*)

6. Tell the students they will now try to decide whether the lake will remain clean or be polluted. Explain that they will be playing two rounds in this activity. In the first round, the households will control the fate of the lake, but everything is up for negotiation. If the business can persuade the household, monetarily, to allow pollution, then the lake can be polluted. Explain the following:

    - The students can make payments using an electronic funds transfer (EFT) form on the bottom of Handouts 2-3A and 2-3B. They just fill in the amounts, fold along the dotted line, and tear off a sheet to give it as payment after entering the payment on their transaction sheets. The person receiving the EFT should note the amount on their transaction sheet and keep the EFT form as a receipt.

- When the round begins, the students should negotiate to see what will become of the lake. Note that in some cases, a deal might not be possible. After they have made any agreements, the households should flip their sheets to reveal what happened.
- Instruct the students to begin round one of negotiations. After a few minutes, call time. Tell the students to make sure their transaction sheets are filled out in their entirety. Remind the students who are households to take their initial wealth, subtract any payments, add any receipts, and then subtract the environmental adjustment (if any) based on what happened to the lake. Remind the students who are businesses to take their total assets, subtract any payments, add any receipts, and then add the environmental adjustment (if any) based on what happened to the lake.

7. Tell the students they will conduct round two. Explain that this round will begin exactly like the last, except now the businesses will determine what happens to the lake. Explain that because the businesses would like to pollute the lake, the students should turn the "dirty lake" side of Handout 2-1 face up. Again, payments may be made via EFT between the households and businesses that may cause the lake to go from dirty to clean. Note again that in some cases, a deal might not be possible. After they have made any agreements, the businesses should flip their sheets to reveal what happened.

8. Instruct the students to begin round two of negotiations. After a few minutes, call time. Tell the students to make sure their transaction sheets are filled out in their entirety. Remind the students who are households to take their initial wealth, subtract any payments, add any receipts, and then subtract the environmental adjustment (if any) based on what happened to the lake. Remind the students who are businesses to take their total assets, subtract any payments, add any receipts, and then add the environmental adjustment (if any) based on what happened to the lake.

9. After completing both rounds of the activity, discuss the following:
   - In the first round, when households controlled the lake, did anyone make payments? What did you pay and why? (*For those with version A, the business savings would be $60 dollars and the household cost would be only $20 to have a dirty lake. This difference meant there was an opportunity for the business to pay the household to pollute the lake. The exact amount—between $20 and $60—would depend on negotiations. For those with version B, the business savings would be only $20, which was lower than the household cost of $60, so no payment would be made.*)
   - Ask those businesses and households who made a payment if the payment made them better off. (*Yes, if they negotiated a price between $20 and $60.*)
   - In the second round, when businesses controlled the lake, did anyone make payments? What did you pay and why? (*For those with version B, the household savings would be $60 dollars and the business cost would be only $20 to have a clean lake. This difference*

meant an opportunity for the household to pay the business between $20 and $60. For those with version A, the business savings would be $60, which was higher than the household cost of $20, so no payment would be made.)

- Ask those businesses and households who made a payment if the payment made them better off. (*Yes, if they negotiated a price between $20 and $60.*)
- Ask those with version A to reveal what the business cost of cleaning up was. (*$60*) Ask the households what it was worth for them to have a clean lake. (*$20*) Ask the class if, based on that information, it's best to have the lake dirty or clean. (*Since the cost of cleaning up is $60 and the value of a clean lake is only $20, the lake should end up dirty.*)
- Ask those with version A, comparing round one with round two, did the lake remain clean or dirty? (*In both rounds, the lake should have been dirty.*) Did the lake being clean or dirty depend on who owned the lake? (*No*)
- Ask those with version B to reveal what the business cost of cleaning up was. (*$20*) Ask the households what it was worth for them to have a clean lake. (*$60*) Ask the class if, based on that information, it's best to have the lake dirty or clean. (*Since the cost of cleaning up is only $20 and the value of a clean lake is $60, the lake should end up clean.*)
- Ask those with version B, comparing round one with round two, did the lake remain clean or dirty? (*In both rounds, the lake should have been clean.*) Did the lake being clean or dirty depend on who owned the lake? (*No*)

10. Explain that a **negative externality** is a negative side effect that results when the production or consumption of a good or service affects the welfare of people who are not the parties directly involved in a market exchange. Ask what the externality was in this simulation. (*If the business polluted the lake, a cost was imposed on the household.*)

11. Explain that the **Coase theorem** says that externalities can be resolved efficiently if the parties can negotiate with low bargaining costs and that the result does not depend on who has **property rights** (legal ownership of something with economic value). Discuss the following:
    - Ask the students with version A what the efficient use of the lake was. (*To be used for pollution—a dirty lake*) Ask them if a dirty lake was the result in both rounds. (*Yes*)
    - Ask the students with version B what the efficient use of the lake was. (*To remain clean*) Ask them if a clean lake was the result in both rounds. (*Yes*)
    - Ask the students if anyone had different results. (*In general, a number of things may affect the results. One is misunderstanding of the rules. In this case, clarify how things were supposed to work. Two, some students will object to any pollution from a moral standpoint, and so will not base their decisions on the costs and benefits as presented in the simulation. In this case, note that people do not always use purely economic incentives when making their decisions, or, looking at it in another way, their moral beliefs increase the benefits of a clean lake in their decisionmaking process.*)

Closure

12. Explain that one takeaway from this lesson is that property rights do not matter in terms of what happens to the lake when the market can operate easily. In both rounds, the lake remained either clean or dirty regardless of who had ownership or control of the lake. Discuss the following:
    - Ask the students who represented businesses if they did better when they controlled the lake. (*Yes, because they never had to make payments and may have received payments.*)
    - Ask the students who represented households if they did better when they controlled the lake. (*Yes, because they never had to make payments and may have received payments.*)

13. Point out that while ownership of the lake does not determine what happens to the lake, it does affect the distribution of wealth/assets in the economy. If someone owns the property, they will be wealthier or richer.

14. Explain that the Coase theorem requires that people have the ability to easily buy and sell access to the lake. Ask the students to imagine a case where one business polluted the air over an area containing 100,000 households (such as in a city). Would it be easy for the business to negotiate with 100,000 households? (*No*) Note that in these cases, there is a role for government to provide rules for polluting the air or to establish a market-based system for deciding how much air pollution should be allowed.

15. Explain that a market-based system used to control pollution is one where a permit is needed to pollute the air. For each unit of pollution, one permit is needed. Discuss the following:
    - Think about what you learned about the lake and decide if it would matter who was given permits to pollute—businesses or households—in terms of how much the air would be polluted. (*No, the result should be the same.*)
    - Would it matter in terms of wealth or assets? (*Yes, the person who gets a permit would get something of value.*)
    - Who do you think should be given the permits—households or businesses? (*Answers will vary, but many people tend toward "the polluter should pay" opinion; it is the action of the business causing the harm, so the business should pay.*)

Assessment

16. Distribute a copy of *Handout 2-4: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice

1. A business can save $100,000 a year if it is not required to reduce the noise levels caused by its factory. However, a city ordinance does not allow the noise unless affected homeowners agree to allow it. Ten homes are close enough to be affected by the noise. The business estimates that soundproofing the homes would cost $5,000 a home. If the business can easily bargain with the homeowners, it is likely that
   a. the homeowners will refuse to allow the business to emit noise.
   b. individual homeowners will accept between $0 and $4,999 to allow the noise.
   c. individual homeowners will accept between $5,000 and $10,000 to allow the noise.
   d. the business will charge the homeowners between $5,000 and $10,000 to reduce the noise.
2. If a polluter and those affected by the pollution can bargain over the impact of pollution and if property rights over the polluted resource are well defined, then it _____ matter who has the property rights for the resource in terms of the amount of pollution that will occur. Who has the property rights _____ affect the distribution of wealth.
   a. does; does
   b. does; does not
   c. does not; does
   d. does not; does not

Short Answer

3. One method of controlling air pollution is to issue tradeable permits. With a permit system, a business must have a permit to pollute (say, for example, one ton of pollution). An issue that arises is how to allocate the permits. Sometimes, at first, the government owns the permits and auctions them to businesses. In other cases, businesses are given permits for no monetary cost. In each case, permits are fully tradeable among businesses. Based on the simulation in class, do you think it will make any difference how the permits are distributed? Explain your answer.

   The distribution of permits will not matter in terms of which firms will end up with the permits and therefore do the most polluting. The firms that want to pollute the most (in terms of willingness to pay) will be the ones who receive the permits. However, who gets the permits will affect the wealth of the firms. A firm that is given a permit is given something of value, and so it is better off than having to buy a permit at auction.

Extension

17. Tell the students that another market-based system to controlling pollution is to require a payment (emissions tax) from businesses to pollute the environment. Yet another market-based system would be to pay (subsidize) businesses not to pollute the environment. Note that a tax implicitly gives the property rights to the government (representing households) and that a subsidy implicitly gives the property rights to the businesses. Discuss the following:
    - Will it matter if a tax or subsidy is used to control pollution? Why or why not? (*No, based on the fact that property rights do not matter.*)
    - Does it matter in terms of the distribution of wealth or assets? Why or why not? (*Yes, a tax costs businesses and helps households. A subsidy helps businesses and costs households through government payments.*)

18. Behavioral economics suggests that people become attached to things they have and are less likely to give them up. How might this affect the results of the lake activity? (*When households have control over the lake, they may be less inclined to give up ownership of the lake. This means that businesses may not be able to easily buy access to the lake.*)

Handout 2-1: Clean or Dirty

Clean

Dirty

Handout 2-2: Transaction Sheets

Transaction sheet for households						
Round	**Beginning wealth**	**Payment to business**	**Receipt from business**	**Wealth after transactions**	**Environmental impact: Home value**	**Final end of round wealth**
1	$100	–	+	=	–	=
2	$100	–	+	=	–	=

Transaction sheet for businesses						
Round	**Beginning total assets**	**Payment to household**	**Receipt from household**	**Assets after transactions**	**Environmental impact: Savings if lake can be polluted**	**Final end of round assets**
1	$100	–	+	=	–	=
2	$100	–	+	=	–	=

Handout 2-3A: Business and Household

"A" Business

You represent the CEO of Alpha Business. Your company needs to dispose of waste materials. If you are allowed to put the waste material in the nearby lake, you will save the following:

$ 60

This means you will add this amount to your wealth under the category "environmental impact" if you can dispose of the waste.

EFT form:

Alpha Company transfers $_____ to _____.

EFT form:

Alpha Company transfers $_____ to _____.

"A" Household

You represent the Avanti household. You do not like the fact that firms put trash in the lake near you. If trash appears in the nearby lake, you will see your wealth—in terms of value of your home—decrease by the following:

$ 20

This means you will subtract this amount from your wealth under the category "environmental impact" if the waste is disposed of into the lake.

EFT form:

Avanti Family transfers $_____ to _____.

EFT form:

Avanti Family transfers $_____ to _____.

Handout 2-3B: Business and Household

"B" Business

You represent the CEO of Beta Business. Your company needs to dispose of waste materials. If you are allowed to put the waste material in the nearby lake, you will save the following:

$ 20

This means you will add this amount to your wealth under the category "environmental impact" if you can dispose of the waste.

EFT form:

Beta Company transfers $_____ to _____.

EFT form:

Beta Company transfers $_____ to _____.

"B" Household

You represent the Boss household. You do not like the fact that firms put trash in the lake near you. If trash appears in the nearby lake, you will see your wealth—in terms of value of your home—decrease by the following:

$ 60

This means you will subtract this amount from your wealth under the category "environmental impact" if the waste is disposed of into the lake.

EFT form:

Boss Family transfers $_____ to _____.

EFT form:

Boss Family transfers $_____ to _____.

Handout 2-4: Assessment

Multiple Choice

Select the best answer for each of the following questions.

1. A business can save $100,000 a year if it is not required to reduce the noise levels caused by its factory. However, a city ordinance does not allow the noise unless affected homeowners agree to allow it. Ten homes are close enough to be affected by the noise. The business estimates that soundproofing the homes would cost $5,000 a home. If the business can easily bargain with the homeowners, it is likely that
   a. the homeowners will refuse to allow the business to emit noise.
   b. individual homeowners will accept between $0 and $4,999 to allow the noise.
   c. individual homeowners will accept between $5,000 and $10,000 to allow the noise.
   d. the business will charge the homeowners between $5,000 and $10,000 to reduce the noise.

2. If a polluter and those affected by the pollution can bargain over the impact of pollution and if property rights over the polluted resource are well defined, then it _____ matter who has the property rights for the resource in terms of the amount of pollution that will occur. Who has the property rights _____ affect the distribution of wealth.
   a. does; does
   b. does; does not
   c. does not; does
   d. does not; does not

Short Answer

Read the scenario below and provide a written answer using complete sentences and correct grammar and punctuation.

One method of controlling air pollution is to issue tradeable permits. With a permit system, a business must have a permit to pollute (say, for example, one ton of pollution). An issue that arises is how to allocate the permits. Sometimes, at first, the government owns the permits and auctions them to businesses. In other cases, businesses are given permits for no monetary cost. In each case, permits are fully tradeable among businesses. Based on the simulation in class, do you think it will make any difference how the permits are distributed? Explain your answer.

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 16: Role of Government and Market Failure

There is an economic role for government in a market economy whenever the benefits of a government policy outweigh its costs. Governments often provide for national defense, address environmental concerns, define and protect property rights, and attempt to make markets more competitive. Most government policies also have direct or indirect effects on peoples' incomes.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

Common Core State Standards

CCSS.ELA-Literacy.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Lesson 3:
Marginal Analysis: How Clean Is Clean Enough?

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Standards and Benchmarks (see page 3.12)

Lesson Description

In this lesson, students participate in a short carpet-cleaning demonstration to illustrate that the marginal cost of cleaning something increases as more and more is cleaned. After thinking about the damage associated with pollution, students then decide what factors determine how clean the environment should be.

Grade Level

High School

Concepts

Marginal cost

Pollution

Objectives

Students will be able to

- describe why the marginal cost of cleaning up pollution (or preventing pollution) increases as more pollution is cleaned up (prevented), and
- decide how much should be cleaned up based on characteristics of the pollution and the costs of cleaning up the pollution.

Compelling Question

Should businesses be required to not pollute at all when they produce their products?

Time Required

45 minutes

Materials

- PowerPoint Slides 3.1-3.6
- Handout 3-1, one copy for each student (optional)
- Handout 3-2, one copy for each student
- Two small carpet samples (about 2' x 2' each)
- Six 4-oz cups with lids, each filled with debris (see Preparation section)
- Paper towels
- Dry black or navy beans
- Small bits of paper (such as from a hole punch)
- Glitter

Preparation

- Before the start of class, set out the two small carpet samples and six small cups of debris as described below. Place the rugs so that students see them as they enter the classroom.
- Divide the six cups into two sets of three. Each set of three cups should be filled with the following: 1) a paper towel balled up as trash; 2) dry black or navy beans; and 3) small bits of paper with a bit of glitter mixed in. (NOTE: While the ingredients are initially distributed as described above, it is not required that the ingredients stay in separate cups. The ingredients will get mixed together during the activity, but each cup should be filled to the top and sealed with a lid. This makes it easier if the simulation is being done for multiple classes.)

Introduction

Economics teaches that decisions are made by comparing the marginal benefits to the marginal costs of an action. This also applies to the environment. While a pristine environment has some benefits, the marginal cost of keeping an environment that clean tends to be very high. In general, the cleaner the environment, the higher the marginal cost of cleaning the environment. Although, the marginal benefit of going from a clean environment to one that is pristine is not very high. So if we compare marginal costs to marginal benefits, the best decision usually isn't to have a pristine environment. Conversely, if there is a highly polluted environment, the marginal benefit of some clean up is high, while the marginal cost of cleaning up the worst of the pollution is low. This implies that no pollution control at all is not the best decision for society, either. As with most decisions, the best level of pollution lies between the two extremes.

Procedure

1. Display Slide 3.2. Ask how many students agree with statement #1 and how many agree with statement #2. Invite a few students to explain their answers. (*Answers will vary.*)

2. Tell the students you will conduct a classroom experiment involving cleaning up pollution in the environment. Ask for four student volunteers and group them into two teams of two students. Have the two teams come to the front of the class and stand in front of the two carpets. Explain the following:

    - The rugs each represent waste materials that flow into a lake. Explain that a factory emits this pollution, a substance that harms the environment, into the lakes when producing its product. Take out the cups of debris. Dump three cups (one of each type of debris) onto each of the two carpets. Spread the debris around the carpet.
    - Tell the two teams they are to clean the dirty rugs (pollution) before the pollution flows into nearby lakes. Explain that they will have three rounds to clean the carpets. For each round, their goal will be to pick up the trash and deposit it into one of the cups as fast as possible. A round will conclude when each team has filled and put the lid on one of their cups. The team who fills a cup the fastest will win the round. To make the experiment work, tell the students they cannot simply pick up the rug and pour the trash into the cup. Also, they cannot use pieces of trash to sweep away, collect, or pick up other pieces of trash. They are to use only their hands to pick up the trash.
    - Appoint a student with a watch that shows seconds or a cell phone with a stopwatch feature as timekeeper. Tell him or her to time each round carefully from when you say start until one of the teams fills a cup. Have the rest of the class sit or stand so they can observe the cleanup.

3. Tell the students to get ready to begin the first round. Remind the two teams that they are in a race and that the first team who fills a cup with debris and covers it with the lid wins the round. The round is over when both teams have completed the task. When the students are ready, begin the round. (NOTE: This round is won quickly by putting a paper towel back into the first cup and sealing the lid.) When the round is finished, ask the timekeeper for the winning time and record it on the board.

4. Repeat the race for two more rounds, reminding the timekeeper to keep careful time. End each round when both teams have each filled and put the lid on a cup. Be sure to record the winning times on the board. For the last cup, you can call time when the cup looks full, even if a bit of glitter remains on the carpet. (NOTE: The second round will go slower than the first because it will take the two teams more time to fill a second cup. The cup will be filled primarily with the beans and some paper bits. The third round will take the longest because the remaining paper bits take a while to pick up.)

5. After the third round, ask the students if the rug is perfectly clean. (*Eagle-eyed students will note the presence of some glitter in the carpet.*) Ask the students how long it would take to clean the final bits of glitter. (*A long time*) Point out that to clean the waste to keep the nearby lake in its original pristine state is very costly in terms of time and effort. Thank the student volunteers for participating and have them sit in their usual places.

6. Project Slide 3.3 or draw the following table on the board and fill in the three winning times (one for each round). The italicized numbers in columns 3 and 4 should be from your time-keeper—the following are examples:

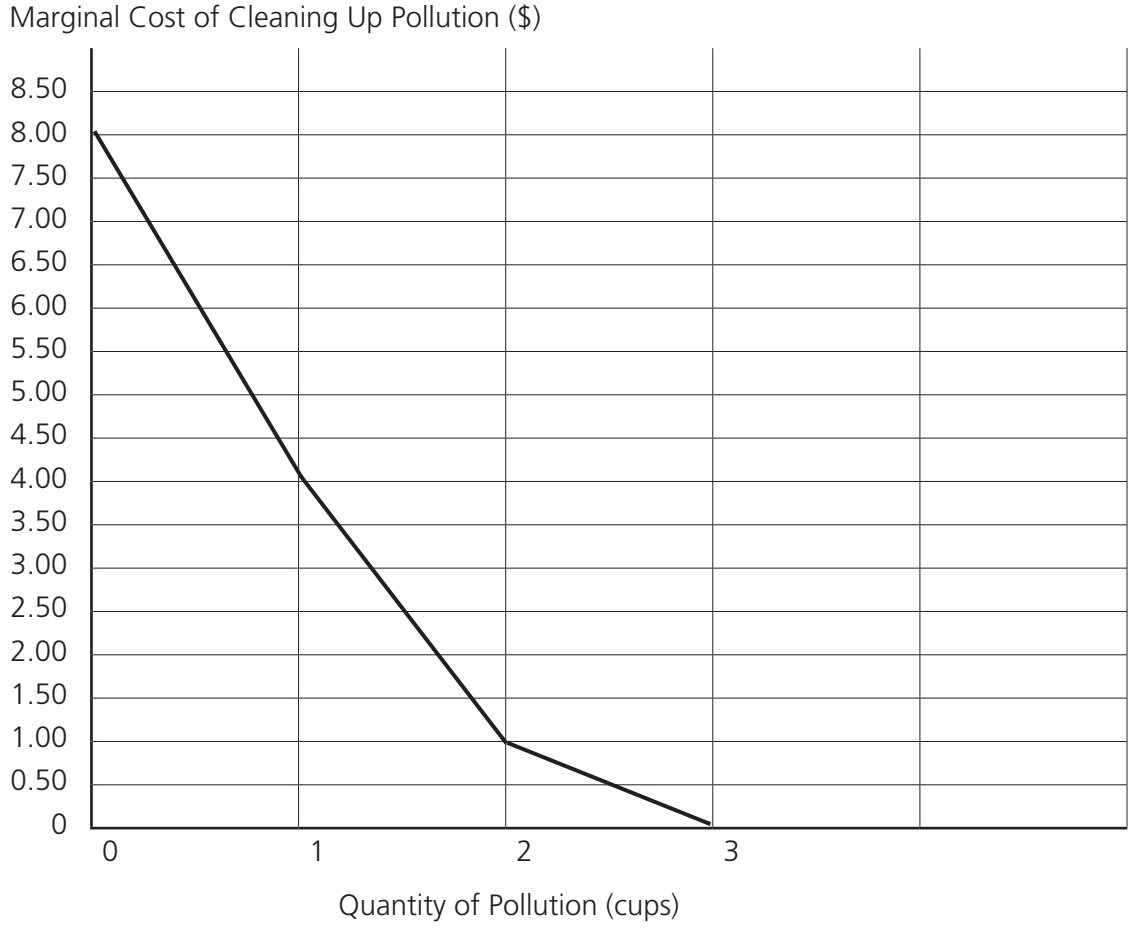
Pollution cleaned (debris in cups)	Pollution in environment (debris from cups)	Time in seconds	Marginal cost ($360 per hour per person = $0.20 per second for both)
0	3	*0*	$0
1	2	*5*	*$1*
2	1	*20*	*$4*
3	0	*40*	*$8*

7. Explain that the table shows the pollution cleaned (debris in cups), the pollution left to flow into the lake (left on the rug), the time it took to clean up the debris, and the marginal cost of the cleanup for each cup. Tell the students that marginal in economics means additional, so the marginal cost is how much it costs to clean up an additional cup of pollution.

8. Explain that the cost is calculated at $360 per hour for each worker. This means that it is $720 per hour for the two workers on a team. This is equivalent to $12 a minute, or $0.20 a second for both workers. Explain that while this is a high estimate for their labor, cleaning up pollution requires labor, materials, and machine rental, so this cost includes the cost of all these items needed for pollution control. Discuss the following:
   - What happens to the marginal cost of cleanup as more pollution is cleaned up? (*The marginal cost increases.*)
   - Why does the marginal cost increase? (*The first cup of pollution was easy to clean, but more time was needed to clean up the tinier pieces of debris.*)
   - How long would it take to remove every small piece of remaining glitter? (*Accept any answer above the last cup's time, but it might take around 2 minutes.*) Note to the students that the marginal cost of the last small bit would be very high.

9. Optional graphing activity: Distribute a copy of *Handout 3-1: Graphing the Costs of Cleaning Up Pollution* to each student. Have the students graph the quantity of pollution and the marginal cost of cleaning up pollution. An example is graphed below and on Slide 3.4. Ask

the students why the line rises toward the left axis as less pollution is left in the environment. (*The marginal cost of cleaning up increases as more pollution is cleaned up.*)



10. Tell the students to try to imagine the decisionmaking process of a business that pollutes. Discuss the following:
    - How much pollution would a business clean up if they were not required to do so? (*The students should answer none, although some may suggest that a business might clean up some pollution as a matter of goodwill toward the community.*)
    - Why would businesses hesitate to clean up all of the pollution? (*The marginal cost of cleaning every last bit of pollution is extremely high.*)
    - Why are businesses willing to pay to be able to pollute? (*They save the cost of having to clean up the pollution.*)

11. Explain to the students that economists define the **demand** for something as the quantity of a good or service that buyers are willing and able to buy at all possible prices during a certain

time period. Typically, at higher prices people are willing and able to buy smaller quantities, and at lower prices they are willing and able to by larger quantities.

12. Tell the students they are now going to use the data from the rug-cleaning example to determine the demand for pollution by the business. Remind the students that a business will clean up pollution if it is cheaper to clean it up than emit the pollution into the environment. Draw two columns on the board. Label the first column "Price" and the second column "Quantity of Pollution Demanded." Discuss the following:

    - If the price the business must pay to leave pollution on the rug is $8 (or use the highest cost in your simulation), how many cups would the business decide to clean up? (*It would clean up all three cups because the cost of cleaning up is equal to or less than $8—$1 for the first cup, $4 for the second cup, and $8 for the third cup in this example.*) How many units of pollution would the business emit or leave on the rug? (*It would leave 0 cups.*) Write $8 under Price and 0 cups under Quantity of Pollution Demanded.
    - If the price the business must pay to leave pollution on the rug is $4 (or use the second highest cost in your simulation), how many cups would the business decide to clean up? (*It would clean up two cups—$1 for the first cup and $4 for the second cup in this example.*) How many units of pollution would the business emit? (*It would emit one unit or cup; since the cost to clean up a third cup is $8, the business would pay $4 to leave the remaining pollution on the rug.*) Write $4 under Price and 1 cup under Quantity of Pollution Demanded.
    - If the price the business must pay to leave pollution on the rug is $1 (or use the lowest cost in your simulation), how many cups would the business decide to clean up? (*It would clean up one cup—$1 for the first cup in this example.*) How many units of pollution would the business emit? (*It would emit two units; since the costs to clean up the second and third cups are $4 and $8, respectively, the business would leave these units on the rug.*) Write $1 under Price and 2 cups under Quantity of Pollution Demanded.
    - If the price the business must pay to leave pollution on the rug is $0 or free, how many cups would the business decide to clean up? (*It would clean up 0 cups.*) How many units of pollution would the business emit? (*It would emit three units; since the costs to clean up the first, second, and third cups are $1, $4, and $8, respectively, the business would leave these units on the rug.*) Write $0 under price and 3 cups under Quantity of Pollution Demanded. The demand should look like the following:

Price	Quantity of Pollution Demanded
$8	0 cups
$4	1 cup
$1	2 cups
$0	3 cups

- Does the demand for pollution "look like" a typical demand curve where the price and quantity demanded move in opposite directions? (*Yes, it is downward sloping.*)
- Have the students compare the demand for pollution to the table. Are there similarities? (*Yes, students should note that the marginal cost column and quantity of pollution column are the same.*)

13. Tell the students that because businesses compare the price of polluting to the marginal cost of cleaning up pollution, the marginal cost of pollution is essentially the demand curve for pollution. If the marginal cost of cleaning up a unit of pollution is less than or equal to the price a business pays to be able to pollute, the business will clean up that unit. If the marginal cost of cleaning up a unit of pollution is more than the price a business pays to be able to pollute, the business will not clean up that unit. Tell the students the main takeaway from this activity is that the demand for pollution is based on the marginal cost of cleaning up pollution. If the marginal cost of cleaning up pollution increases (maybe because the firm is expanding its production), then the demand for pollution increases. If the marginal cost of cleaning up decreases (maybe because of better pollution control technology), then the demand for pollution decreases.

14. Explain that pollution causes damage to the environment. Ask the students to speculate what happens to the marginal—or additional—damage caused by another unit of pollution as more pollution is put into the environment. (*The students will guess, hopefully, that the marginal damage increases.*) Discuss the following:
    - What is the "best" amount of pollution for society? (*Answers will vary. Some students may say none and others may say some should be allowed.*)
    - Why, based on the demonstration, is "perfectly clean" probably not the best option? (*Students may note the high costs for the business to clean up the pollution.*)
    - Why is letting businesses pollute all they would like not the best option? (*Students may note that the damage caused by pollution is extremely high.*)
    - What is the "best" amount of pollution for society? (*Answers will vary but may be somewhere between perfectly clean and very dirty.*)

15. Conclude the conversation by asking the students to speculate about whether the best amount of pollution to clean up is relatively high or relatively low, based on the characteristics/pollutant you will name (see below and on the slides). Display Slides 3.5 and 3.6, which list the following different scenarios:
    - Polonium-210 (http://www.medicalnewstoday.com/articles/58088.php): Toxicologists estimate that 1 gram of polonium-210 would be enough to kill 50 million people, in addition to another 50 million people who would become ill. (*More clean; high damage to the environment*)

- Household dust in a typical household (*Less clean; low damage to the environment*)
- Household dust in a household with a highly asthmatic child (*More clean; high damage to the environment*)
- Paper airplanes in a classroom (*More clean; low cost to clean up*)
- Glitter on a carpet in a classroom (*Less clean; high cost to clean up*)

16. Display Slide 3.2 again and ask how many agree with statement #1 and statement #2. Probably more students will agree with statement #2 than before. Emphasize that the point of the activity is to compare the marginal benefits to the marginal costs of cleaning up (preventing) environmental pollution when deciding how much pollution should be allowed. The point is not that a clean environment is undesirable, but that trade-offs must be made when trying to decide how clean the environment should be.

Closure

17. Conclude the lesson by asking students what, according to economic thinking, determines how clean the environment should be. (*The exact amount depends on the cost of cleaning up versus the cost of the damage caused by the pollution. The environment will be somewhere between perfectly clean and totally dirty.*)

Assessment

18. Distribute a copy of *Handout 3-2: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice

1. The environment should be cleaned up more if the cost of cleaning is relatively _____ and the damage caused by the pollutant is relatively _____.
   a. high; high
   b. high; low
   c. *low; high*
   d. low; low

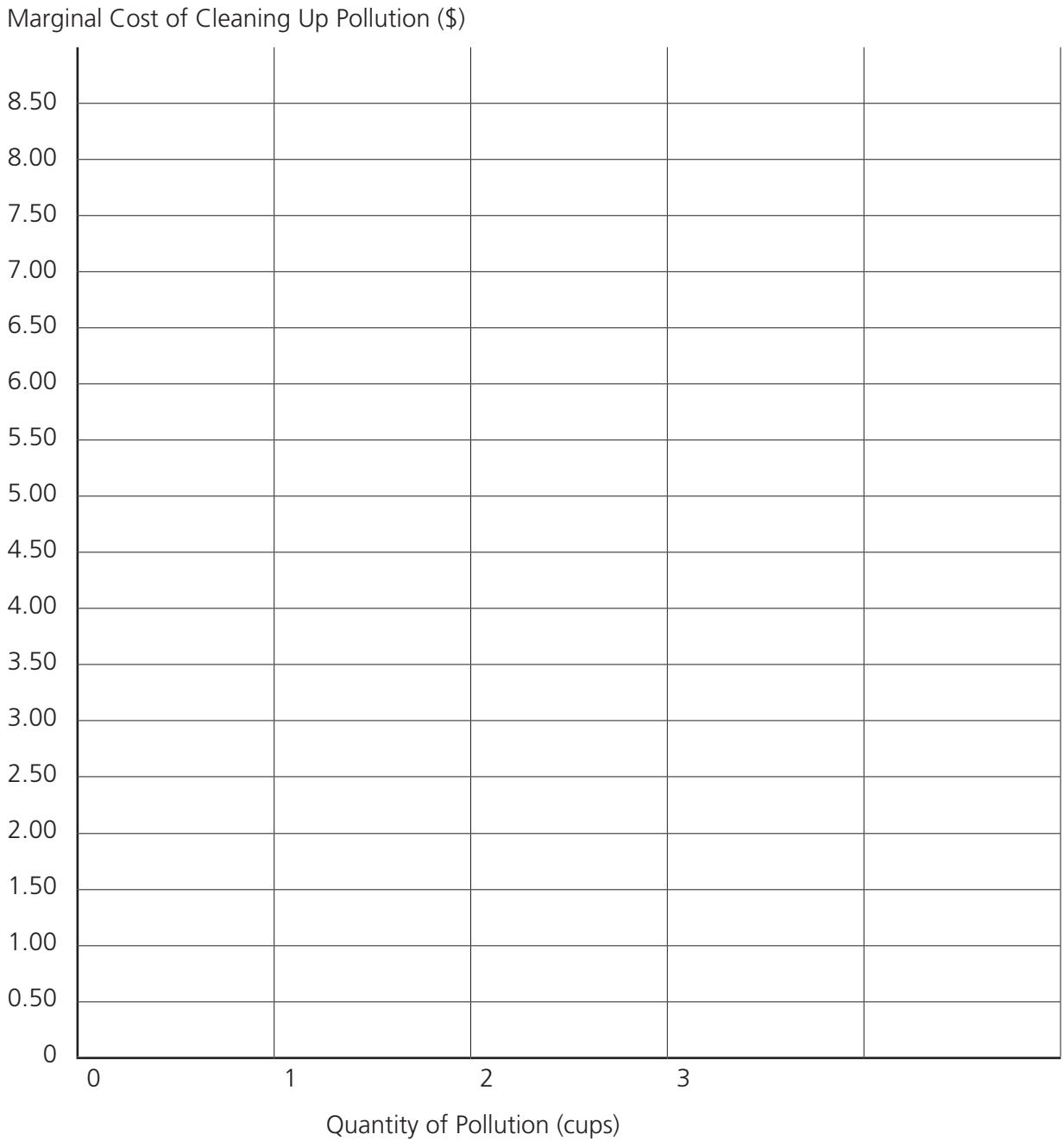
2. A business is trying to clean up a spill of 500 gallons of toxic chemicals that went into a nearby lake. The business has spent $5 million dollars and has managed to clean up 250 gallons. To finish cleaning the lake, a reasonable estimate (based on the simulation in class) would be an additional payment of
   a. $0 to $2 million dollars.
   b. $2 to $4 million dollars.
   c. exactly $5 million dollars.
   d. *over $5 million dollars.*

Short Answer

3. Argue why allowing some quantities of most pollutants into the environment is a reasonable economic policy.

   Most pollutants can be absorbed by the environment in small quantities with little effect on the environment. Because the damage caused is so small, spending a lot of money to keep the environment completely free of the pollutant would be inefficient in that the marginal cost of the damage is less than the marginal cost of cleaning up the pollution.

Handout 3-1: Graphing the Costs of Cleaning Up Pollution



Handout 3-2: Assessment

Multiple Choice

Select the best answer for each of the following questions.

1. The environment should be cleaned up more if the cost of cleaning is relatively _____ and the damage caused by the pollutant is relatively _____.
   a. high; high
   b. high; low
   c. low; high
   d. low; low

2. A business is trying to clean up a spill of 500 gallons of toxic chemicals that went into a nearby lake. The business has spent $5 million dollars and has managed to clean up 250 gallons. To finish cleaning the lake, a reasonable estimate (based on the simulation in class) would be an additional payment of
   a. $0 to $2 million dollars.
   b. $2 to $4 million dollars.
   c. exactly $5 million dollars.
   d. over $5 million dollars.

Short Answer

Write a response to the prompt below using complete sentences and correct grammar and punctuation.

3. Argue why allowing some quantities of most pollutants into the environment is a reasonable economic policy.

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 2: Decision Making

Effective decision making requires comparing the additional costs of alternatives with the additional benefits. Many choices involve doing a little more or a little less of something: few choices are "all or nothing" decisions.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

Common Core State Standards

CCSS.ELA-Literacy.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Note

MacGill, Markus. "Polonium-210: Why Is Po-210 So Dangerous?" *Medical News Today*, updated July 28, 2017; http://www.medicalnewstoday.com/articles/58088.php.

Lesson 4:
Supply and Demand of Pollution

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Standards and Benchmarks (see page 4.14)

Lesson Description

The lesson shows students how basic supply and demand concepts can be used to analyze the effects of an emissions tax or a cap and trade system. Using supply and demand illustrates how markets can be used to allocate the amount of pollution released into the environment.

NOTE: Students need a basic understanding of supply and demand, the factors that cause increases or decreases in supply and demand, and the results of increases or decreases in supply and demand on market equilibrium.

Grade Level

High School

Concepts

Cap and trade system

Emissions tax

Objectives

Students will be able to

- describe cap and trade system and emissions tax,
- use supply and demand analysis to find the equilibrium level of pollution, and
- describe the effects of growth in the economy or improved pollution control technology on the equilibrium level of pollution.

Compelling Question

How can markets be used to solve pollution problems?

Time Required

45 minutes

Materials

- PowerPoint Slides 4.1-4.9
- Handout 4-1, one copy for each student

Introduction

Market-based systems are increasingly being used as methods to control pollution. These systems use price incentives (either taxes or permit systems) to encourage firms to reduce pollution. Economists advocate market-based systems because these systems are efficient in reducing pollution. For example, the U.S. SO_2 trading program was successful in reducing the quantity of pollution at a low cost to the power plants that emitted SO_2.[1] The program's additional benefit was the reduction in the amount of particulates released. Currently, a carbon tax is being championed as a way to combat climate change.[2] This lesson demonstrates how these environmental tools work using simple supply and demand analysis, which opens the door to introducing environmental policies early in a high school economics course.

Procedure

1. Introduce the topic by discussing the following:
   - Why do firms pollute when they produce products? (*Answers may include that waste is created during production and needs to be released somewhere.*)
   - Why don't firms either (a) clean up the pollution from the environment, (b) prevent it from escaping into the environment, or (c) use technology that results in less pollution? (*Answers may include that it is expensive to do any of those alternatives.*)
   - Is there a cost to society for releasing pollution into the environment? (*Yes, pollution damages people's health and property, among other things.*)

2. Explain that the goal of this lesson is to understand the balance between allowing harmful pollution into the environment and keeping a firm's costs of cleanup low. The lesson will use supply and demand analysis to help them understand how pollution can be managed in a market economy. To analyze pollution through a market lens, they must understand that firms create waste when they produce goods and services. Firms need someplace to dispose of that waste.

[1] See Schmalensee and Stavins, 2013.

[2] See Climate Leadership Council.

3. Tell the students that it is helpful to think of pollution control markets as providing pollution disposal "services" instead of merely a place to dump pollution. For example, if a firm wants to emit smoke (particulates) into the air, the firm is making use of the air as a place to dispose of its smoke. So if the air is viewed as a service that the firm views as "pollution disposal," then this disposal service can be thought of as something demanded by firms. Ask the students who demands "pollution disposal." (*Firms who produce products and want to release pollution into the environment*) Tell the students that the demand for pollution services is the relationship between the prices firms must pay to dispose of their pollution in the environment and the quantities of pollution they will emit into the environment.

4. Explain that you will use the example of CO_2 as a pollutant that contributes to climate change.[3] The question is how pollution might be controlled in a market setting. Discuss the following:

    - If firms do not have to pay to dispose of pollution in the environment, will firms pollute a lot or a little? (*Answers may include that firms will undoubtedly pollute a lot. Some students may suggest that goodwill on a firm's behalf may limit the amount it pollutes.*)
    - If firms had to pay $1,500 per ton of CO_2 they released (students may not really know if this is a high or low value, but they will probably infer that it is high), how much would firms pollute? (*Answers may include close to no pollution, but certainly less than if no charges were assessed.*)
    - What might firms do to reduce the amount of CO_2 they release into the environment? (*Answers may include that firms either use production techniques that do not emit so much CO_2 pollution or clean up the CO_2 pollution created instead of disposing of it into the environment. Firms may also reduce production of the good.*)

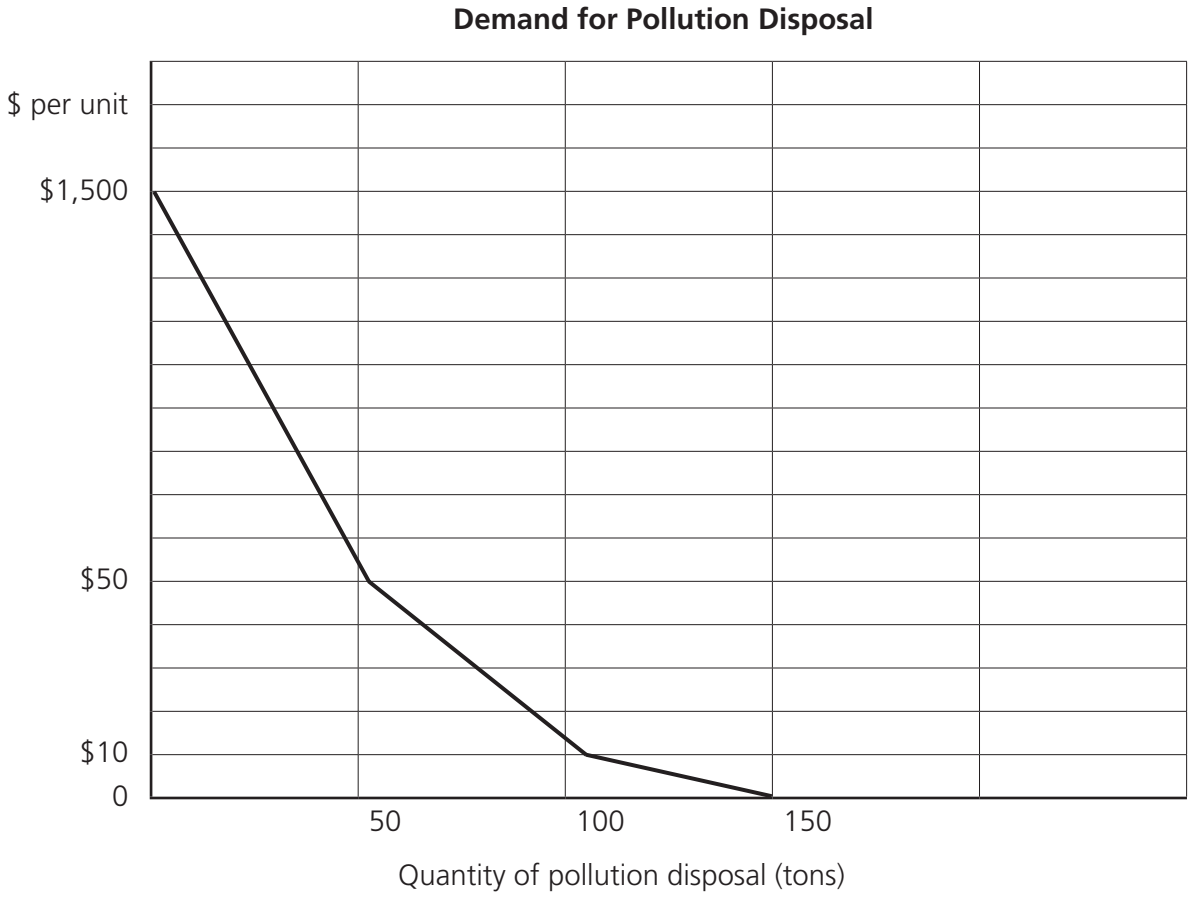
5. Tell the students to note that firms have to decide between either disposing of pollution in the environment or taking actions to reduce the amount of pollution they produce.

6. Display Slide 4.2. Tell the students that the graph shows firms' demand for pollution disposal services—that is, the quantities of pollution firms will want to put into the environment at various prices. Note that the endpoints of the demand for pollution are at a price of $1,500 for zero pollution and a price of $0 for a large quantity of pollution (the graph shows 150 tons). Tell them that as the price of pollution disposal increases, firms reduce the amount of pollution disposed of. This is the demand for pollution disposal.

7. Discuss the following:

    - Based on the graph, how much CO_2 would firms dispose of into the environment if they had to pay nothing to do so? (*150 tons*)

[3] See Intergovernmental Panel on Climate Change (IPCC), 2018.



- What do you think about this "free to dispose of pollution" approach? (*Answers may include that the emissions cause harm to people and the environment and should be reduced.*)
- Why would governments allow any pollution? (*Answers will vary. The students should realize that we want the goods produced by firms, so allowing no pollution might result in no goods.*)

8. Tell the students that one of the roles of government in a market economy is to intervene when markets aren't able to fix a problem such as pollution. Pollution is an externality. When an externality is not corrected, markets are inefficient. Discuss the following:
   - The government must decide how much firms should be allowed to pollute. Ideally, the government would use cost-benefit analysis to decide how much pollution (CO_2 in this example) should be allowed into the environment.

- In other words, the government becomes the supplier of pollution disposal services. Through laws, the government decides how much pollution is allowed to be disposed of into the environment and/or at what price.

9. Explain that the laws of local, state, or federal government provide the supply of pollution disposal. The supply of pollution disposal includes the quantities of pollution available at various prices. While many ways of providing "pollution disposal services" exist, tell the students that you will talk about two market-based systems—a tax system and a **cap and trade** system. These systems are called market based because firms are not told how to manage their pollution. Specifically, they are not told what technology to use or to reduce their output. Instead, they are given incentives to reduce emissions and then must decide on their own how to respond to the incentives.

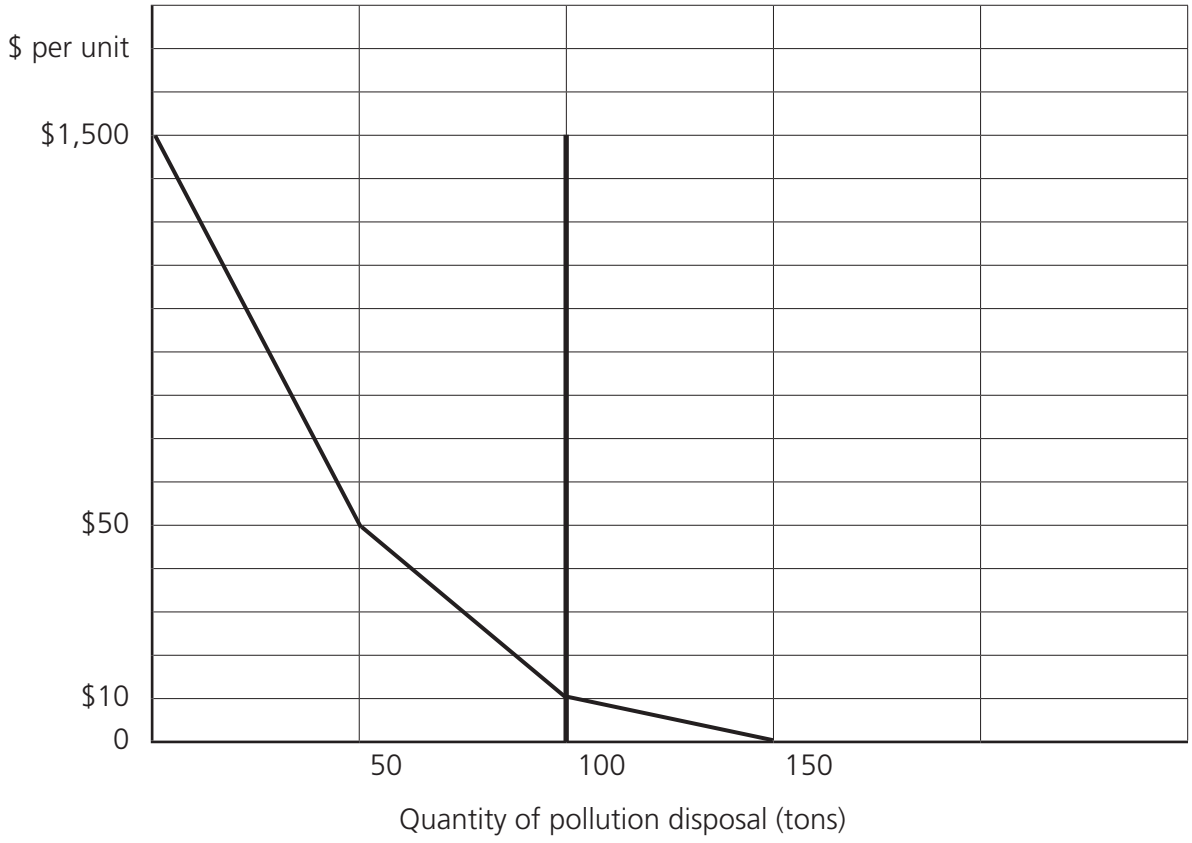
10. Display Slide 4.3. Tell the students that one way to cap the amount of pollution at a fixed amount is for government to issue permits (say one ton of pollution per permit) and then allow businesses to buy and sell the permits among themselves. The price of a permit is determined in an open market. This system is known as cap and trade. Review the advantages of a cap and trade system as follows:
    - The quantity of pollution emitted is known and equal to the amount given by the permits.
    - Firms whose cost of controlling pollution is high can buy permits from firms whose cost of controlling pollution is low. This means high-cost firms don't have to spend a lot to control pollution and low-cost firms are rewarded by being able to sell permits.
    - A firm is free to choose whichever method or technology it finds best to meet its cap. Firms have an incentive to reduce pollution by adopting new technologies because this would allow them to sell their excess permits.
    - The government can earn revenue if the permits are initially sold at auction. (However, many times existing firms are given allocations of permits for free.)

11. Display Slide 4.4. Have the students think about what the supply of pollution disposal graph would look like under a cap and trade system. (Encourage them to think about how the quantity of pollution disposed of is fixed no matter what the price. This means a vertical supply curve.) Tell the students that the supply curve is what economists call perfectly inelastic—the quantity does not change when the price changes. Ask the students what the graph would look like if 50 units of pollution were allowed under a cap and trade system. (*The curve would shift to the left.*)

12. Display Slide 4.5. Tell the students that this graph has both the supply and the demand for pollution illustrated. With a cap and trade system, a market for pollution is created. The market determines the price of pollution: In the graph, this is the price at which supply and demand cross. Ask the students what the price of permits will be. (*$10*)

13. Explain that if the government auctions off the permits, the amount the government would earn would be $1,000 (Price x Quantity of permits). Tell the students that with a cap and trade system, sometimes permits are given for free to businesses. In this case, firms receive the money from the sale of their permits or benefit from not having to buy permits if they save the permits for their own use.[4] The good thing about tradeable permits is that even if the government gives the permits to firms that don't need them (because they can control their waste at a low cost), firms can earn revenue by selling their permits to firms who can't cheaply reduce their waste. In this case, low-cost firms will trade their permits to high-cost firms, restoring the market to equilibrium and ensuring that the most efficient firms are the ones that reduce their waste.

Supply and Demand for Pollution Disposal with Cap and Trade



14. Display Slide 4.6. Tell the students that a second way to limit the disposal of pollution emissions into the environment is to tax pollution emissions. With this type of option, firms can pollute as much as they would like as long as they pay the tax for each unit of pollution. This system is described as an emissions tax. Review the advantages of an **emissions tax** as follows:

[4] See Weber, 2002.

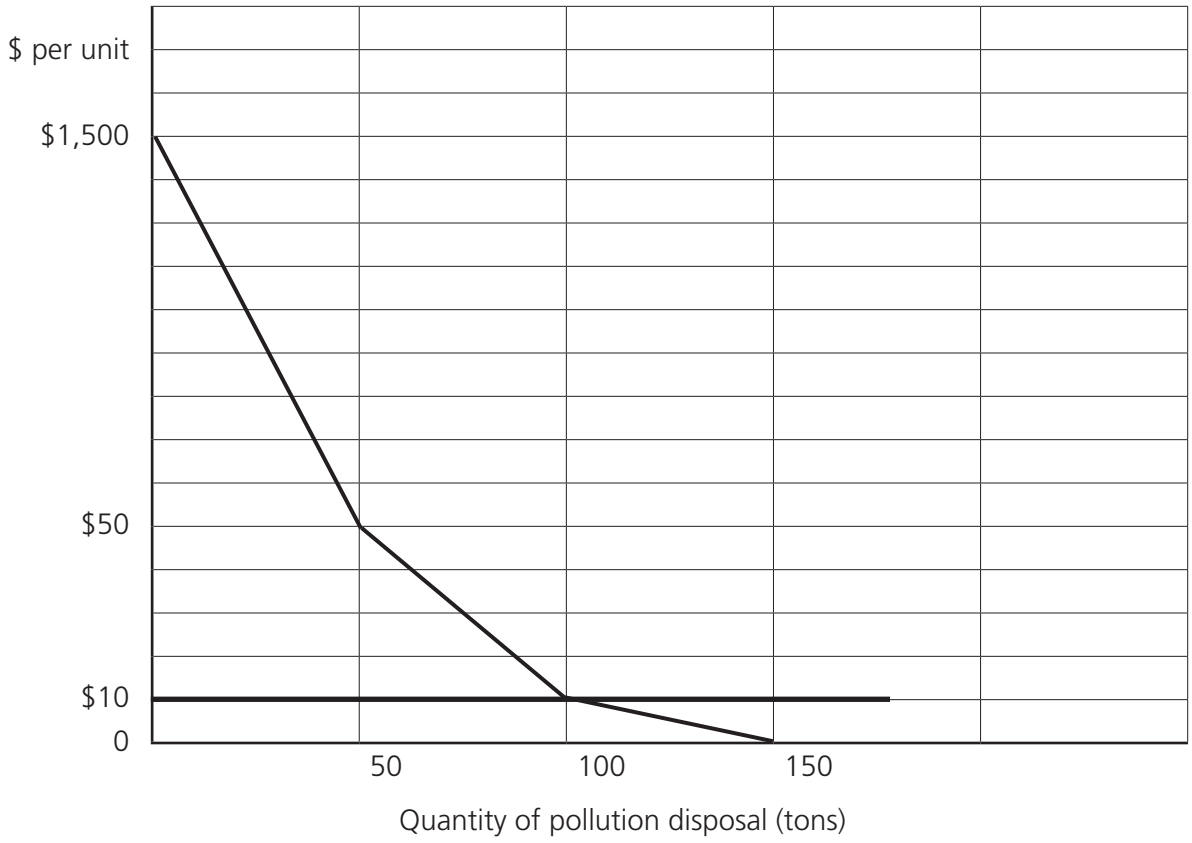
- The cost of pollution disposal (the amount of the tax) is known to businesses, and it provides some security in planning for the costs of doing business in the future.
- Firms whose cost of controlling pollution is high can pay the tax and pollute. Low-cost firms can control their emissions and avoid paying the tax for pollution disposal.
- Firms are free to choose whichever method or technology they find best to avoid paying the tax. Firms have an incentive to adopt new technologies to reduce pollution and avoid the tax.
- The government will earn revenue from the tax. From an efficiency standpoint, implementing an emissions tax, if done properly, will improve efficiency. If the government uses the revenue from the emissions tax to lower taxes that might cause inefficiencies (for example, lowering income taxes to encourage working), then overall efficiency can be improved. This is called the "double dividend" of fixing pollution problems.

15. Tell the students to assume the tax to dispose of pollution into the environment is $10 a unit. This means the government will allow (supply) firms as many units of pollution as they want at the price of $10. Ask the students what they believe the supply curve looks like in this example. (*A horizontal line at the $10 mark*) Explain that this is a perfectly elastic supply curve.

16. Display Slide 4.7. Ask the students how much pollution will be released based on the graph. (*100 units*) Remind the students that the demand for pollution disposal is based on the fact that cleaning up or avoiding creating the pollution costs firms money. The cleaner the environment, the more expensive it is to continue to clean up. Discuss the following:
    - If firms did not have to pay to dispose of pollution into the environment, how much would they release? (*150 tons*)
    - Why do firms reduce pollution from 150 units to 100 units when the tax is imposed? (*It is cheaper to reduce emissions than to pay the tax; the demand curve is below the tax amount.*)
    - How high would the tax have to be to have a firm not dispose of any pollution into the environment or, in other words, have the quantity of pollution disposal services used be equal to zero? (*$1,500*)
    - Why does the price have to be so high—$1,500—to get firms to not dispose of any pollution? (*It is very expensive for firms to adopt technologies where nothing is emitted into the environment.*)

17. Point out that in this example, the $10 tax and the permit system with 100 permits are equivalent. The price in the permit system is $10 and the quantity in the tax system is 100. However, the differences between the two systems become apparent when the demand for pollution changes.

Supply and Demand for Pollution Disposal with Cap and Trade



18. Explain that the demand curve can shift if the cost for firms to reduce pollution is lowered. If the cost is reduced, the amount of pollution that needs to be disposed of is lowered, and firms will not need to demand as much pollution disposal. Ask the students how the following might shift the demand for pollution by firms:

    - An innovation in pollution technology that makes it cheaper for firms to reduce pollution (*It would shift the demand for pollution to the left; it deceases demand for pollution disposal.*)
    - Growth by firms in the production of the good they produce (*It would shift the demand for pollution to the right because more production will result in more pollution to dispose of; it increases demand for pollution disposal.*)

19. Draw a demand curve and a supply curve for pollution disposal with a cap and trade system on the board (or doc cam). Discuss the following, shifting the curves as answers are given:

- What happens to the amount of pollution and the price of permits if the technology for reducing pollution emissions improves? (*The demand curve shifts to the left. As a result, the price decreases; the same quantity is emitted.*)
- What happens to the amount of pollution and the price of permits if the demand for a product that firms produce increases? (*The demand curve shifts to the right. As a result, the price increases; the same quantity is emitted.*)

20. Draw a demand curve and a supply curve for pollution disposal with an emissions tax on the board (or doc cam). Discuss the following, shifting the curves as answers are given:
    - What happens to the amount of pollution and the "price" firms pay if the technology for reducing pollution emissions improves? (*The demand curve shifts to the left and the price [the tax] is the same; the quantity decreases.*)
    - What happens to the amount of pollution and the "price" firms pay if the demand for a product that firms produce increases? (*The demand curve shifts to the right and the price [the tax] is the same; the quantity increases.*)
    - Suppose the government decides that too much pollution is being disposed of into the environment. What would be a solution? (*Increase the tax, which would shift supply vertically and result in less pollution*)

Closure

21. Conclude the lesson by projecting Slide 4.8. Tell the students that the United States does not currently control CO_2 emissions. However, many other examples of cap and trade exist, including the following:
    - U.S. Acid Rain Program, SO_2 trading (https://www.epa.gov/airmarkets/acid-rain-program); SO_2 levels are now low, so prices are almost zero.
    - California's Cap-and-Trade Program for carbon (https://www.arb.ca.gov/cc/capandtrade/capandtrade.htm)
    - European Union Emissions Trading System for many pollutants (https://ec.europa.eu/clima/policies/ets_en)

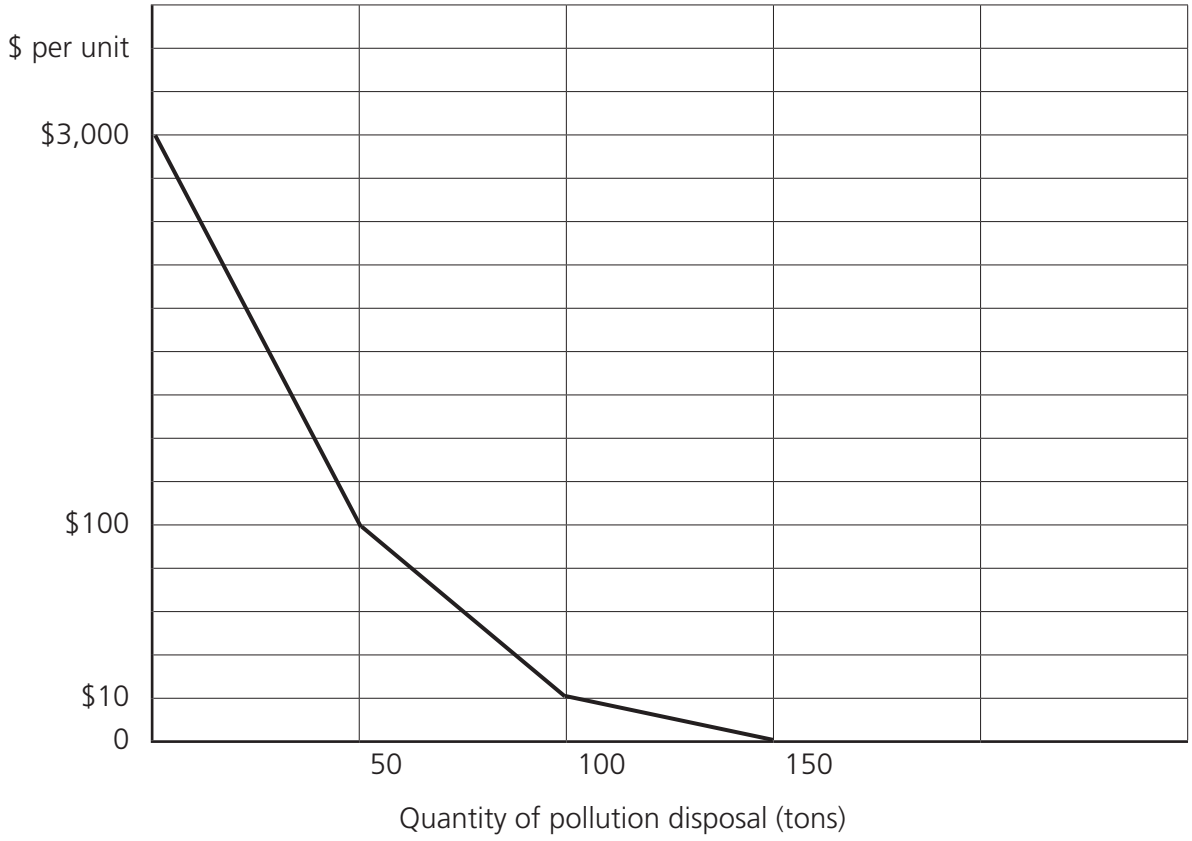
22. Also, note that some countries (and some U.S. states) are taxing carbon as a method to reduce CO_2 emissions. See Slides 4.9 and 4.10, from World Bank and Ecofys, 2018.

23. Ask the students what the main advantage of a market system is as opposed to government regulations that specify the technologies firms must use to control pollution. (*In a market system, firms can use whatever technology or method they wish to reduce pollution. Or, if they decide to do so, they can pay more to pollute more—either the tax or the price of the permit. This allows firms to figure out what is the cheapest thing for them to do.*)

Assessment

24. Distribute a copy of *Handout 4-1: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice



1. Suppose the government allows 50 units of pollution into the environment. The cap for a cap and trade system should be _____ tons. An equivalent method would be to charge a tax of $_____ on pollution.

   a. 50; 100

   b. 100; 50

   c. 50; 50

   d. 100; 100

2. As an industry grows, the demand for pollution disposal will _____. Under an emissions tax system, the quantity of pollution emitted will _____.

   a. increase; increase

   b. increase; stay the same

   c. decrease; decrease

   d. decrease; stay the same

3. As pollution control technology improves, the demand for pollution will _____. Under a cap and trade system, the quantity of pollution emitted will _____.

   a. increase; increase

   b. increase; stay the same

   c. decrease; decrease

   d. decrease; stay the same

Short Answer

4. Recommend either a tax on pollution or a cap and trade system in which the permits are auctioned to firms by the government for the following scenarios:

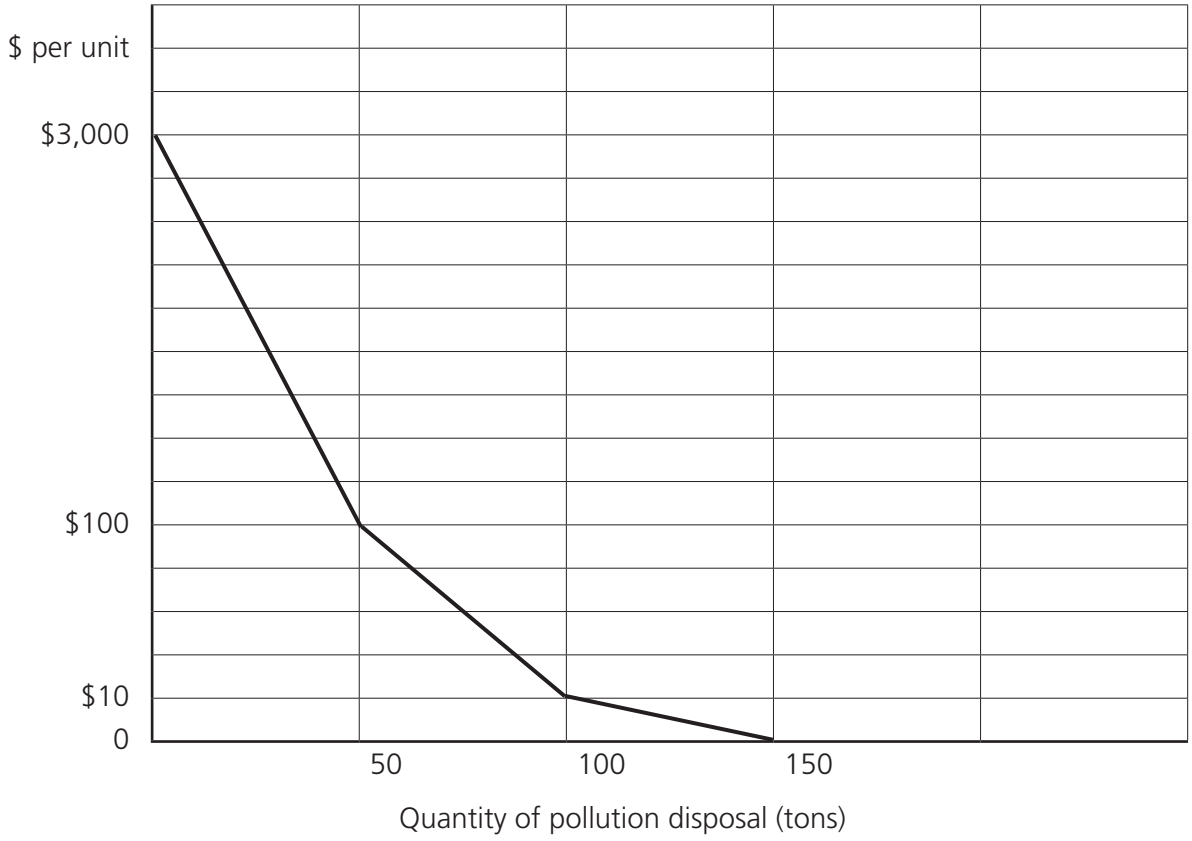
   - You felt the environment's capacity was at a "tipping point" where increases in pollution might result in a large amount of damage. (*Cap and trade*)
   - You want to provide firms with predictability in their costs of pollution control. (*Tax*)
   - You want to allow firms an opportunity to grow without increasing pollution control costs. (*Tax*)
   - You want pollution to shrink as pollution-control technologies improve. (*Tax*)

Handout 4-1: Assessment (page 1 of 2)

Multiple Choice

Directions: Select the best answer for each of the following questions.

1. The diagram below shows the demand for pollution disposal services by firms. Use the diagram to answer the questions that follow.



1. Suppose the government allows 50 units of pollution into the environment. The cap for a cap and trade system should be _____ tons. An equivalent method would be to charge a tax of $_____ on pollution.

   a. 50; 100

   b. 100; 50

   c. 50; 50

   d. 100; 100

Handout 4-1: Assessment (page 2 of 2)

2. As an industry grows, the demand for pollution disposal will _____. Under an emissions tax system, the quantity of pollution emitted will _____.

   a. increase; increase

   b. increase; stay the same

   c. decrease; decrease

   d. decrease; stay the same

3. As pollution control technology improves, the demand for pollution will _____. Under a cap and trade system, the quantity of pollution emitted will _____.

   a. increase; increase

   b. increase; stay the same

   c. decrease; decrease

   d. decrease; stay the same

Short Answer

Directions: Write responses to the prompt below.

4. Recommend either a tax on pollution or a cap and trade system in which the permits are auctioned to firms by the government for the following scenarios:

   - You felt the environment's capacity was at a "tipping point" where increases in pollution might result in a large amount of damage. _____
   - You want to provide firms with predictability in their costs of pollution control. _____
   - You want to allow firms an opportunity to grow without increasing pollution control costs. _____
   - You want pollution to shrink as pollution-control technologies improve. _____

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 2: Decision Making

Effective decision making requires comparing the additional costs of alternatives with the additional benefits. Many choices involve doing a little more or a little less of something: few choices are "all or nothing" decisions.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

Common Core State Standards

CCSS.ELA-Literacy.RH.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Notes

Climate Leadership Council; https://www.clcouncil.org/economists-statement/.

Intergovernmental Panel on Climate Change (IPCC). "Summary for Policymakers," in Masson-Delmotte, Valérie; Zhai, Panmao; Pörtner, Hans-Otto; Roberts, Debra; Skea, Jim; Shukla, Priyadarshi R.; Pirani, Anna; Moufouma-Okia, Wilfran; Péan, Clotilde; Pidcock, Roz; Connors, Sarah; Matthews, J. B. Robin; Chen, Yang; Zhou, Xiao; Gomis, Melissa I.; Lonnoy, Elizabeth; Maycock, Tom; Tignor, Melinda and Waterfield, Tim, eds., Global Warming of 1.5°C: An IPCC Special Report on the Impacts of *Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Geneva, Switzerland: World Meteorological Organization, 2018.

Schmalensee, Richard and Stavins, Robert N. "The SO2 Allowance Trading System: The Ironic History of a Grand Policy Experiment." *Journal of Economic Perspectives*, 2013, *27*(1), pp. 103-22; doi: 10.1257/jep.27.1.103.

Weber, David W. "Pollution Permits: A Discussion of Fundamentals." Journal of Economic Education, 2002, 33(3), pp. 277-90; doi: 10.1080/00220480209595192.

World Bank and Ecofys. "State and Trends of Carbon Pricing 2018 (May)." World Bank, Washington, DC, 2018; doi: 10.1596/978-1-4648-1292-7.

Lesson 5:
The Emissions Simulation

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Standards and Benchmarks (see page 5.21)

Lesson Description

Students play the roles of companies that must decide to either clean up their pollution or release it into the air. They make their decisions under a variety of scenarios, including a tax on emissions and a tradeable permit (cap and trade) system. The students then compare the results of the scenarios.

Grade Level

High School

Concepts

Emissions tax

Tradable permit system

Objectives

Students will be able to

- define emissions tax and tradable permit system,
- explain why firms decide to either pollute or clean up their emissions,
- explain how firms respond to a tax on emissions,
- explain how a tradable permit system might work, and
- compare regulation to market-based incentives in terms of costs of controlling pollution.

Compelling Question

Why do emissions taxes or tradable systems minimize the cost of cleaning up the environment?

Time Required

45 minutes

Materials

- PowerPoint Slides 5.1-5.24
- Handout 5-1, one copy for every two students (See Preparation section)
- Handout 5-2, one copy for every two students, cut apart so that each student gets six units/cards (Print on blue paper, if possible.)
- Handout 5-3, one copy for each student
- Handout 5-4, one copy for the teacher (Optional: use with a document camera)
- Handout 5-5, one copy for every four students, cut apart so that each student gets three permits (Print on yellow paper, if possible.)
- Handout 5-6, one copy for every two students, cut apart so that each student gets $1,500 (Print on green paper, if possible.)
- Handout 5-7, one copy for each student
- Standard letter-size envelopes, one per student

Preparation

For *Handout 5-1: Emissions Clean-Up Envelope Covers*: The sheet has two sets of instructions. The instructions should be cut apart and taped on envelopes so that half the class gets an envelope with one set of instructions and the other half gets an envelope with the alternate set of instructions.

Introduction

Economists advocate the use of market-based systems that control the disposal of pollution in the environment. Disposal control happens because firms that pollute are able to seek out the lowest-cost method to achieve the levels of pollution prescribed by the government. For example, in a permit system, firms that find pollution control expensive can buy permits from firms that have a lower cost of controlling pollution, making both firms better off and reducing the overall cost of controlling pollution. Market-based systems also provide firms incentives to develop new technologies to reduce pollution.

Procedure

1. Tell the students they will participate in a simulation that illustrates how using market-based incentives minimizes the costs of controlling pollution. Explain that economists recommend market-based incentives as the best way to control pollution because of the cost-minimizing feature of these incentive systems.

2. Tell the students they will each represent a company. Distribute the following to each student:
   - Six units (cards) of CO_2 emissions from *Handout 5-2: Emissions*
   - An emissions clean-up envelope (see Step 3 for special instructions)
   - One *Handout 5-3 Student Sheet—Calculating Profit for Your Company*

3. While handing out the envelopes, be sure to alternate between the two types of envelope covers (one has higher costs than the other). If you have an odd number of students, enlist one student to help with administrative tasks so that the envelopes are evenly distributed.

4. Explain the following (also outlined in Handout 5-3 and Slide 5.2):
   - Your company produces cement. In one month, your company sells $1,500 worth of cement.
   - Your company is polluting six tons of CO_2 into the air every month. Each card represents one ton of CO_2.
   - This emissions game is played in five rounds. At the beginning of each round, you will start with six emissions cards and an emissions clean-up envelope. The cards begin each round outside of the envelope on your desk or table. The cost of cleaning up the emissions is taped to the envelope.
   - In each round, you clean up CO_2 emissions by placing a CO_2 emissions card into the envelope. Your company must pay the amount shown on the envelope to clean up the CO_2. CO_2 emissions that are not cleaned up are released into the air. To release emissions, you will hold the cards up in the air. Each round is a new month.
   - After you decide what to do in each round, you must calculate your costs and profits. At the end of each round, you must put the six emissions cards back on your desk or table for the next round's instructions.

5. Have the students look at their clean-up envelopes. Explain that the cover of each envelope tells them how much it costs to place an additional unit of pollution into the envelope. Explain the following:
   - The first line tells you how much it costs to put the first unit into the envelope.

- The second line tells you how much it costs to put a second unit into the envelope. This is a marginal cost, which means the second unit adds the cost listed to a firm's total costs.
- To find the firm's total cost of cleaning up two units, you must *add together* the marginal costs. For example, if the first unit costs $10 and the second unit costs $30, the total cost for the two units is $40. Or, if the first unit costs $100 and the second unit costs $500, the total cost for the two units is $600.
- Adding marginal costs is very important because to determine your profits, you must figure out the total cost of cleaning up pollution.
- To find the cost of cleaning up more units, you continue to add together the marginal costs.

6. Ask the students why the marginal (additional) costs increase as more pollution is cleaned up. (*They should correctly guess that it gets technologically more difficult to clean up more units of pollution, and so it is more expensive.*)

7. Tell the students they will need to understand how to calculate profit for their company. Explain the following:
   - The total revenue is the amount your company received for selling its product. For this simulation, your total revenue will be $1,500 for each round. A round represents one month.
   - To simplify the calculations, your firm has no labor or material costs. The firm only has pollution clean-up costs. Point out that in the real world things wouldn't be this simple.
   - While later rounds will have taxes and other ways to earn revenue, to calculate profit for the first few rounds, you must subtract the *total* pollution control costs from the total revenue.

8. Tell the students that in the simulation, the decision they must make is to either clean up their CO_2 by placing the units in the envelopes or release their CO_2 by holding the units high in the air. Answer any questions the students may have before beginning the first round.

9. After each round, *briefly* discuss the results. Save a full discussion for after the last round when you will compare all the rounds. As you debrief after each round, fill in the summary sheet from *Handout 5-4: Profit Reporting Sheet* while using a document camera. The steps below provide the instructions followed by the intended answers, which should be written on the sheet and noted to the students. Or as an alternative, Slides 5.3 to 5.12 provide the instructions followed by the intended answers for each round.

Round 1

10. Tell the students that to get rid of their emissions they can either release them into the atmosphere for free by holding them up in the air or clean up their emissions and pay the costs found on their envelope. Give the students some time to decide and then tell the students to raise the CO_2 emissions into the air or place them in the envelope. Mentally note the students' decisions and tell them to calculate their profits on their sheets. Display a copy of Handout 5-4 and record the information for each type of firm. Discuss the following:
    - Who put their CO_2 emissions into the air? (*All of the students should have*)
    - If you didn't put emissions into the air, why didn't you? (*Answers will vary. Some students may not have understood. Some students may have refused for ethical reasons to put pollutants into the air.*)
    - Were your firms profitable? (*If they decided to release all of their pollution into the air, then their firms should have been profitable.*) See the following table (Slides 5.3 and 5.4):

Each firm:	Total Rev. $1,500	Total Cost $0	Profit $1,500
Pollution released: Twelve total for each pair of firms (a high- and low-cost firm); six by each firm			

Round 2

11. Tell the students to place their six emissions cards on their desks or tables for Round 2. Explain that in this round, releasing emissions into the air is forbidden by government regulation, so they must clean up the units and pay the costs on their envelopes. Allow time for the students to compute costs and profits. NOTE: Students should have put all of the CO_2 emissions into the envelope. If they did not (some will not), tell them that as the government regulator, you will enforce the pollution law and they must put their pollution into the clean-up envelope. Display Handout 5-4 and record the information for each type of firm. Ask the students if their firms were profitable. (*For firms with lower clean-up costs, the answer is yes. For firms with higher clean-up costs, the answer is no.*) See the following table (Slides 5.5 and 5.6):

Low-cost firm:	Total Rev. $1,500	Total Cost $1,000	Profit $500
High-cost firm:	Total Rev. $1,500	Total Cost $6,000	Profit –$4,500
Pollution released: Zero total for each pair of firms; zero by each firm			

Round 3

12. Tell the students to place the six emissions cards on their desks or tables for Round 3. Explain that as the government regulator, you will charge an **emissions tax** of $400 for each unit of CO_2 released into the air. Tell them to decide what they are going to do (put units into the air or into the clean-up envelope) and to write the total tax on their sheets. Then, ask them to raise their CO_2 emissions into the air. (As they raise their emissions into the air, verify they have paid the tax on their sheets.) Tell the students to calculate their profit. Display Handout 5-4 and record the information for each type of firm. Discuss the following:

    - Which firms decided to pay the tax to put emissions into the air? Why? (*High-cost firms will pay to pollute five units because it is cheaper for them to pay the tax than to clean up five units. Low-cost firms will pay to pollute only one unit.*)
    - Which firms decided not to pay the tax? Why? (*Low-cost firms should have decided not to pay because it is cheaper for them to clean up than to pay the tax. The high-cost firm will clean up only one unit.*)
    - Which firms made a profit? (*Low-cost firms made a profit.*) See the following table (Slides 5.7 and 5.8):

Low-cost firm:	Total Rev. $1,500	Total Cost $500	Tax $400	Profit $600
High-cost firm:	Total Rev. $1,500	Total Cost $100	Tax $2,000	Profit –$600
Pollution released: Six total for each pair of firms; one by low-cost firms and five by high-cost firms				

Round 4

13. Tell the students to place the six emissions cards on their desks or tables for Round 4. Distribute three permits from *Handout 5-5: Permits* to each student. Tell them they can put an emissions card into the air only if they have a permit to hold with it. Any other emissions need to be placed in their clean-up envelopes and paid for. After giving them a short time to realize they have no real decision to make, ask them to hold up their CO_2 emissions and permit cards. Tell the students to calculate their profits. Display Handout 5-4 and record the information for each type of firm. Discuss the following:

    - Did you have any real choice to make? (*No, unless students decided to clean up more than required*)
    - Which firms made profits? (*The low-cost firms made profits.*)
    - Which firms broke even—neither profits nor losses? (*The high-cost firms should break even.*) See the following table (Slides 5.9 and 5.10):

Low-cost firm:	Total Rev. $1,500	Total Cost $100	Profit $1,400
High-cost firm:	Total Rev. $1,500	Total Cost $1,500	Profit $0
Pollution released: Six total for each pair of firms; three by each firm			

Round 5

14. Tell the students to keep the three permits and place the six emissions cards on their desks or tables for the final round. Distribute $1,500 in revenue from *Handout 5-6: Money* to each student. Tell the students they can either use their permits, sell permits to other students, or buy permits from other students with their revenue. Tell them that to encourage trading, there can be only one trade between any two companies. If they want to make additional trades, they should do so with a different student. Give them about five minutes to make their trades. After five minutes, tell them to hold up their emissions with permit cards. Any other emissions need to go into their clean-up envelopes and paid for. Have the students calculate their profits, reminding them that their revenue may be less if they bought permits or more if they sold permits. Display Handout 5-4 and record the information for each type of firm. Discuss the following:

    - Who traded permits? (*Answers will vary.*)
    - For what price did you sell your permits? (*Answers will vary.*)
    - Which firms made profits? (*This will vary considerably depending on students' negotiating skills. The simulation is designed such that both firm types are likely to make profits.*)

    NOTE: A low-cost firm would be willing to sell its first permit if the price is $100 or more, a second permit if the price is $300 or more, and a third permit if the price is $500 or more. A high-cost firm would be willing to pay up to $900 for the first permit, up to $500 for the second permit, and only $100 for the third permit. Ultimately, high-cost firms will buy two permits from low-cost firms. There is a potential gain of $1,000 = ($900 – $100) + ($500 – $300). The following assumes a price of $400 for each permit (Slides 5.11 and 5.12):

Low-cost firm:	Total Rev. $2,300	Total Cost $500	Profit $1,800
High-cost firm:	Total Rev. $700	Total Cost $100	Profit $600
Pollution released: Six total for each pair of firms; one by low-cost firms and five by high-cost firms. Since permits are fixed, the six total for each pair will be true for the class as a whole.			

15. Discuss the following:

    - In which round did the two types of companies together make the most profit? How much? (*Round 1, with no regulation; $3,000*) Why? (*They did not have to pay for any pollution control.*) See Slides 5.13 and 5.14.
    - In which round did the two types of companies together make the least profit? How much? (*Round 2, with no pollution allowed; –$4,000*) Why? (*They had to clean up all their pollution.*) See Slides 5.15 and 5.16.
    - How much total pollution was released by each pair of companies in each of the last three rounds (with regulation)? (*In each round, the total pollution released by a high-cost firm and a low-cost firm together was six units.*) Emphasize that you will now compare these three ways of regulating pollution. See Slides 5.17 and 5.18.
    - Do companies prefer tax regulation or permit regulation? (*Companies prefer permit regulation. In this game [much like in reality] permits are given to companies, so they do not have to pay for them. They prefer this is as opposed to paying a tax to pollute.*) See Slides 5.19 and 5.20.
    - Is it fair to give permits to companies? (*Answers will vary. Ultimately it is a question of who receives the right to pollute—government, representing society as a whole, or firms.*)
    - Which rounds resulted in the lowest clean-up costs to the companies? (*If the companies made good decisions, then Round 3, the tax round, and Round 5, the tradable-permits round, should be the same—$600. The tax of $400 is equivalent to issuing six permits in terms of protecting the environment. Results may vary in the permit scenario because of negotiating by students.*) See Slides 5.21 and 5.22.
    - Which type of government policy do companies prefer: Emissions tax, non-tradable permits, or tradable permits? (*Tradable permits result in the highest profits because firms can trade to reduce costs and do not have to pay for the permits, as in an auction.*) See Slides 5.23 and 5.24.
    - Why might a government prefer an emissions tax? (*It is easier to administer in many situations and raises revenue for the government.*)

Closure

16. Summarize the following points of the simulation:

    - While firms prefer no pollution control because it is inexpensive and allows for greater profit, pollution causes great damage for society.
    - Allowing no pollution gives society a pristine environment; it also means that people wouldn't get the goods and services they want at prices they could afford because companies would have to pay such high costs to clean up all of their pollution.
    - Therefore, society usually must choose between an environment with no pollution at all and one where firms can pollute as much as they want. This means the government

must choose a method to control the amount of pollution that is released into the environment.

- An emissions tax and a **tradable permit system** can attain the same results if they are set appropriately. Both result in the lowest possible cost to firms. This is because market-based systems allow firms to make their own choices that result in the lowest cost combinations.
- A non-tradable permit system does not minimize costs because firms can't trade with one another to minimize costs.

Assessment

17. Distribute a copy of *Handout 5-7: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice

The table gives the marginal costs for two firms to clean up their pollution. Assume each firm would pollute four units of pollution (a total of eight units) if they were not regulated. Use the table to answer the next three questions.

Marginal cost to clean up	Firm A	Firm B
1st unit	$10	$30
2nd unit	$20	$40
3rd unit	$30	$50
4th unit	$40	$60

1. Suppose the government charged a tax on pollution of $25 per unit released into the environment. Firm A would clean up _____ units of pollution and pay the tax to release _____ units into the environment.
   a. 0; 4
   b. 1; 3
   c. 2; 2
   d. 3; 1

2. Suppose the government charged a tax on pollution of $25 per unit released into the environment. Firm B would clean up _____ units of pollution and pay the tax to release _____ units into the environment.
   a. 0; 4
   b. 1; 3
   c. 2; 2
   d. 3; 1

3. Suppose the government created a permit system where one permit would allow a firm to emit one unit of pollution into the environment, and the government gave Firm A and Firm B two permits each. If the permits were tradable, what would happen?

   a. Firm A would buy one permit from Firm B.

   b. Firm A would buy two permits from Firm B.

   c. *Firm B would buy one permit from Firm A.*

   d. Firm B would buy two permits from Firm A.

Short Answer

4. When governments create permit systems to control pollution, why is it important that the permits are tradable?

   If permits are non-tradable, then the government is just telling firms how much they can pollute without considering costs. When permits are tradable, firms with higher costs of cleaning up their pollution can buy permits from firms with lower costs of cleaning up. This means that cleaning up is accomplished at the lowest possible cost.

5. The table gives the marginal costs for two firms to clean up their pollution. Assume each firm would pollute four units of pollution (a total of eight units) if they were not regulated. Use the table on page 1 to answer the next three questions.

   a. Suppose the government wanted the firms to cut pollution to a total of six units, which means the firms must clean up a total of two units between them. What is the lowest-cost clean-up method?

      Firm A would clean up two units for a total cost of $30.

   b. Explain why charging the firms a tax of $25 per unit of pollution released would result in the same results as the lowest-cost clean-up method.

      Firm A would clean up two units since the cost of doing so ($10 and $20) is lower than the tax. Firm A would pay the tax to emit two units since the cost of cleaning up ($30 and $40) is higher than the tax. Firm B would pay the tax for all four units because the cost of cleaning up ($30 and up) is always higher than the tax. This results in the lowest cost possible of cleaning up—$30 in total.

   c. Suppose the government issued six permits. Each permit allows a firm to emit one unit of pollution into the environment. What would be the most a firm would be willing to pay for a permit?

      The most would be $60, which is the highest cost for a firm to clean up the pollution instead of buying a permit.

Handout 5-1: Emissions Clean-Up Envelope Covers

Clean-Up Envelope

Any unit of emissions placed in this envelope is cleaned up.
But your firm must pay a cost for each unit as described below.

Emissions unit placed in envelope	Cost for this unit (marginal cost)
1st	$10
2nd	$30
3rd	$60
4th	$100
5th	$300
6th	$500

Clean-Up Envelope

Any unit of emissions placed in this envelope is cleaned up.
But your firm must pay a cost for each unit as described below.

Emissions unit placed in envelope	Cost for this unit (marginal cost)
1st	$100
2nd	$500
3rd	$900
4th	$1,300
5th	$1,500
6th	$1,700

Handout 5-2: Emissions

One unit of CO_2 emissions	One unit of CO_2 emissions
One unit of CO_2 emissions	One unit of CO_2 emissions
One unit of CO_2 emissions	One unit of CO_2 emissions
One unit of CO_2 emissions	One unit of CO_2 emissions
One unit of CO_2 emissions	One unit of CO_2 emissions
One unit of CO_2 emissions	One unit of CO_2 emissions

Handout 5-3: Student Sheet—Calculating Profit for Your Company (page 1 of 2)

Your company produces cement. In one month, your company sells $1,500 worth of cement (total revenue = $1,500).

Your company is polluting six tons of CO_2 into the air every month. Each card represents one ton of CO_2. To make this exercise simple, your company has no labor or material costs. The only cost your company may have depends on whether the company will have to reduce its CO_2 emissions. You "clean up" CO_2 emissions by placing a CO_2 emissions card into the envelope. Your company must pay the amount shown on the envelope to clean up the CO_2. Each round is a new month.

Round 1: Pollute as much as you want

Total Rev.	–	Total Cost	=	Profit
$1,500	–	_____	=	_____

Round 2: No pollution allowed

Total Rev.	–	Total Cost	=	Profit
$1,500	–	_____	=	_____

NOTE: Your total cost is found by adding the values of each emissions card you placed in the envelope.

Government Regulation

The government has decided that while not controlling pollution causes harm, controlling all pollution is too expensive. The government is going to try a number of different policies.

Round 3: Tax on pollution: For every emissions card you put into the atmosphere, you must pay $400.

Total Rev.	–	Total Cost	–	Total Tax	=	Profit
$1,500	–	_____	–	_____	=	_____

Handout 5-3: Student Sheet—Calculating Profit for Your Company (page 2 of 2)

Round 4: Permits: For each permit you have in your possession, you are allowed to release one unit of CO_2 for free. If you do not have a permit for a unit of pollution, you must clean it up.

Total Rev.	–	Total Cost	=	Profit
$1,500	–	_____	=	_____

Round 5: Tradable permits: You may buy permits from others with your revenue and sell permits to others. You may trade only one permit with a trading partner. To trade more, you must find another trading partner. Write down the total revenue you have remaining after trades.

Total Rev.	–	Total Cost	=	Profit
_____	–	_____	=	_____

Handout 5-4: Profit Reporting Sheet (page 1 of 2)

Round: Firm	Total revenue	Total cost	Total tax	Profits	Pollution released by firm (units)	Total pollution (units)
1: Low-cost						
1: High-cost						
2: Low-cost						
2: High-cost						
3: Low-cost						
3: High-cost						
4: Low-cost						
4: High-cost						
5: Low-cost						
5: High-cost						

Handout 5-4: Profit Reporting Sheet (page 2 of 2)

Round 1

Each firm: Total Rev. $1,500 Total Cost $0 Profit $1,500

Round 2

Low-cost firm: Total Rev. $1,500 Total Cost $1,000 Profit $500

High-cost firm: Total Rev. $1,500 Total Cost $6,000 Profit –$4,500

Round 3 (if done correctly by student)

Low-cost firm: Total Rev. $1,500 Total Cost $500 Tax $400 Profit $600

High-cost firm: Total Rev. $1,500 Total Cost $100 Tax $2,000 Profit –$600

Round 4

Low-cost firm: Total Rev. $1,500 Total Cost $100 Profit $1,400

High-cost firm: Total Rev. $1,500 Total Cost $1,500 Profit $0

Round 5

The revenue will now depend on the price of a permit. NOTE: A low-cost firm would be willing to sell its first permit for $100 or more, a second permit for $300 or more, and a third permit for $500 or more.

A high-cost firm would be willing to pay up to $900 for the first permit, up to $500 for the second permit, and only $100 for the third permit. Ultimately, high-cost firms will buy two permits from low-cost firms. There is a potential gain of $1,000 = ($900 – $100) + ($500 – $300). The following assumes a price of $400 for each permit:

Low-cost firm: Total Rev. $2,300 Total Cost $500 Profit $1,800

High-cost firm: Total Rev. $700 Total Cost $100 Profit $600

Pollution released, for each *pair* of firms (low cost and high cost)

Round 1: Twelve; six by each firm

Round 2: Zero; zero by each firm

Round 3: Six; one by low-cost firms and five by high-cost firms

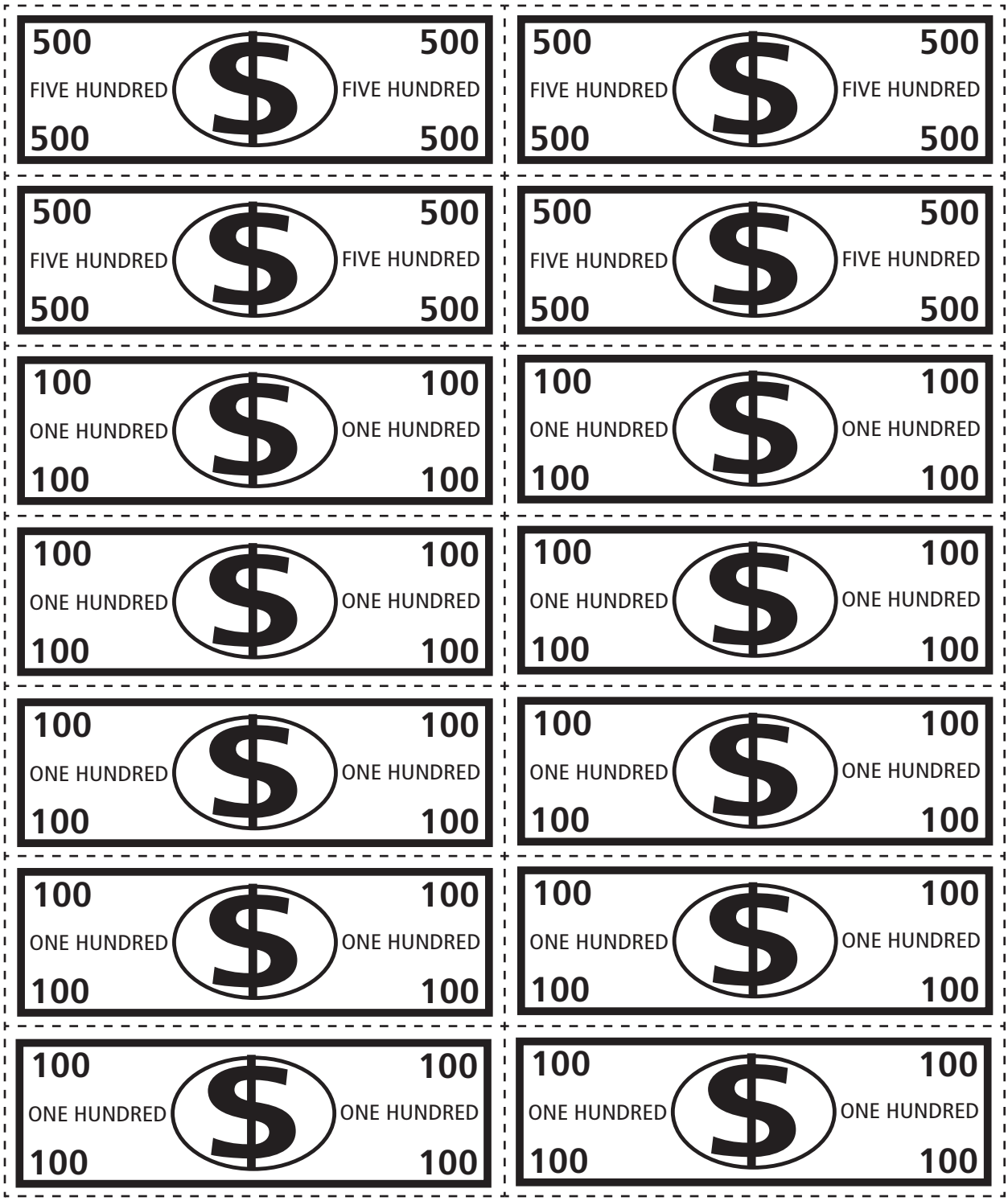
Round 4: Six; three by each firm

Round 5: Six; one by low-cost firms and five by high-cost firms (if all trades occur)

Handout 5-5: Permits

Pollution permit	**Pollution permit**
Pollution permit	**Pollution permit**
Pollution permit	**Pollution permit**
Pollution permit	**Pollution permit**
Pollution permit	**Pollution permit**
Pollution permit	**Pollution permit**

Handout 5-6: Money



Handout 5-7: Assessment (page 1 of 2)

Multiple Choice

Select the best answer for each of the following questions.

The table gives the marginal costs for two firms to clean up their pollution. Assume each firm would pollute four units of pollution (a total of eight units) if they were not regulated. Use the table to answer the next three questions.

Marginal cost to clean up	Firm A	Firm B
1st unit	$10	$30
2nd unit	$20	$40
3rd unit	$30	$50
4th unit	$40	$60

1. Suppose the government charged a tax on pollution of $25 per unit released into the environment. Firm A would clean up _____ units of pollution and pay the tax to release _____ units into the environment.
   a. 0; 4
   b. 1; 3
   c. 2; 2
   d. 3; 1

2. Suppose the government charged a tax on pollution of $25 per unit released into the environment. Firm B would clean up _____ units of pollution and pay the tax to release _____ units into the environment.
   a. 0; 4
   b. 1; 3
   c. 2; 2
   d. 3; 1

3. Suppose the government created a permit system where one permit would allow a firm to emit one unit of pollution into the environment, and the government gave Firm A and Firm B two permits each. If the permits were tradable, what would happen?
   a. Firm A would buy one permit from Firm B.
   b. Firm A would buy two permits from Firm B.
   c. Firm B would buy one permit from Firm A.
   d. Firm B would buy two permits from Firm A.

Handout 5-7: Assessment (page 2 of 2)

Short Answer

Write a response to the following prompts using complete sentences and correct grammar and punctuation.

4. When governments create permit systems to control pollution, why is it important that the permits are tradable?

5. The table gives the marginal costs for two firms to clean up their pollution. Assume each firm would pollute four units of pollution (a total of eight units) if they were not regulated. Use the table on page 1 to answer the next three questions.

   a. Suppose the government wanted the firms to cut pollution to a total of six units, which means the firms must clean up a total of two units between them. What is the lowest-cost clean-up method?

   b. Explain why charging the firms a tax of $25 per unit of pollution released would result in the same results as the lowest-cost clean-up method.

   c. Suppose the government issued six permits. Each permit allows a firm to emit one unit of pollution into the environment. What would be the most a firm would be willing to pay for a permit?

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 2: Decision Making

Effective decision making requires comparing the additional costs of alternatives with the additional benefits. Many choices involve doing a little more or a little less of something: few choices are "all or nothing" decisions.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

Common Core State Standards

CCSS.ELA-Literacy.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Lesson 6:
Green Is the New Gold

Author

Andrea Caceres-Santamaria, Federal Reserve Bank of St. Louis

Standards and Benchmarks (see page 6.18)

Lesson Description

In this lesson, students work in groups to solve an issue that businesses face: Resources used in the production process are scarce, and it can be expensive to throw away a lot of waste, especially since many industries depend on the same resources. There are two rounds in which students will assess the production process for toy wooden shapes. In the first round, students are presented with an inefficient use of resources and the production costs, revenue, and profit associated with it. In the second round, students brainstorm the most creative and efficient way to use a resource while increasing production, reducing waste, and increasing profits; students actively participate and calculate how they can do all three. The lesson closes with a case study on land tipping fees and questions for discussion.

Grade Level

High school

Concepts

Capital
Factors of production
Fixed costs
Innovate
Labor
Land
Opportunity cost
Profit
Revenue
Scarcity
Total cost
Variable costs

Objectives

Students will be able to

- define capital, factors of production, fixed costs, innovation, labor, land, opportunity cost, profit, revenue, scarcity, total costs, and variable costs;
- explain why the factors of production are necessary for the production of goods and services; and
- analyze how businesses can increase and improve their production process while capturing waste, or reducing it significantly, and increasing profitability.

Compelling Question

How can companies reduce waste, and increase profit, while the costs of production rise?

Time Required

60-75 minutes

Materials

- PowerPoint Slides 6.1-6.14
- Handout 6-1, one copy for each group of two to four students, and two extra copies for the teacher, all printed on cardstock
- Handout 6-2, one copy for each group of students, printed on cardstock
- Handout 6-2 Sample Answers, one copy for the teacher
- Handout 6-3, one copy for each group of students
- Handout 6-3 Sample Answers, one copy for the teacher
- Handout 6-4, one copy for each student
- Handout 6-5, one copy, cut apart, and one uncut copy for the teacher
- Two pairs of scissors for each group of students (or students can use their own scissors to make cutting faster)
- One calculator for each group of students
- Clear resealable sandwich bags, one for each group of students
- Small scale that weighs in grams (can be borrowed from a science teacher)

Introduction

"Reduce, reuse, recycle" are now the three Rs of business. Being innovative and taking the "green" approach to doing business have increased in priority for businesses today. With waste-limiting laws, public image concerns, and scarcer resources, businesses are innovating and finding very profitable ways to produce more and waste less. Businesses are becoming aware that what they are wasting has value. By capturing the waste, they save on both money and materials. Today's leaders in green initiatives are also making big profits because of their efforts in being less wasteful and more mindful.

Procedure

1. Tell the students they will be participating in a production simulation. Before beginning the simulation, ask the students to think about some of the items they have with them and what materials were needed to produce those goods. Instruct the students to pick an item and describe the resources. Record their responses on the board. (*Answers will vary. Example responses may include a T-shirt made of cotton; a pen consisting of plastic, ink, a small spring, and a metal tip; paper made from trees; or bottled water consisting of plastic and filtered water.*)

2. Display Slides 6.2-6.5. Explain to the students that every type of industry depends on three essential resources to produce their good or service. These resources are land, labor, and physical capital. They are known as the factors of production. As you review each slide, be sure to emphasize the examples given for each type of resource as follows:

    - **Land:** Things that occur naturally in and on the earth that are used to produce goods and services. Examples include oceans, air, mineral deposits, virgin forests, and actual fields of land. Land resources are also called natural resources. When investments are made to improve fields of land or other natural resources, those resources become, in part, capital resources.
    - **Labor:** The quantity and quality of human effort available to produce goods and services.
    - **Capital:** Resources and goods made and used to produce other goods and services. Examples include buildings, machinery, tools, and equipment.

3. Display Slide 6.6. Explain that the factors of production come at a cost to producers. The payment for each of the resources is listed on the slide.

4. Display Slide 6.7. Explain that producers have **fixed costs** and **variable costs**. Review the information on the slide.

5. Display Slide 6.8. Discuss the definition of **scarcity** and how it applies to the factors of production. It is because of scarcity of these resources that an economy cannot produce an endless

amount of goods and services. Society's wants for goods and services are unlimited, but we face scarcity; that is, the resources needed to produce all the goods and services we want are limited.

6. Display Slide 6.9. Explain that because of scarcity—wants exceeding the supply of resources—producers must make choices about how to maximize their resources in the production process. Every choice results in a cost, something that is given up. In economics, the highest-valued or most-important option that is given up when a choice is made is referred to as **opportunity cost**. Discuss the following:
   - Give some examples of resources that are increasingly scarce. (*Answers may include oil, fresh water, land, metals, or trees.*)
   - What happens as these resources become scarcer? (*Producers can't produce as many goods and services.*)
   - What happens if producers don't produce goods and services efficiently with these resources? (*Fewer goods and services are produced and resources are wasted.*)
   - What will happen to the price of these resources? (*The price of the resources will increase.*)
   - What will happen to the price of goods and why? (*The price of goods will increase because as producers pay more for their resources, they mostly cover the increased production costs by increasing the price of their goods.)*

7. Explain that when the price producers pay for resources increases, producers earn less **profit** unless they raise the price for which they sell their goods and services. Display Slide 6.10. Explain the definitions and calculations for **revenue** and profit. Tell students that they must know how to do these calculations for the simulation.

8. Arrange the class into groups of two to four students, depending on class size and amount of materials available. Explain that they are all producers of wooden toys. The toys they are producing today are educational toys—shapes for kids. Each group represents a separate company that produces the same type of toys. Because they all make wooden toys, every producer depends on the same resource—wood.

9. Distribute a copy of *Handout 6-1: Round 1—Shapes*, a copy of *Handout 6-3: Calculations Worksheet*, a clear resealable sandwich bag, and a calculator to each group. Distribute two pairs of scissors to each group or ask the students to use their own scissors. Explain that the box on Handout 6-1 represents a sheet of plywood and the number of toy pieces (30) currently being produced from one sheet of plywood this size.

10. Refer to Handout 6-3 and review the costs of production for Round 1 with the students. Explain that given the current supply of wood, each producer will pay $2.50/sheet, and each

group will work with only one sheet for each round. The variable cost for this round will be the waste disposal fee. Calculations will be completed after students complete Step 12 below.

11. Explain that the wooden shapes are sold in sets of three—a triangle, a square, and a circle. For Round 1, each group will work together to cut out each shape and group each set together. As they cut, students should place all the excess paper in the resealable sandwich bag. This represents the waste that results from their production. Allow time for the students to cut out the shapes.

12. Ask the students how many sets they were able to produce from the one sheet. (*Students should answer 10 sets.*) Have the scale ready and tell the students to choose one person from each group to come up with the bag of waste and calculations worksheet. Weigh each group's bag of waste and remind them to record the weight and calculate the **total cost** of waste on Handout 6-3, Line C.

13. Using their calculators (if needed), students should complete Handout 6-3 for Round 1. *Handout 6-3: Calculations Worksheet—Sample Answers* provides an example of what the costs would calculate to if the waste disposal weighed 6 grams. Discuss the following:
    - Look at your bags with the wasted resources. Did disposing the waste cost anything? (*Yes, we paid $0.50/gram for disposing the unused portions of wood/paper.*)
    - How many grams of waste did you have and what was your cost? (*Answers will vary but could range from 6-8 grams and cost between $3 and $4.*)
    - How could you save some of these costs? (*By having less waste*)

14. Ask the students if any group would like to produce more shapes. Hold up the two extra copies of Handout 6-1 and announce that there is an increased demand for wooden shapes. Discuss the following:
    - What will happen to the price of a sheet of plywood as a result of increased demand? (*The price will rise.*)
    - What effect will this have on their costs of production? (*Their costs will rise.*)
    - What will happen to their profit if they continue to sell shapes at the same price? (*It will decrease their profit.*)

15. Distribute one copy of *Handout 6-2: Round 2—Blank* to each group. The blank box represents a sheet of plywood used in the production of wooden shapes. The wood that is used to produce the plywood sheets has become scarcer. As a result, the price of plywood has increased to $3 per sheet, and the waste disposal fee has increased to $0.55. Each set of shapes is still selling for $4.

16. For this Round 2, group members will work together to **innovate** a new pattern for positioning the shapes to maximize their resources and produce more sets that consist of a square, a triangle, and a circle. Students will use one of the sets already produced to trace their patterns on Handout 6-2 so that they are the same size as those produced in Round 1.

17. Explain that their goals are to maximize their scarce resource of plywood, decrease their waste disposal fee by wasting less, and increase their profit even though the cost of the plywood sheets has increased. Students should be sure to produce full sets of shapes as they innovate so that they do not have shapes left over. Have students empty the waste from their bags and put aside their shapes from the first round, except for one set to be used for tracing in Round 2. Students will place the new waste in the emptied plastic bags. Allow time for the students to innovate, trace, and cut out their new sets. Refer to *Handout 6-2: Round 2—Sample Answers* for a possible layout of the shapes. NOTE: It is strongly encouraged that the teacher walk around the room to check each group's progress.

18. Have the scale ready and tell the students to choose one person from their group to come up with the bag of waste and calculations worksheet. Weigh each group's bag of waste and remind students to record the weight and calculate the total cost of waste on Handout 6-3, Line C for Round 2.

19. Review Handout 6-3, Round 2 with the students, allowing time for the groups to work on their calculations. Walk around the room to make sure students are completing the calculations correctly. Handout 6-3 Sample Answers has a sample response using 21 sets of the shapes from Handout 6-1. Discuss the following:

    - Were you able to increase your profit in Round 2? (*Students should report a higher profit if they were able to produce more sets.*)
    - Share with the class your innovative strategies for maximizing the amount of sets you produced. (*Answers will vary.*)
    - Are there alternative uses for the waste in the bags? (*The pieces could be recycled.*)

20. Explain that unstained, engineered woods like plywood can be sent to recycling plants where they are shredded into compost or mulches. Recycling is a very effective way for businesses to decrease their waste and costs because recycling plants usually collect the material at little to no cost.

21. Explain that some companies capture their waste. Capturing waste means taking the waste produced in one part of the production process and using it in another part of the production process. It is a form of recycling. Some students may have some knowledge or ideas about how the waste from the activity could be captured. Discuss the following:

- Considering the definition of capturing waste, what are some ways the extra wood pieces in your bags could be captured for energy? (*Answers will vary. Students may suggest the wood pieces could be burned and used as a form of energy for the business, keeping in mind that the wood does not contain contaminants that are harmful when burned.*)
- If wood chips are not needed, how can other manufacturers use the wood pieces? (*Answers will vary. One way is to sell the leftover pieces to a manufacturer of particle board, which is engineered wood from different scraps of various types of wood.*)

22. Explain that, just as the students did in the activity, many businesses consider their production processes so that they make the most of their resources while increasing productivity and profits. Businesses today need to add environmental thinking to their production strategies.

23. Distribute a copy of *Handout 6-4: Case Study* to each student. Tell them they will be reading a case study that explains what land tipping fees are and gives examples of how some companies have made reducing waste a top priority, which has proved to be efficient, effective, and—most of all—profit increasing. Allow time for the students to read the case study and answer the comprehension questions, and then review the answers as follows:
    - What are land tipping fees? (*Land tipping fees are charges to businesses by waste management companies for the pick-up, removal, sorting, and other operations associated with the waste management process.*)
    - Explain how Apple Inc. increased recycling in its production process. (*When building its new campus, Apple Inc. implemented an effective recycling program that saves the company $1 million per year. In the manufacturing process of all iPhones and Apple watches, recyclable materials are sorted within the production line itself. The company is putting forth many efforts and innovations to have zero waste from the development, production, and selling stages in its production process.*)
    - What are some reasons businesses are increasingly more aware of their waste disposal? (*Businesses look for ways to reduce their production costs, and by decreasing the amount of waste they produce, they can cut what could be a significant cost. Capturing waste has proved to be a more profitable venture than wasting.*)
    - Calculate how much a company would have to pay in land tipping fees if a small manufacturer of wooden puzzles has 200 tons of waste and the land tipping fee is $85 per ton. (*$17,000*)
    - If the wooden puzzle manufacturer hires you as a consultant to study and provide solutions for greener production methods that could decrease its waste and land tipping fees, what solutions might you suggest? (*Answers will vary. Suggestions could include getting together with other producers that use the same resource and coming up with more efficient ways to use the resource. The business could also recycle the excess wood by using it in another product or find ways to maximize every piece of material so that very little, if any at all, is wasted.*)

24. Display Slide 6.11. Discuss some highlights about land tipping fees.

25. Display Slides 6.12-6.14. Referring to Slide 6.12, ask the students if they know what the companies listed produce. (*Tesla: all-electric, zero-emissions cars; Chipotle: burritos and fast, casual dining; Toyota: automobiles; GE's Ecomagination: GE makes industrials such as aircraft engines, power generators, medical imaging machines, and oil and gas production equipment. Ecomagination is the name of their strategic plan to reduce their impact on Earth; Patagonia: outdoor clothing*) Point out that more and more companies are learning that using resources wisely and reducing waste has proved to be very profitable.

Closure

26. Have the students participate in a review activity called "I Have a Question, I Have an Answer." Divide the class—evenly, if possible—and distribute cards from *Handout 6-5: Closure Activity* so that one-half of the class gets an "I Have a Question!" card and the other half gets an "I Have an Answer!" card. NOTE: If not all questions and answers are used, be sure that each question handed out has a corresponding answer.

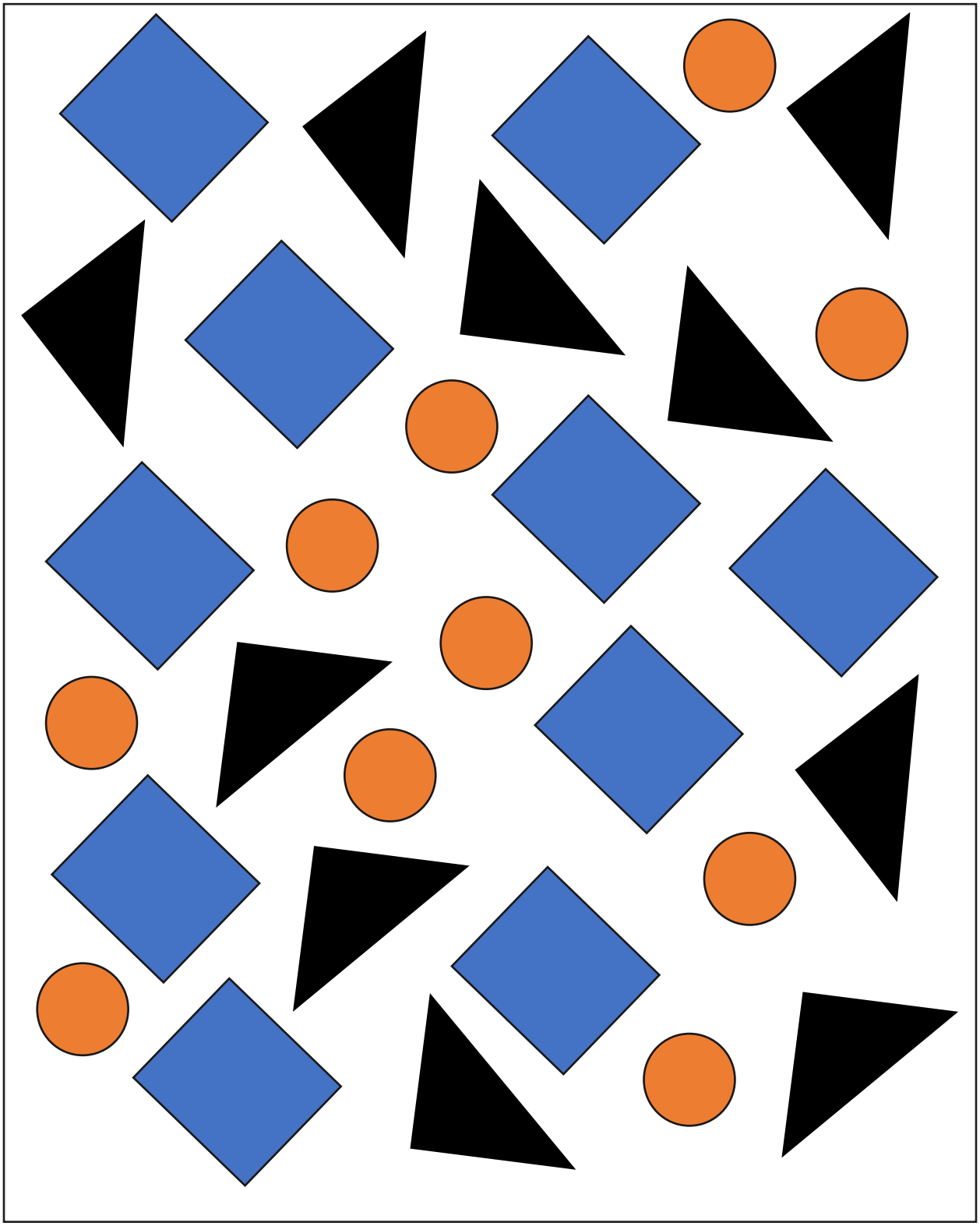
27. Explain that the students who have the question cards will each read their question aloud. The students who have the answers need to listen carefully so that they can both determine if theirs is the one that answers the question and then read the answer aloud. An extra uncut copy of Handout 6-5 can be used as a key for the teacher.

28. Continue the activity until all questions have been asked and answered. For extra review, you can reverse the roles for the students and switch some of the used questions and answers with any unused ones.

Assessment

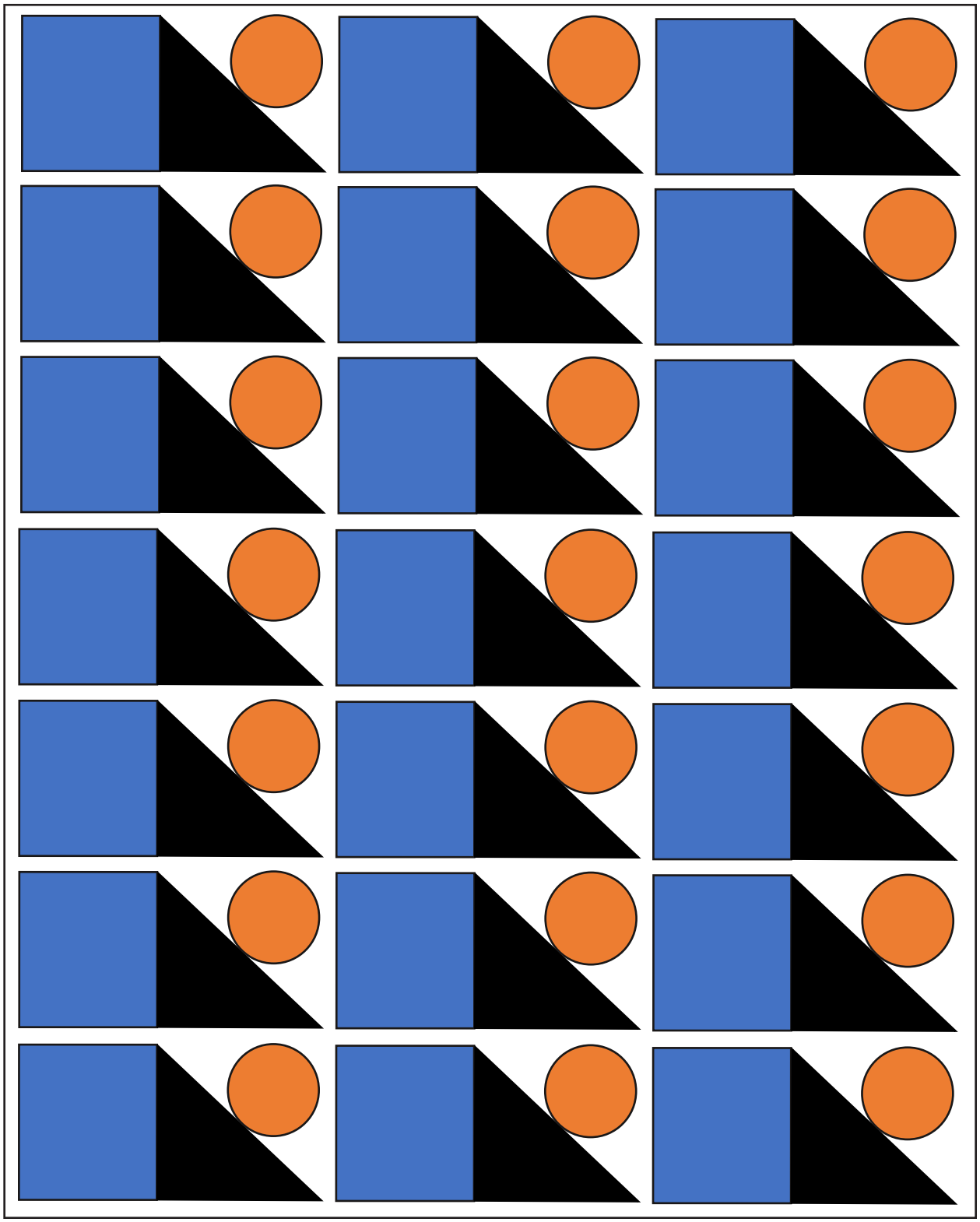
29. Have students research and write a few paragraphs about the waste management efforts of a company of their choice. Their research should specifically highlight what the company produces, how it produces it, and what its savings are from innovating more-efficient forms of production.

Handout 6-1: Round 1—Shapes



Handout 6-2: Round 2—Blank

Handout 6-2: Round 2—Sample Answers



Handout 6-3: Calculations Worksheet

Round 1

Wood sheet = $2.50
Labor per set (circle, triangle, square) = $1
Waste disposal fee per gram = $0.50
Other resources (capital, land) = $1
Each set sells for $4

A. Total sets produced per sheet ..... _____

B. Total sets produced x Cost of labor per set ..... $_____

C. Waste disposal (Grams x Cost) Grams = _____ ..... $_____

D. Cost of wood sheet and other resources..... $_____

E. Total cost (B + C + D) ..... $_____

F. Total sets x Sale price = **Revenue** ..... $_____

G. Revenue (F) – Total cost (E) = **Profit** ..... $_____

Round 2

Wood sheet = $3
Labor per set (circle, triangle, square) = $1
Waste disposal fee per gram = $0.55
Other resources (capital, land) = $1
Each set sells for $4

A. Total sets produced per sheet ..... _____

B. Total sets produced x Cost of labor per set ..... $_____

C. Waste disposal (Grams x Cost) Grams = _____ ..... $_____

D. Cost of wood sheet and other resources..... $_____

E. Total cost (B + C + D) ..... $_____

F. Total sets x Sale price = **Revenue** ..... $_____

G. Revenue (F) – Total cost (E) = **Profit** ..... $_____

Total Profit Round 1: ..... $_____

Total Profit Round 2: ..... $_____

Total Difference: ..... $_____

Handout 6-3: Calculations Worksheet—Sample Answers

Round 1

Wood sheet = $2.50
Labor per set (circle, triangle, square) = $1
Waste disposal fee per gram = $0.50
Other resources (capital, land) = $1
Each set sells for $4

A. Total sets produced per sheet *10*

B. Total sets produced x Cost of labor per set ..... *10 × $1 = $10 (Labor cost)*

C. Waste disposal (Grams x Cost) Grams = ***6*** ..... *$0.50 × 6 = $3 (Disposal cost)*

D. Cost of wood sheet and other resources..... *$2.50 + $1 = $3.50 (Other cost)*

E. Total cost (B + C + D) *$16.50*

F. Total sets x Sale price = **Revenue** ..... *10 × $4 = $40*

G. Revenue (F) – Total cost (E) = **Profit** ..... *$40 – $16.50 = $23.50*

Round 2

Wood sheet = $3
Labor per set (circle, triangle, square) = $1
Waste disposal fee per gram = $0.55
Other resources (capital, land) = $1
Each set sells for $4

A. Total sets produced per sheet *21*

B. Total sets produced x Cost of labor per set ..... *21 × $1 = $21 (Labor cost)*

C. Waste disposal (Grams x Cost) Grams = ***4*** ..... *$0.55 × 4 = $2.20 (Disposal cost)*

D. Cost of wood sheet and other resources..... *$3 + $1 = $4 (Other cost)*

E. Total cost (B + C + D) *$27.20*

F. Total sets x Sale price = **Revenue** ..... *21 × $4 = $84*

G. Revenue (F) – Total cost (E) = **Profit** ..... *$84 – $27.20 = $56.80*

Total Profit Round 1: *$23.50*

Total Profit Round 2: *$56.80*

Total Difference: *$33.30*

Handout 6-4: Case Study (page 1 of 2)

Less Wasteful Waste

Landfills are not free plots of land where waste is collected and nothing is done with the waste. Waste management is a business of its own with operating costs that need to be paid for, just like any other business. Every company, whether it provides a good or service, has a significant amount of waste that needs to be processed and disposed of safely to minimize harm to the environment. Waste management businesses charge other businesses gate or land tipping fees. These are charges that vary based on the type and amount of waste that is collected, and they are used to cover the costs of waste collection, transportation, and sorting. It is usually measured in tons and ranges from $20 to slightly above $100 per ton, depending on where the businesses are located. Hazardous waste disposal fees can be more than 10 times higher.

These fees are a cost that can be decreased, providing businesses with the motivation to innovate more-efficient production methods that result in less waste. These companies look for ways to recycle and reuse their waste in ways that decrease their waste disposal costs, which in turn increases their profits. Collecting materials that can be recycled costs less, and companies use this as an opportunity to innovate other uses for the recycled material. For example, Apple Inc. implemented an active recycling program that saves the company $1 million per year. In the manufacturing process of all iPhones and Apple watches, recyclable materials are sorted within the production line itself. The company is putting forth many efforts and innovations to have zero waste from the development, production, and selling stages in its production process.

Capturing waste—redirecting waste to be used in other parts of the production process within a company's own manufacturing, or selling it to other manufacturers as a resource—has proved for many companies a much more profitable venture than wasting. With society's increasing use of social media outlets, companies are under a finer lens of the public eye, and this is especially true of their efforts to be greener. Image is everything for companies looking to thrive in a consumer world like ours; when consumers feel good about a company's products, they purchase more. There have been proven negative effects on companies that are not cautious about their production and resource management. For example, Conagra Brands Inc., which makes Reddi-Wip® whipped cream, Hunt's® ketchup, and Orville Redenbacher's® popcorn, has been cited as one of the top 10 companies with the worst sustainability record. The company has paid high pollution fines because their Oregon plant exceeded the limit of nitrate pollution disposal, which can harm freshwater sources. Their reputation, through news outlets and online sources, was tarnished some years ago as a result. This in turn can hurt profits. Being green pays, and some companies are not only following government regulation, but going beyond and creating their own initiatives for profit, public image, and non-depletion of the resources needed to produce their goods.

Handout 6-4: Case Study (page 2 of 2)

Comprehension Questions

1. What are land tipping fees?

2. Explain how Apple Inc. increased recycling in its production process.

3. What are some reasons businesses are increasingly more aware of their waste disposal?

4. Calculate how much a company would have to pay in land tipping fees if a small manufacturer of wooden puzzles has 200 tons of waste and the land tipping fee is $85 per ton.

5. If the wooden puzzle manufacturer hires you as a consultant to study and provide solutions for greener production methods that could decrease its waste and land tipping fees, what solutions might you suggest?

Handout 6-5: Closure Activity (page 1 of 2)

I Have A Question! What are the factors of production?	**I Have An Answer!** Land, labor, and capital
I Have A Question! What type of capital is used in the production of vanilla ice cream?	**I Have An Answer!** Factory, blender, pasteurization machine, processing machine, conveyer belt, carboard, and electricity
I Have A Question! What is the form of payment for labor?	**I Have An Answer!** Wages
I Have A Question! Why are goods and services scarce?	**I Have An Answer!** Because resources are scarce
I Have A Question! What is an example of a resource we get from land?	**I Have An Answer!** Natural resources such as air, oil, and mineral deposits
I Have A Question! What is the form of payment for land?	**I Have An Answer!** Rent
I Have A Question! How is revenue calculated?	**I Have An Answer!** Selling price of a good or service × the number of units sold
I Have A Question! What is profit?	**I Have An Answer!** The surplus remaining after total costs are deducted from total revenue

Handout 6-5: Closure Activity (page 2 of 2)

I Have A Question! What is an example of a labor resource?	**I Have An Answer!** The baker at a grocery store
I Have A Question! Businesses can increase their profitability by doing what with their waste?	**I Have An Answer!** Businesses can use their resources more efficiently by capturing their waste and reusing it in other goods in the production process.
I Have A Question! What is the form of payment for land?	**I Have An Answer!** Rent
I Have A Question! Why is capturing waste more profitable than just throwing it away?	**I Have An Answer!** It results in the manufacturer paying less in land tipping fees, producing less pollution, having a better social image, and earning more profit.
I Have A Question! What is an example of a resource we get from land?	**I Have An Answer!** Natural resources such as air, oil, and mineral deposits
I Have A Question! Can you name some companies that are making sustainability profitable?	**I Have An Answer!** Tesla, Chipotle, Toyota, GE's Ecomagination, and Patagonia
I Have A Question! How have companies that looked beyond profit and increased their sustainability efforts performed since 2011?	**I Have An Answer!** Companies that have increased sustainability efforts have outperformed the competition by 11.7 percent.
I Have A Question! What are variable costs?	**I Have An Answer!** Costs of those factors of production that vary as production changes

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 1: Scarcity

Productive resources are limited. Therefore, people cannot have all the goods and services they want; as a result, they must choose some things and give up others.

- **Benchmark: Grade 12**

  1. Choices made by individuals, firms, or government officials are constrained by the resources to which they have access.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

- **Benchmarks: Grade 12**

  1. Acting as consumers, producers, workers, savers, investors, and citizens, people respond to incentives in order to allocate their scarce resources in ways that provide them the most possible net benefit.
  2. Decision making in small and large firms, labor unions, educational institutions and not-for-profit organizations has different goals and faces different rules and constraints. These goals, rules, and constraints influence the benefits and costs of those who work with or for those organizations, and therefore their behavior.

Standard 8: Role of Prices

Prices send signals and provide incentives to buyers and sellers. When supply or demand changes, market prices adjust, affecting incentives.

- **Benchmark: Grade 12**

  2. Supply of a product changes when there are changes in either the prices of the productive resources used to make the product, technology used to make the product, the profit opportunities available to producers from selling other products, or the number of sellers in a market.

Notes

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