

Are You Really Better Off?

Subject Area(s): Reasoning and Proof, Science and Technology

Activity Title: Are You Really Better Off?

Header

Image 1

ADA Description: Graphic of the classic game theory, prisoners dilemma problem

Caption: The prisoners' dilemma is a well-known problem in game theory. It demonstrates how communication between the participants can drastically alter their best strategy.

Image file name: are you really better off_activity_image1.gif

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Prisoners' dilemma		prisoner B	
		confess	remain silent
prisoner A	confess	 5 years 5 years	 0 year 20 years
	remain silent	 20 years 0 year	 1 year 1 year

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Grade Level: 5 (5-12)

Activity Dependency

Time Required: 30 mins. – 45 mins.

Group Size: 4

Expendable Cost per Group: US\$5

Summary

This lesson will introduce students to some environmental issues and how human behavior affects them. Students will recognize that although environmental engineers have many solutions to common problems like air and water pollution, social, economic and policy problems also contribute to the problems. Students also learn that finance, marketing and dealing with people are as essential to engineering as science. Students get a very brief introduction to game theory, which attempts to mathematically capture human behavior in *strategic situations*.

Engineering Connection:

Environmental issues or problems are complex and require many solutions in addition to available technology. Engineers not only use math and science in the design process, but also to model human behavior as it relates to issues and for decision making. Environmental issues are not just technical in nature but are also social issues. The health of the environment is affected by the behavior of the people using it, and the health of the environment affects the health of the people in it.

Keywords:

Environmental issue, social science, natural science, environmental policy

Educational Standards:

PA Science:

3.6.7.A - Explain how human activities may affect local, regional, and global environments*

4.3.7.A - Identify environmental issues and explain their potential long-term health effects (e.g., pollution, pest control, vaccinations)

PA Math:

2.4 - Reasoning

2.6A - Display and/or interpret data shown in tallies, tables, charts, pictographs, bar graphs, and using a title, appropriate scale and labels

Pre-Requisite Knowledge**Learning Objectives:**

After this activity, students should be able to:

- **Identify environmental issues in their communities and globally**
- **Explain how they are affected by the issue**
- **Explain how their choices affect the issue**
- **Identify the implications of the issue (economic, social, environmental, health, etc.)**
- **Understand that the cooperation of all the stakeholders involved in the issue is required for the best outcome**
- **Understand the difference between a natural science and a social science**

Materials List:

Each group needs:

- None

To share with the entire class:

- 2 large bags of candy

Introduction / Motivation:

Environmental engineers use math and science in many different ways. Some of them are more obvious than others. Students know about some of the ways that engineers use math and science to design new devices, systems or processes. (Have students list some of their ideas on the board.) It may be less obvious how understanding peoples' behaviors is important to engineering. Students are also aware of some of the environmental issues in the world. They may be able to list some common problems like air pollution, but not realize that this problem is both social and technical in nature and that engineers must consider both aspects when coming up with feasible solutions. By going through this exercise students become aware that engineering problems are social problems. They also become aware that engineers are interested in human behavior as well as non-human behavior. This can be a really powerful lesson for students to realize that as citizens their behaviors affect what scientists and engineers do.

Vocabulary / Definitions

Word	Definition
natural science	Term used to distinguish those fields that use the scientific method to study nature from the social sciences and the humanities, which use the scientific method to study human behavior and society
Pay-off	A payment or reward
defect	To abandon or turn against; to cease or change one's loyalty.

Procedure:

Background: (Wikipedia 2009)

Game theory is a branch of applied mathematics that is used in the social sciences (most notably economics), biology, engineering, political science, international relations, computer science (mainly for artificial intelligence), and philosophy. Game theory attempts to mathematically capture behavior in strategic situations, in which an individual's success in making choices depends on the choices of others.

The Prisoner's Dilemma constitutes a problem in game theory. It was originally framed by Merrill Flood and Melvin Dresher working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence payoffs and gave it the "Prisoner's Dilemma" name (Poundstone, 1992).

Strategy for the classical prisoner's dilemma:

The classical prisoner's dilemma can be summarized thus:

	Prisoner B Stays Silent	Prisoner B Betrays
Prisoner A Stays Silent	Each serves 6 months	Prisoner A: 10 years Prisoner B: goes free
Prisoner A Betrays	Prisoner A: goes free Prisoner B: 10 years	Each serves 5 years

In this game, regardless of what the opponent chooses, each player always receives a higher payoff (lesser sentence) by betraying; that is to say that betraying is the strictly dominant strategy. For instance, Prisoner A can accurately say, "No matter what Prisoner B does, I personally am better off betraying than staying silent. Therefore, for my own sake, I should betray." However, if the other player acts similarly, then they both betray and both get a lower payoff than they would get by staying silent. Rational self-interested decisions result in each prisoner's being worse off than if each chose to lessen the sentence of the accomplice at the cost of staying a little longer in jail himself. Hence a seeming dilemma.

In environmental studies, the Prisoners Dilemma is evident in crises such as global climate change. All countries will benefit from a stable climate, but any single country is often hesitant to curb CO2 emissions. The benefit to an individual country to maintain current behavior is greater than the benefit to all countries if behavior was changed, therefore explaining the current impasse concerning climate change.

Before the Activity

- This is a class activity. Divide the class into groups of four or five students. The only requirement is that you have a functional group – meaning the group can come up with a decision in a reasonable amount of time. If the class requires less groupings, modify the payoffs so that all scenarios are represented for the number of groups.
- Before the activity: List the pay-offs on the board. For six groups use the following scheme.

C-C-C-C-C-C	6-6-6-6-6-6
C-C-C-C-C-D	5-5-5-5-5-10
C-C-C-C-D-D	4-4-4-4-9-9
C-C-C-D-D-D	3-3-3-8-8-8
C-C-D-D-D-D	2-2-7-7-7-7
C-D-D-D-D-D	1-6-6-6-6-6
D-D-D-D-D-D	5-5-5-5-5-5

- For four groups use the following scheme.

C-C-C-C	4-4-4-4
C-C-C-D	3-3-3-5
C-C-D-D	2-2-4-4
C-D-D-D	1-4-4-4
D-D-D-D	3-3-3-3

C stands for cooperate and D stands for Defect.

With the Students

1. Break the class up into groups.
2. Tell the class that they need to decide whether their group is going to cooperate or defect. They will get the listed payoff in number of pieces of candy, based on the outcome of the choices from the other groups.

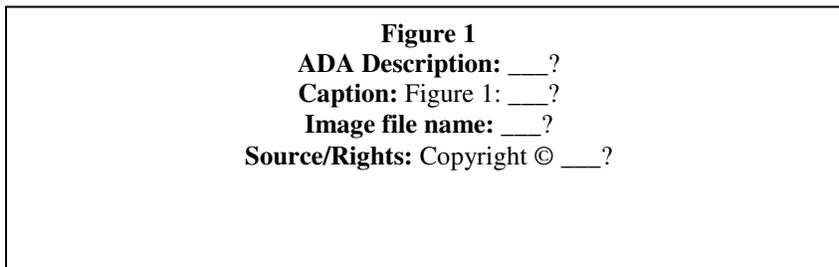
For example:

If the class is broken up into four groups and a group decides to cooperate and the other groups decide to defect then the group gets 1 piece of candy and the other groups get four pieces each.

If the class is broken up into six groups and two groups decide to cooperate and the other four groups decide to defect then the groups that cooperate get 2 pieces of candy and the groups that defect get 7 pieces of candy.

3. Repeat the voting among groups several times. Explain more and more about the game during each round based on the results. Show the students that everybody is better off when they cooperate because the total payoffs decrease by one as groups defect.

Image



Attachments

Investigating Questions

1. Name some environmental issues that you may be aware of. [Students might say pollution (air and water), Global warming, use of non-renewable resources, etc.]
2. Ask the students what kind of solutions they think would help the problem. [See if students can get to the conclusion that cooperation among interested parties might help.]
3. Ask the students what are the advantages and disadvantages of cooperating to the interested party and what are the advantages and disadvantages to society.
4. See if the students can identify differences. Give an example if necessary: for instance, reducing emissions will contribute to a cleaner atmosphere, but might reduce productivity, industrialization and have negative economic factors. If every company did it than it would not be unfair an unfair situation, but if some did and others didn't than the ones that did would be at a disadvantage and society as a whole would also be disadvantaged.
5. Another example might be global warming and the Kyoto Protocol.

Assessment:

Pre-Activity Assessment

Title: Ask the students to list some environmental issues in the world as well as in their local community. Ask them to list some solutions that they think would help. (e.g. recycling paper from their classroom, water and air pollution, alternative energy, global warming, etc.)

Activity Embedded Assessment

[Monitor the votes of each group. Ask the student why they think the overall payoffs decrease as groups defect. Keep playing until they get it (or the candy runs out.)]

Post-Activity Assessment

Environmental Issues Essay: Have the students write an essay elaborating on one of the issues they identified earlier and explain how cooperation of people (i.e. countries, citizens, students, etc.) could help to solve the problem.

Activity Extensions:

Have the students research an environmental issue in their community and identify their state or local representative on the internet. Ask them to write a letter asking the representative to support their position based on their new understanding of the issue and what is involved in finding a solution.

References:

Wikipedia.com, Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a U.S. registered 501(c)(3) tax-deductible nonprofit charity. – Prisoners’ Dilemma; URL: http://en.wikipedia.org/wiki/Prisoners_Dilemma#In_science Accessed: January 5, 2009

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