

Teacher's Guide

The purpose of this lesson is to introduce students to the idea of the “Tragedy of the Commons,” an extended metaphor for problems of shared environmental or man-made resources that can become overused and eventually depleted. In this metaphor, shared resources are compared to a common grazing pasture, or a “commons,” on which any dairy farmer can graze as many cows as he/she wishes. If too many cows are added to the commons, they will overeat the grass in the pasture and the shared resource will become unusable – a disadvantage to everyone. But the farmers have other options – there are multiple ways they can work together to avoid a “tragedy” of the commons! In this lesson, students will be inspired to think about possible solutions to this problem. To get there, they will use basic math to frame the problem and will discover how useful this can be in considering consequences of various actions. Most importantly, they will become comfortable with the concept of problems of shared resources – and will learn to recognize, and seek out, examples all around them.

The metaphor of the Tragedy of the Commons has relevance in scientific fields such as ecology and economics. It is extremely significant in today's world where many of the problems of shared resources have only recently begun to really matter as a result of rapid population growth and clustering. When our grandparents were growing up, major global issues such as fishery depletion, global warming, air and water pollution, plastic accumulation in the oceans, and overcrowding of telecommunication connections were not things they had to worry about. Today, issues such as these abound, threatening to dominate our lives and the lives of our children in coming decades. In this lesson, we want students to become profoundly aware of the behaviors that lead to these problems, which need to be examined closely to be truly understood. We use the metaphor of cows on the commons because it is a fun way to illustrate an example problem and its causes, not to mention the namesake of the problem! It is also a good setting for bringing in some math, which is especially useful for understanding limits.

First and foremost, we want students to understand that there are very real limits to the number of cows that a pasture can sustainably support, even if it can physically support more. In the case of the cows on the commons, there is a specific threshold below which adding a cow benefits that farmer and has no impact on the others, and above which each cow added has negative impact on all others...and eventually on the farmer who added the cow. This threshold is the “optimal carrying capacity” of the field, or the amount that it can best support. We ask students to think about examples of functions that depict this increasing-decreasing behavior, then produce a few of our own (with further examples in the accompanying animation). While we would encourage you to work with your students to think critically about the different aspects of the functions that should be depicted, it is most important that they understand this increasing (up to a point) – decreasing (after that point) behavior.

We also introduce the logic and a bit of the psychology behind what we consider to be the most critical aspect of understanding the tragedy of the commons problem: the individual choice-maker's decision to add an additional cow when the commons is already above capacity, and given he knows that more milk cannot be produced from the commons on the whole. At this point, we already understand that such an action is against everyone's long-term best interest, including the farmer adding the cow. What we want to get across, then, is why and when (under what conditions) such a decision actually does make sense to an individual farmer acting in his own best interest. We also bring up the more subtle point of why it might be difficult for him to make any other decision.

But, all hope is not lost, and we love getting to the part of the lesson where students can come up with ways to prevent the tragedy from continuing, or from happening at all! This is a place in the lesson where creativity

can really shine, as students are pushed to think of ways the farmers and their communities can work together to create policies that will prevent the tragedy of the commons from unfolding. Of course, it will be important to emphasize to your students that any mitigation measure has its advantages and disadvantages. Another more subtle, yet equally important, point here is that problems of shared resources are dilemmas without a solely technical solution. The math we introduce here is important because it helps us to understand the consequences of various actions, allowing us to base the discussion of possible mitigation measures on the real ‘physics’ of the problem and its possible outcomes. But eventually, it is individuals working together that can solve the problem – and this can prove to be the most complex part of the solution! The animation that accompanies this lesson is an excellent resource for students to technically explore specific examples of the impact of various solutions on outcomes. It falls short, however, in illustrating the social or psychological complexity that accompanies people working towards solutions on problems of this size.

We end the lesson by asking the students to come up with examples of problems of shared resources that are particular to their community, city, country, and the world at large. This is a great opportunity to focus on problems that are especially relevant to you and your students.

Here are some useful things to keep in mind as students work through the activities:

- We ask students to work in groups of 4, but groups of 3 to 5 should work well too; you know best what will work for your class.
- You may use anything you’d like for the prize in the final activity of the Tragedy of the Commons lesson. Perhaps something that exemplifies sustainability would be a nice choice, such as reusable water bottles. But (socially-conscious) chocolate is always a nice prize as well!
- This lesson comes with an accompanying animation that serves two main purposes: to help students to realize the connection between a functional form and the scene on the commons that it is describing (in terms of milk output according to grass availability), and to allow students to explore the impact of a select set of policy decisions for avoiding the tragedy. We highly recommend using this animation in conjunction with the video lesson.

“Tragedy of the Commons” problems are avoidable tragedies, if we know when and how to recognize them, and if we can work together to prevent them. We hope that by exposing students to this lesson, they will develop a very clear understanding of what these types of problems are, enabling them to recognize them in their day-to-day life. The video lesson shows students how they can use simple math to characterize one example of this type of problem, and to help them to consider the consequences behind multiple actions. By understanding what causes these problems, and thinking through different methods to mitigate, solve, or prevent the problem that directly address those causal factors, students should be inspired to think creatively about multiple ways that people can work together to make the world better – while at the same time gaining respect for the complexities involved in bringing these solutions to fruition. But, at the end of the day, we want students to know that they can come up with solutions to the commons problem themselves – and it is indeed they who will be solving these problems in the future!