## OSU_COE_horizontal_2C_O_over_B.epsLesson Description

Gone Fishin’

Systems Thinking Skills

## Levels

Grades 6-8

## Content Areas

Systems Thinking

## Lesson Time

45 minutes, with optional extensions.

## Next Generation Science Standards

* MS-ESS3-3 – Apply scientific principles to design a method for monitoring and minimizing human impact on the environment
* SEP-2 – Developing and using models
* CC-2 – Cause and effect

## Learning Objectives

Students will be able to:

* Draw basic relationships between elements or parts in a system
* Describe basic features of a relationship between parts through labelling or cause-and-effect.
* Identify examples of the “Tragedy of the Commons” archetype

## Materials

* Opaque container for holding objects (e.g. a tin can)
* ~200 coins or other small objects
* Small Post-it Note Pads (one per team)
* Small paper cups (one per team)
* Lesson worksheet printouts

This lesson provides students with an introduction into systems thinking, in particular the identification of relationships between elements through the classic systems archetype of “The Tragedy of the Commons.” This archetype describes a situation where a shared resource is used by various individuals who act only to fulfill their own self-interest. With this behavior acting against the common good, the shared resource is typically depleted or spoiled, and everyone suffers. Through the modelling of the system and a focus on relationships within the system, students will learn to understand the behavior of this archetype and ways to modify system to achieve more positive outcomes.

## Using This Lesson

This lesson consists of 2 primary parts and 2 extensions. Part 1 runs through an iteration of the Harvest activity, where teams of students acting as fishing companies compete to catch the most fish from a shared resource. Part 2 debriefs the results of the simulation, introduces the systems thinking concept of relationships, and walks students through a modelling activity where students draw relationships between the elements to understand the archetype. Part 3 runs through the simulation again with new rules the class generates. Part 4 provides examples of additional Tragedy of the Commons problems.

This lesson is a part of a series of lessons teaching the fundamentals of systems thinking.

## Importance of This Lesson

It is important to teach systems thinking for a couple of reasons.

1. As a society, we are faced with increasingly complex, systemic problems, it is important for all people to be equipped with the skills necessary to solve these problems. Systems thinking provides the fundamental basis for all skills related to approaching these systemic problems.
2. DSRP provides students a vocabulary to think about their own thinking—metacognition. When one is aware of the way in which they think, they are able to monitor their own thinking and find opportunities for developing better or new ways to approach problems.

# Content Background

## Systems Thinking Overview

What is systems thinking? Systems thinking is the method of thinking used to think about systems. It is based in four basic rules, described below with their accompanying co-implication:

* **Distinctions Rule:** Any idea or thing can be distinguished from the other ideas or things it is with (thing-other).
* **Systems Rule:** Any idea or thing can be split into parts or lumped into a whole (part-whole).
* **Relationships Rule:** Any idea or thing can relate to other things or ideas (action-reaction).
* **Perspectives Rule:** Any thing or idea can be the point or the view of a perspective (point-view).

These four rules (abbreviated to DSRP) are applied in parallel in systems thinking and can be found as the basis for practically all forms of thinking and methodologies related to systems.

## The Tragedy of the Commons

This lesson provides students with an example of the classic systems archetype, “The Tragedy of the Commons.” This archetype is used to describe a situation in which a shared resource is used by individuals to only forward their own selfish goals, contrary to the common good; this in turn leads to the degradation and/or depletion of the common resource. Examples include:

* Fishing companies acting individually to overfish a population of fish, leading to the degradation of the fish population.
* Logging activities operating faster than the rate of regeneration, leading to deforestation.
* Commuters sharing the resource of highways and freeways, leading to traffic congestion.
* Members of the community sharing the swimming pool, leading to overcrowding.
* Individuals and companies sharing the resource of the atmosphere, with all parties adding pollutants and emissions, contributing to climate change and air quality issues.

This problem can be approached through the lens of systems thinking by identifying elements within this problem and drawing relationships between these elements. By understanding these relationships and the role of feedback loops and cause and effect through this system, opportunities for improvement can begin to present themselves. In the example of the Tragedy of the Commons, typical solutions require setting up a regulating body or policy system in relation to the individual actors (e.g. the Environmental Protection Agency) to improve communication and set limits on greed. This regulates the rate of consumption to ensure the preservation of the commons.

Gone Fishin’

# Materials List

* An opaque container for holding the objects (e.g. a tin can or large cup)
* ~200 coins (to represent resources)
* One pad of small sticky notes per team (for submitting fishing orders)
* One small paper cup or similar container per team
* One worksheet per student
* The teacher tracking table Excel file (for documenting results)
* Writing utensils for students

# Preparation Instructions

1. Place 50 coins into the container
2. Split students into 3-5 teams.
3. Write a team number on the inside of each cup. Give each team one cup (their ship) and pad of sticky notes.
4. Give each student the first worksheet with Part 1 content.

# Lesson Outline

The steps listed in this outline are also reflected within the PowerPoint presentation.

## Part 1 – Running Harvest

1. Introduce students to the Harvest game [introduction in slides].
   1. The teacher may read this introduction to students: “Congratulations! You and your team are the proud brand-new owners of a small fishing company! Your goal as a fishing company is to try to catch the most fish over the next few years to earn the most money.”
2. Game rules [posted in slides]:
   1. There will be 6-8 rounds (depending on the amount of time available), each representing a year’s worth of fishing.
   2. Catching Phase:
      1. For each round, each team will have 1 minute to determine how many fish they want to catch. They will write the number of fish desired on a slip of paper, put it in their ship, and submit it to the teacher.
      2. The teacher will shuffle these up and choose to fulfill them in random order. **It is important not to read the order out loud.** If there are not enough fish to meet the order, the order will not be filled.
         1. As each order comes in, input the order into the teacher tracking table. *Instructions for usage are in the tracking table file.*
      3. Return ships when completed. **The teacher should not share how many fish were caught by each team.** There are no restrictions on how teams may communicate between each other.
3. Regeneration Phase:
   1. Each team will tally the number of fish they received and decide on their next catch.
   2. The teacher will refill the fish population based on following rules:
      1. The fish population is capped at 50 fish. It regenerates by doubling the population each year, but is capped at 50 fish (e.g. if there are 30 fish left in a year, just refill to 50).
4. After reading the rules, provide students with 2 minutes to come up with an initial long-term strategy.
   1. **It is highly recommended to tell teams not to talk to each other.**
5. Possible outcomes:
   1. Students are greedy and quickly go through the entire fish population in a couple rounds. You may stop the game after an additional couple of rounds to allow teams to experience the consequences of their actions.
   2. Students adopt a strategy that will allow the fish population to be maintained. You can stop the game after that point as well. This is unlikely if teams cannot talk to each other.
   3. It typically takes 6-8 cycles before teams will fully experience the consequences of their actions.

## Part 2 – Debrief & Systems Thinking Lesson

1. Review the results of the game.
   1. Put up the graphs and let students interpret the results. Take 2 minutes to answer the debrief questions on their worksheet and then discuss as a class.
   2. While students are writing, pass out the next worksheet on modelling the system.
2. Transition to the systems thinking lesson: “We have some general ideas about what happened, but now let’s figure out how to think about the game more like scientists and engineers. We’re going to use something called systems thinking.”
   1. Introduce the basics of what a system is:
      1. “In our game, we were all part of a system. Could someone tell me what a system is?” Get 2-3 responses.
      2. “Here is one definition of a system: ‘A system consists of parts (elements) that interact with each other (relationships) to produce a certain behavior/function or accomplish a certain goal.’”
      3. Show examples of systems.
   2. Have students identify relationships in the system. Students may work individually, in pairs, or as a team.
      1. “On your worksheets, you’ve been provided some of the elements to the system.” Explain what these components are. “Just having the elements to a system is not enough, of course. *The key to the way a system behaves is in it’s relationships.* Individually or within your team, try to draw some of the relationships between the elements. Be descriptive of those labels as well!
      2. After approximately 5 minutes, have students share out some of the interactions they observed. Key interactions include:
         1. The Fish Population determines the Regeneration Rate
         2. The Individual Amount of Fish Demanded determines how many fish are removed from the fish population.
         3. The Actual Amount of Fish Caught determines the next Amount of Fish Demanded.
            1. This may not be the case for some teams, depending on their strategy (especially if they were the greedy team).
      3. Finally, discuss as a class how these interactions played out over time to result in the behavior that we observed in the system.
         1. **The key feedback loop**: as more fish are removed from the population, we reach the 25 fish threshold and less fish can regenerate over time. This is quickly worsened if the amount of fish caught does not affect the order for fish.
3. Now transition to a discussion on how we could change the game to have everyone benefit and prevent total system collapse.
   1. Initial question: What is the maximum number of fish that could be caught over 8 years?
      1. Calculation: Maximum possible number of fish that could’ve been caught over 8 rounds (8 \* 25 = 200).
   2. Guiding questions for this discussion:
      1. How might the goal of the game (maximize your own company’s profits) need to change?
      2. What elements of the system weren’t interacting?
         1. Examples: Communication between teams, amount caught and the amount desired, amounts caught between teams were not communicated
      3. What elements or rules might be added to the system to improve behavior? What would these interact with? Potential solutions include:
         1. Changing the goal of the game to having the community as a whole maximizing their gains
         2. Having teams coordinating their catches to make sure no one exceeds the limits of the fish population (creating relationships between teams)
         3. Having a centralized authority that regulates how much fish each team can take (creating a new element with relationships to the demand of each team)

## Part 3 – Second Run

This part of the lesson is optional based on time availability. It will likely take approximately 15 minutes to go through a second iteration of the lesson.

1. Using the new rules, go through a second run of the game.
2. After the run, have another debrief as a class.
   1. Guiding questions:
      1. What happened?
      2. What worked better than before? Did anything work worse?
      3. Are there more changes that need to be made?
      4. How long would this system be able to go on for?

## Part 4 – Tragedy of the Commons

This last part of the lesson provides an introduction to the Tragedy of the Commons archetype. There are two ways to modify this section. One may either a) run through a list of examples on the Tragedy of the Commons or b) have students work on the third worksheet containing the Tragedy of the Commons table to figure out examples.

1. Provide a closing lesson on the Tragedy of the Commons archetype
   1. Definition: “This game provides an example of the Tragedy of the Commons archetype. This is when a shared resource is used selfishly by a bunch of individuals without considering the public good, which eventually leads the spoiling the resource for everyone.”
   2. Option a) – Run through list of examples

|  |  |  |  |
| --- | --- | --- | --- |
| **Example** | **Shared Resource** | **Users** | **What Happens** |
| Overfishing | Fish Populations | Fisherpeople, Fishing companies | Individuals try to catch as much fish as they can for themselves without considering others’ needs or the fish regeneration rate |
| Crowded Swimming Pools | The public swimming pool | Community Members | Everyone wants to go swimming, and there ends up being no room for anyone to actually have fun. |
| Traffic Congestion | Roadways, Freeways, Highways, etc. | Individual Commuters | Everyone wants to use the road to get to where they need to go but end up clogging up the road; no one can get anywhere! |
| Earth’s Atmosphere | The Atmosphere | Individuals, Companies | Everyone dumps pollutants and greenhouse gas emissions into the atmosphere, eventually ruining the environment for all community members. |

* 1. Option b) – Have students fill out the Tragedy of the Commons table worksheet.
     1. Further options for modifying this include:
        1. Have every team work through all of the rows themselves.
        2. Turn this into a jigsaw activity where, in the first round, students investigate one of the rows, and in the second round, share out their individual findings.
        3. Depending on time constraints, this may even be assigned as homework.
  2. “Solutions to the Tragedy of the Commons include:
     1. Educate users so everyone understands the consequences of using up the resource.
     2. Strengthen the feedback loop between the condition of the resource and the decisions of the users.
     3. Create an entity with the power to regulate access to a resource.
     4. Privatize a resource so users feel the consequences of abusing the resource.
  3. “Do you see how our solutions match up with these?”

Optional: Bonus video to show a solution to the Tragedy of the Commons from conservation: [How a handful of fishing villages sparked a marine conservation revolution | Alasdair Harris](https://www.youtube.com/watch?v=3-mhddgkaJc)

Gone Fishin’ – Student Worksheet

**Your Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Team Member Names:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Team Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Introduction:**

Congratulations! You and your team are the proud brand-new owners of a small fishing company! Your goal as a fishing company is to try to catch the most fish over the next few years to earn the most money.

# Part 1 – Run the Game

**Order Example**

**Round rules:**

Team Number

15

* 1 round = 1 year.
* [1 min] Determine # of fish to catch.
* Orders filled randomly.
* Order too much? No catch!
* Keep track in table on the back

Number of Fish

**Fish regeneration rules:**

* Population doubles at end of every year…
  + BUT it’s capped at 50.

*Discuss your team’s strategy for catching fish and write down your approach here:*

**Score Keeping Table:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Round Number** | **Fish Ordered** | **Fish Caught** | **Notes on the round** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| **Total Fish Caught** | |  |  |

# Part 2 – Debrief

Answer the following questions individually, then share with your team after a few minutes:

*What happened to the fish population over time?*

*How did orders change over time? Why?*

**Your Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Model the System**

Work by yourself, in pairs, or as a team to model interactions within the system.

*Draw lines between parts to show relationships. Label these relationships like the examples from the presentation. How did one thing affect another? You can also add additional parts that you think would help model the system better.*

**How can we improve the system?**

Here are questions to think of for this part:

* *What is the maximum number of fish that could be caught over 8 years?*
* *Add elements?*
* *Add/change relationships?*

# Part 3 – Run the Game Again

**Score Keeping Table:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Round Number** | **Fish Ordered** | **Fish Caught** | **Notes on the round** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| **Total Fish Caught** | |  |  |

# Part 4 – Tragedy of the Commons

**Your Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Our game provided an example of the Tragedy of the Commons archetype. This is when a shared resource is used selfishly by a bunch of individuals without considering the public good, which eventually leads the spoiling the resource for everyone.

Work individually or with your team to identify the parts of the common scenarios below. Maybe you can even find one or two scenarios yourself!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scenario** | **Shared Resource** | **Users** | **What happens in this situation?** | **What are potential fixes?** |
| Overfishing | Fish | Fishing Companies | Individuals try to catch as much fish as they can for themselves without considering others’ needs or the fish regeneration rate. This collapses the fish population. | Create a central government body that limits the fish catch; educate the companies so they understand how much they can take. |
| Crowded Swimming Pools |  |  |  |  |
| Traffic Congestion |  |  |  |  |
| Groundwater Usage |  |  |  |  |
| Earth’s Atmosphere |  |  |  |  |
|  |  |  |  |  |