



Gone Fishin'



Systems Thinking Skills

Levels

Grades 6-8

Content Areas

Systems Thinking

Lesson Time

50 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

Lesson Description

This lesson provides students with an introduction into systems thinking 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, eventually destroying the shared resource. Through the modelling of the system and a focus on relationships within the system, students will learn to see how understanding interactions in a system is crucial to understanding its behavior.

Using This Lesson

This lesson consists of 4 parts. Part 1 runs through an iteration of the Gone Fishin’ game (modified from the Harvest activity in Sweeney & Meadows (1995)), where teams of students acting as fishing companies compete to catch the most fish from a shared resource (a resource they will likely end up destroying). Part 2 debriefs the results of the simulation, introduces the systems thinking concept of relationships, and walks students through a modelling activity. Part 3 (optional) 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 for students to understand systems thinking for a couple of reasons.

1. As a society, we are faced with increasingly complex, systemic problems. Systems thinking provides the fundamental basis for all skills related to solving these systemic problems.

2. These lessons teach students a vocabulary to think about their own thinking—metacognition. When one practices metacognition, they are able to monitor their own thinking and find opportunities for developing better or new ways to approach problems.

3. Being able to recognize key relationships in systems is vital to being able to understand how the behavior of a system emerges. This provides the guidance for a person to figure out which part of the system to change to get better results.

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 (Cabrera & Cabrera, 2015, p. 52).

Relationships Overview

The relationships rule of DSRP describes how we identify relationships (also referred to here as interactions) between parts of a system. These relationships typically consist of an action and a reaction, what A does to B and what B does to A. Understanding relationships within a system is crucial to systems thinking as it is from these interactions that the behavior of a system begins to emerge. A bicycle system has a biker exerts a force on the pedals, which is transferred through the chain and gears to the wheels, which interact with the ground to produce locomotion. Muscle cells receives signals from nerve cells to contract and exert force on other muscle cells and our skeleton, producing movement. Employees of a company interact through social and technical means to carry out the mission of the company and serve customers.

Understanding the connections between the parts of a system allows one to better understand the system as a whole and identify opportunities for changing the system through modifying existing relationships in the system structure. Changing the gear ratio in the transmission changes your car's performance and efficiency. Speeding up the feedback loop between student work and teacher feedback can improve learning. All types of systems methodologies (and thinking in general) require identifying relationships within a system.

The Tragedy of the Commons

This lesson provides students with an example of the classic systems archetype, "The Tragedy of the Commons" (Meadows, 2008). 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 cause and effect through this system, opportunities for improvement can begin to present themselves. In the example of the Tragedy of the Commons, the primary reason for the system behavior is the lack of feedback or interaction between the state of the resource and the demand of the individuals (e.g. fishing companies do not act within the bounds of the fish population's regeneration limit, effects of polluting the atmosphere are not felt until decades later, etc.). 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
- Worksheets for students (which to print depends on the lesson variant.)
- The teacher tracking table Excel file (for documenting results)
- Writing utensils for students

Preparation Instructions

1. Lesson prep:
 - To prepare the slides, hide all slides in the corresponding sections that you are not using.
 - Print worksheets that correspond to the sections you are using.
 - It is recommended to set your display to extend so that you may display the PowerPoint on the projector and have the teacher tracking table open on your computer.
 - Familiarize yourself with filling in this table before you start. Make sure that students do not get to see it as you play the game; it will mess up the entire activity!
2. Game prep:
 - Place 50 coins into the container
 - Split students into 3-5 teams.
 - Write a team number on the inside of each cup. Give each team one cup (their ship) and pad of sticky notes.
 - 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. The slides are grouped in sections which reflect the outline provided here.

This lesson has three parts.

Part 1 consists of running the "Gone Fishin'" simulation.

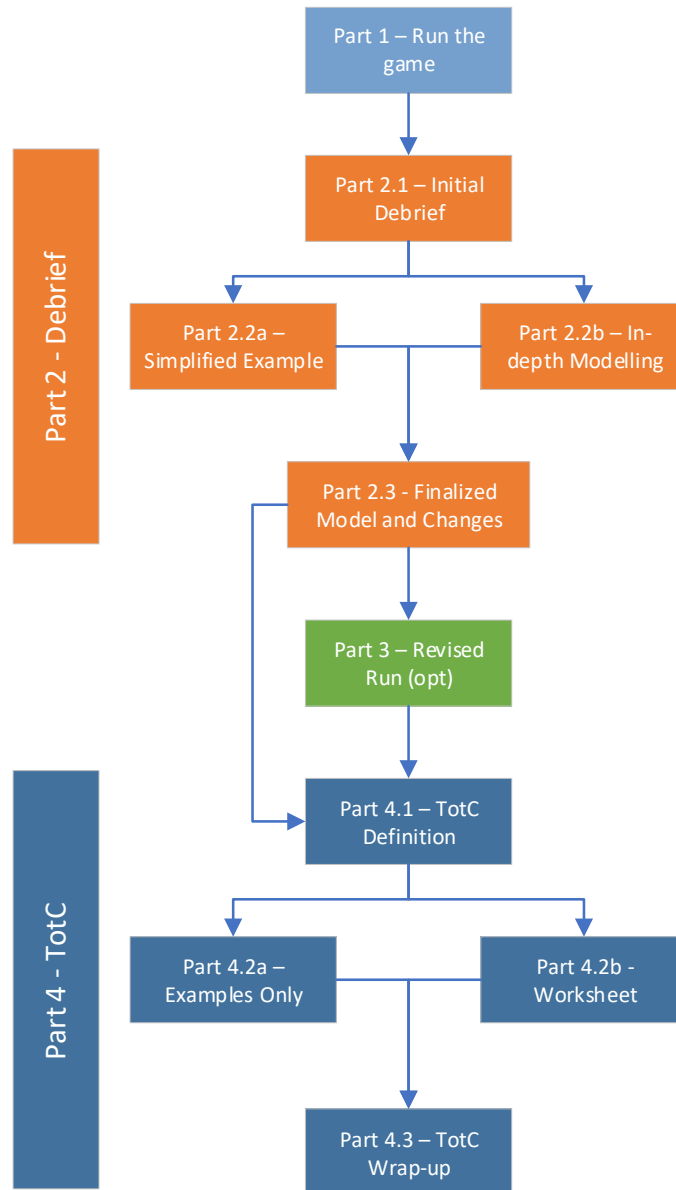
Part 2 consists of a debrief of the simulation and a lesson on the relationships aspect of systems thinking. Part 2 has two versions: the simplified version, 2.2a, has students model basic relationships found within a classroom, then walks through the model of the game. The complex version, 2.2b, has students attempt to draw relationships in the classroom as well. This second version is much more difficult and requires more time.

Part 3 requires running the game again with modifications to the system that the class creates. This part is optional and is dependent on your available time.

Part 4 is a lesson on the Tragedy of the Commons archetype. It also has two variants: the default (4.2a) is to go through a lecture/in-class discussion of examples of the archetype; the alternative (4.2b) has students complete a worksheet to try to characterize different Tragedy of

the Commons situations. The second version is also more difficult and requires more time; there is potential to assign the worksheet as homework if desired.

The flowchart below summarizes the components of this lesson, as well as the different variants that may be taken. The final lesson may be run in approximately 50-90 minutes depending on the variants chosen. The default structure of this lesson uses parts 2.2a and 4.2a and skips part 3 to yield a 50 minutes lesson. The alternative components are written in the "Alternatives" section.



Part 1 – Run the game

1. Introduce students to the Gone Fishin' game.
 - a. 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:
 - a. There will be 6-8 rounds (depending on the amount of time available), each representing a year's worth of fishing.
 - b. Catching Phase:
 - i. 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.
 - ii. 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.*
 - iii. 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.
 - c. Regeneration Phase:
 - i. Each team will tally the number of fish they received and decide on their next catch.
 - ii. 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).
3. After reading the rules, provide students with 2 minutes to come up with an initial long-term strategy.
 - a. **Tell teams not to talk to each other.**
4. Play through the game. Possible outcomes:
 - a. 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.
 - b. 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 highly unlikely if teams cannot talk to each other.
 - c. It typically takes 6-8 cycles before teams will fully experience the consequences of their actions.

Part 2 – Debrief & Systems Thinking Lesson

This section provides opportunities for discussion and debriefing the activity. Part 2.2a is a more simplified example that should be faster to run through than part 2.2b. The primary goals of this lesson are to show that relationships are key to a system’s behavior and to have students try their hand at modelling relationships within a system.

Part 2.1 – Initial Debrief

1. Review the results of the game.
 - a. 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.

Expected Responses

Question	Typical Response (<i>may only describe the behavior at a basic level</i>)	Detailed Response (<i>describes the behavior in greater detail and/or notes additional cause and effect</i>)
<i>What happened to the fish population over time?</i>	The fish population decreased	The fish population decreased quickly and then levelled off
<i>How did orders change over time? Why?</i>	The orders got smaller	The orders got smaller over time because we weren’t catching fish so we had to adjust

- b. Ask the question, “Did anyone REALLY win?” This helps students consider the real-world implications of this system behavior.
 - i. Generally, you can guide folks towards the answer of “Within the rules of the game, yes, but in the real world, we’d all run out of fish and starve.” Then you may ask about what would be a better goal for the game, which is something along the lines of “Still getting good yields from the system while not destroying the fish population.”
 - c. While students are writing, pass out the next worksheet on modelling the system.
 - i. Use the worksheet for part 2.2a that shows the example of a classroom. “(2.2a)” is also shown in the top left corner.
 - ii. If doing 2.2b, use the worksheet that shows only the parts of the entire system. “(2.2b)” is also shown in the top left corner.
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.”
 - a. Introduce the basics of what a system through the example of a car:
 - i. Ask the question: “If I take apart all the parts of the car, would I still have a car system? Why or why not?”
 1. Answers should generally align with the fact that none of the parts are connected or **in relationships** anymore. As such, the system doesn’t exist.
 2. Here, the teacher may highlight the key insight: “So there is more to a system than just having all the parts. The relationships between the parts is key!”
 - b. Define relationships/interactions
 - i. They usually contain cause-and-effect, action reaction
 - ii. They may contain physical connections or flows, or information flows.

- c. The teacher can now provide a 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.”
- d. Returning to the example of the car, demonstrate how the parts of a car have relationships which together exhibit movement behavior.

Part 2.2a – Simplified Example

1. Have students use the worksheet to draw relationships between components in a classroom system. Give them 2-3 minutes to draw as many relationships as they can.
 - a. During this time, it is recommended to walk around and help emphasize drawing arrows and labelling the relationships.

Possible Responses

Incomplete	Basic	Intermediate	Advanced
No relationships are drawn between components	Some lines are drawn between parts. They may not be labelled and not all parts may have relationships drawn.	Each part is drawn with at least one relationship. Relationships are directional (have arrows drawn) and may be labelled.	Parts are drawn with directional relationships and most relationships are labelled. Some parts may have two-way relationships drawn.

2. Have students share out some of the relationships they drew before providing a completed example. You may also ask: “What behavior do these relationships end-up exhibiting?” The answer is (hopefully) learning.
3. Transition to 2.3 for an example of modelling the system.

Part 2.3 – Finalized Model and Changes

1. Go through the complete model of the system [see slides for details].
 - a. Explain individual parts first.
 - b. Walk through the different relationships.
 - c. Point out two key “loops” in the diagram: one on the loop between orders and catches, and the other between fish population and regeneration rate.
 - i. Ask which “loop” is connected to the fish population change (primarily the one between fish population and regeneration rate).
 - ii. Ask which “loop” is connected to how the orders changed (primarily the loop between orders and catches).
2. Now transition to a discussion on how we could change the game to have everyone benefit and prevent total system collapse.
 - a. Guiding questions for this discussion:
 - i. How might the goal of the game (maximize your own company’s profits) need to change?
 - ii. What elements of the system may need to be added/removed/changed? What elements weren’t interacting?
 1. Examples: Communication between teams, amount caught and the amount desired, amounts caught between teams were not communicated
 - iii. 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)
- iv. As a challenge, have students draw the new structure in their diagrams.

Potential solutions from students and ways to respond:

1. Increase the regeneration rate
 - a. Ask students, would this really fix the problem? How would this play out over time?
 - b. Unless the regeneration rate is extremely aggressive, the companies can still run out the fish (and even with a high regeneration rate, there is still a chance of the companies catching all the fish at once and running out the population).
 - c. The system structure would not change, so we'd observe the same behavior.
2. Increase the starting number of fish
 - a. Ask students, would this really fix the problem? How would this play out over time?
 - b. With a higher number of fish, students would probably just try to catch more fish at the beginning. We would still see the same behavior!
 - c. The system structure would not change, so we'd observe the same behavior.
3. Have orders filled in the order they come in
 - a. Ask students, would this really fix the problem? How would this play out over time?
 - b. This may work out for students who are quick on their feet, but would this really fix the problem? Would we meet our new goal?
 - c. The system structure changes marginally, but we'd observe the same behavior in the fish population.
4. Add communication between teams
 - a. This is an appropriate solution. Ask students to clarify this response: what would be communicated? How would this affect orders? How would this be enforced? Also ask students how this adds/removes relationships in the structure.
5. Limit the amount of fish each team can take
 - a. This is an appropriate solution. Ask students to clarify this response: How would this be communicated? How would this be enforced? Also ask students how this adds/removes elements/relationships in the structure.
 - b. You may also do a simple calculation with students to figure out the maximum yield and how much each team should take
 - i. $25 * \# \text{ of rounds} = \text{maximum total yield over all rounds.}$
 - ii. $25 / \# \text{ of teams} = \text{how much each team should take per round.}$

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. You do not need to go through as many rounds if the system behavior is clearly sustainable, or if it immediately trends towards failure as the previous round.

1. Using the new rules, go through a second run of the game.
2. After the run, have another debrief as a class.
 - a. Guiding questions:
 - i. What happened?
 - ii. What worked better than before? Did anything work worse?
 - iii. Are there more changes that need to be made?
 - iv. 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 (TotC) archetype. There are two ways to modify this section. One may either run through a list of examples on the Tragedy of the Commons (Part 4.2a) or have students work on the worksheet containing the Tragedy of the Commons table to figure out examples (Part 4.2b).

Part 4.1 – TotC Definition

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."

Part 4.2a) – Examples Only

1. Run through a few of examples of the TotC. You may ask students what the shared resource is, the users, and results of each situation as a part of an in-class discussion. The table below characterizes these situations.

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.

Part 4.3 – TotC Wrap-up

1. Solutions to the Tragedy of the Commons include:
 - a. Educate users so everyone understands the consequences of using up the resource.

- b. Strengthen the feedback loop between the condition of the resource and the decisions of the users.
 - c. Create an entity with the power to regulate access to a resource.
 - d. Privatize a resource so users feel the consequences of abusing the resource.
2. "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](#)

Lesson Component Alternatives

Part 2.2b – In-depth Modelling

1. Walk through the example of a simple classroom system [see slides for details].
 - a. Ask the class as a whole for 3-4 relationships in the system. Reveal the relationships afterwards.
 - b. Ask them what sort of behavior the system exhibits. The answer is learning.
2. Have students identify relationships in the simulation. Students may work individually, in pairs, or as a team.
 - a. "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 its relationships.* Individually or within your team, try to draw some of the relationships between the elements. Be descriptive of those labels as well!
 - b. After approximately 5 minutes, have students share out some of the interactions they observed. Key interactions include:
 - i. The Fish Population determines the Regeneration Rate
 - ii. The Individual Amount of Fish Demanded determines how many fish are removed from the fish population.
 - iii. 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).

Part 4.2b) - Worksheet

1. Have students fill out the Tragedy of the Commons table worksheet.
 - a. Further options for modifying this include:
 - i. Have every team work through all of the rows themselves.
 - ii. 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.
 - iii. Depending on time constraints, this may even be assigned as homework.

References

Cabrera, D., & Cabrera, L. (2015). *Systems thinking made simple*.

Meadows, D. (2008). *Thinking in Systems - A Primer*. Chelsea Green Publishing.

Sweeney, L., & Meadows, D. (1995). *The Systems Thinking Playbook*. Chelsea Green printing.



To find the complete virtual lesson "Using Systems Thinking 'Harvest' with Dustin Diep" and other lessons visit our Precollege Programs virtual professional development page.

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