Teaching the tragedy of open access: a classroom exercise on governing the commons

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Abstract: This paper addresses a prominent misconception in environmental economics and environmental studies concerning the 'tragedy of the commons' and sustainable management of common-pool resources. The open-commons dilemma prevents many students and instructors from realising the important role of common property regimes in sustainably managing resources. And, recognising the important role simulations play in enhancing student comprehension and retention of complex material, this paper outlines a unique way for students to participate in the development of common property relationships through the use of the online simulation *Fishbanks*. This activity has been highly successful when conducted in my classes, and students have responded to the exercise with enthusiasm.

Keywords: pedagogy; common property; tragedy of the commons; simulation; classroom exercise; governing the commons; system dynamics; open access.

Reference to this paper should be made as follows: Fisher, W. (2019) 'Teaching the tragedy of open access: a classroom exercise on governing the commons', *Int. J. Pluralism and Economics Education*, Vol. 10, No. 3, pp.278–287.

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"One must learn by doing the thing, for though you think you know it, you have no certainty until you try." (Sophocles)

1 Introduction

The important role for alternative pedagogical methods outside of the traditional 'chalk and talk' or 'sage on the stage' method for educators has been well documented (King, 1993; Becker, 2000; Becker et al., 2006; Hoyt and McGoldrick, 2012). These alternative methods tend to encourage student engagement and enhance participation and material retention by allowing students to make mistakes and learn from their errors (Knowles, 1980; King, 1993). Adherents to this constructionist pedagogy state,

> Despite some differences, all [constructionists] argue that learning (only) occurs when learners (re)construct their mental models, beliefs and habits through active engagement with a system. Constructionists stress the importance of interaction between learners and the issues through experience and experimentation, not merely (though not entirely instead of) the presentation of facts, theory, formulae and examples. [Sterman, (2014a), p.90]

One important classroom participatory activity is the use of computer-based simulations. As Asal notes, simulations allow students to actively participate in the models, becoming "the lab rat and then ... discuss[ing] the experiment" (2005, p.361). In addition, "students construct their own knowledge together, gaining insight and motivation from each other. Students are encouraged to take the initiative and are often empowered by the roles they play within the simulation" [Pettenger et al., (2014), p.492]. Many studies show that students not only enjoy the simulation activities when compared to traditional instruction techniques (Pettenger et al., 2014; Yang et al., 2016), but these activities also enhance student comprehension and retention of the subject matter (Krain and Shadle, 2006). For example, when Pettenger et al. (2014) conducted a classroom climate change simulation, the experiment showed marked improvement in student factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge, or 'awareness of one's learning' [Pettenger et al., (2014), pp.498–502].

With advances in internet-technology and increasing accessibility to computers, web-based simulations are becoming important pedagogical tools. The system dynamics community has developed a number of microworld web-based simulations in order to enhance the learning of complex systems (Meadows, 2007; Sterman, 2014a, 2014b). "Microworld simulations play an increasingly important role in education and training curricula in many disciplines, including management, medicine, military, aviation, physics, engineering, and mathematics" [Yang et al., (2016), p.204]. In addition,

> Scholars have emphasized numerous benefits of using microworlds, including: providing a more complex and realistic learning environment than other training approaches; learning in a compressed time frame compared with on-the-job experience; opportunities to apply theories learned in the classroom to practical situations; more engaging for learners than traditional lectures; a risk-free environment for experimentation and exploration of the problem space; and a balance between the complexity of the real world and the simplicity of other training approaches. [Yang et al., (2016), p.204]

The MIT Sloan School of Management has developed six (free) simulations for educators in several fields that enhance the ease of access to complex, systemic scenarios (Sterman, 2014a, 2014b). These fields include business management, finance, environmental policy, international relations and economics. I use three simulations in environmental policy; two on climate change, and the other on the bioeconomics of fisheries. The three exercises have been conducted in the following upper-division classes: 'energy economics and climate change policy'; 'environmental and natural resource economics'; and 'the economics of a sustainable society'. These three are interdisciplinary courses with students from diverse majors including natural science, environmental studies, economics, business, and general education. However, I have adapted the use of one of these simulations in a unique and important way in the classroom in order to convey Ostrom's (1990) extremely important and seldom taught solution to the so-called 'tragedy of the commons'.

2 *Fishbanks:* the tragedy of open-access and the open-commons confusion

Fishbanks originally operated as a board game but has evolved into an easily operable web-based platform in which individuals, or groups of individuals, operate fishing companies with the motivation of maximising each company's net worth. The class is divided into five to ten teams, with each team owning a simulated fishing company. In each round each team decides whether to build, purchase or sell boats, where to fish their fleet (in different fishing regions), while recording profits/losses based on their catch. The simulation is designed to provide students with a better understanding of renewable resource management (fish); the relationship between stock populations; extraction rates (fish extracted and number of ships operating in the ocean); and reproduction rates which are contingent on the stock population. As Sterman articulates, ultimately "the simulation exposes participants to the tragedy of the commons" (2014b, p.209) popularised by Hardin (1968).

The essence of Hardin's argument is that if a resource is not privately owned, and rational self-interested individuals intent on maximising profit can access 'the commons', each will do so. Because gains are privatised and many costs are socialised, each owner (herder in Hardin's paper) will continuously extract more than a sustainable level of resources from the 'commons'. This happens because private benefits outweigh private costs, and ultimately the stock of common pool resources collapses. The *Fishbanks* simulation adeptly exposes students to this phenomenon.

Yet the 'tragedy of the commons' is no tragedy of the commons at all. "To treat common property as open access is the 'open-commons confusion' and has been chronic at least since H. Scott Gordon's 'The Economic Theory of a Common Property Resource: The Fishery' (Gordon, 1954). This confusion was further entrenched with Hardin's 'The Tragedy of the Commons'" [Swaney, (1990), p.452].[1] As Swaney correctly points out "common property is not synonymous with open access" (1990, p.451). Common property and open access are distinctly different ownership regimes that set the rules (or lack thereof) that govern common-pool resources (Hackett, 2011). "Open access (*res nullis*) refers to resources that can be exploited by anyone without limit…Common property (*res communes*) means a group of owners or users share use rights to the resource" [Swaney, (1990), p.452].

As academics agree, language is extremely important, and Hardin's use of 'the commons' is extraordinarily misleading. "Linear thinking has also contributed to the open-commons confusion. A continuum is frequently pictured with open access – no property – at one extreme, and completely private property (conducive to perfect competition) at the other…The farther from efficient [private] property rights, the closer to open access" [Swaney, (1990), p.452]. By utilising the language of the 'tragedy of the commons' in our classrooms, we as educators perpetuate this misconception. This can lead our students to a narrow understanding of the possible solutions to managing our renewable resources. Thus, the open-commons confusion is neither insignificant nor pedantic.

Unfortunately, with this 'linear thinking' and the chronic misuse of the term 'commons', common property relations have seldom been articulated as a viable alternative to either private or government property. It is also worth noting that experiments conducted utilising pure private property rights, where each group had sole control over its own ocean fishery, still mismanaged the renewable resource (Moxnes, 1998; Moxnes, 2000). Participants, including 'professionals', misunderstood stock dynamics and consistently 'overinvested and overutilised' the privately held resources "even when there [was] no commons problem" [Moxnes, (2000), p.325]. This occurred even with access to important information concerning the fishery where "at best, only a few subjects made an appropriate use of *prior* information" [Moxnes, (1998), p.1244].

Linear thinking often prevents instructors from providing students with an understanding of common property despite it predating private property by millennia, along with myriad examples of successfully governed commons (Wade, 1987; Ostrom, 1990; Swaney, 1990; Dietz et al., 2003). There are three solutions to the 'tragedy of open access', as we call the phenomenon of overexploitation of common-pool resources devoid of rules limiting access and appropriation: private property; government property; and common property relations [Hackett, (2011), p.64]. Common property relations, whether with formal or informal rules, allow for nuanced governance evolution outside of the conventional economic solution to overuse which is private property, or when absolutely necessary, government property. Thus, it is important to provide students with an understanding of successful alternatives to governing common-pool resources, other than private property or government property regimes. The unique adaptation of the *Fishbanks* simulation to governing the commons accomplishes this in an experiential way, providing students with a pluralistic way of understanding this issue.

3 Governing the commons and *Fishbanks*

As stated above, the *Fishbanks* simulation was designed to articulate the idea of the tragedy of open-access and enhance students' understanding of why the tragedy occurs. The simulation does this very well and is extremely useful. However, in an effort to educate students to an alternative form of ownership regime, *Fishbanks* can also be utilised to articulate key ideas of successfully governed commons (Ostrom, 1990) and can be established as a common property regime.

This classroom exercise has been conducted three times in my course 'The Economics of a Sustainable Society' at Humboldt State University in Arcata, California. In total, utilising *Fishbanks* as a sustainable common property regime exercise takes approximately six 50-minute class periods. This might be prohibitive for some educators; it could be reduced in classes with a longer class meeting and more active facilitation from the instructor. The results of the exercise have been very interesting and informative.

Prior to setting up the fishery as a common property regime, the class plays *Fishbanks* how it was intended, as an open-access fishery. The goal of the students is to maximise the value of their assets. Each time the students over-fish and the fishery collapses. During the debrief portion of the class we discuss the empirical reality of fisheries collapse; Hardin's (1968) 'tragedy of the commons'; and the difference between common property and open-access. Students also discuss the questions: 'why didn't you communicate with other groups?' and 'why didn't you cooperate with other groups once you recognised the fishery was going to collapse?'.

The following class period a briefing on common property is conducted. Students are introduced to the eight design principles for successfully governed commons, articulated by Ostrom (1990) in her influential research on common property relationships.[2] These design principles are utilised as the guide for developing rules for governing the fishery as a common property regime. Students are told that in the following class period they will begin generating rules for governing the commons and that the winning team will maximise the value of their assets but only if the fishery remains sustainable over time (an additional incentive is that donuts will be provided to the winning team but only if the fishery is sustainable).

It often takes three or four 50-minute class period to develop agreed upon rules for governing the commons, which might be prohibitive for instructors looking to adopt this exercise in their classroom.[3] The development of rules for governing the commons generally follows Ostrom's eight principles. Some of the principles are inherent in the simulations structure and others are not relevant. The eight principles are:

1 clearly defined boundaries

2 congruence between appropriation and provision and local conditions

3 collective-choice arrangements

4 monitoring

5 graduated sanctions

6 low-cost conflict-resolution mechanisms

7 minimal recognition of rights to organise

8 nesting (Ostrom, 1990).

The classroom exercise draws directly from principles 2, 3, 4, 5, and 6; while principles 1, 2, and 8 are less relevant. Principle 3 takes up the majority of the exercise time, where "all stakeholders (people who use or are impacted by the CPR [common-pool resource]) are included in the formation of appropriation/provision rules and in rule adaption over time" [Hackett, (2011), p.412]. Rules are to be developed according to consensus and students are told that there are no 'correct' rules, only that each rule needs to be agreed upon by the group.[4] Very little guidance is provided by the instructor regarding potential rules, as the point of the exercise is to empower students to develop their own rules for governing the commons. While cumbersome because of the lack of guidance, the rules developed can be extremely creative. With that said, the instructor should ensure that students stay on task, and that everyone has a chance to speak. Students propose rules; the class debates and revises until consensus is reached. Often the classroom dynamic is governed by the competitive nature of some students to avoid regulations that will make the game completely egalitarian and somewhat boring.[5] As rules develop, the instructor should record the rules that will guide the game.

As stated above, a number of the rules developed by Ostrom are not applicable, or can be sidestepped. For example, minimal recognition of the right to organise and low-cost conflict resolution are guaranteed by the instructor. The most important rules that the students develop revolve around the number of ships that can be used to fish in the different regions; how those fishing spots are allocated to different companies; the aggregate boat cap (if any) per team and for the entire fishing fleet; and the graduated sanctions for rules violation.

Designing rules for the *graduated sanctions* is important and interesting. Students are informed that the penalty for the first violation should not be too strict in case a group violates the rules accidentally but strict enough to try to prevent intentional violations. The instructor should allow violations to occur during the game if students feel it is in their best interest to violate the rules, with the penalties assessed in the following fishing year according to the *graduated sanctions* rules. It is important for the instructor to post the rules for governing the commons, including the graduated sanctions, so that both students and instructor are informed (see the Appendix for an example). The instructor is the sanctioning authority and will need to monitor fleet size and allocation each round to police and sanction offenders.[6] Often groups will violate rules intentionally if they deem the benefits to outweigh the costs of violating which is why graduated sanctions and anticipation of potential incentives to violate are important. At times groups will accidentally violate rules by allocating boats to regions off limits. This mimics the real world where accidents occur and highlights the problem of overly punitive penalties for violating rules, especially for the first violation.

It requires a lot of effort and problem solving by students to anticipate events such as cheating or mis-estimating the sustainable fish stock/extraction rate and potential population collapse that may occur multiple rounds into the future. Inevitably there will be rules that do not accomplish their intended purpose because of unanticipated events. One important component of common property relations is that stakeholders are able to participate in *rule adaption over time*. Thus, students also decide how often to revisit the rules and alter them in accordance with how effectively the original rules accomplish their stated objectives. This can mean restructuring sanctions that are too harsh/too weak, or allowing more or fewer boats into the fishery depending on the level of the fish stock and net recruitment relative to the harvest rate. Appendix A shows an example of the rules generated by one class.

Fishbanks contains myriad information that the instructor can access in real time including data on the fishery, number of boats per team, net-worth of each team, etc. The instructor functions as the governmental agency collecting data on the fishery. During years when rules are to be revisited students can ask for data on the fishery and fishing fleet operations. This data can be utilised to rewrite the rules governing the commons so as to maintain a sustainable fishery.

The game is played between sixteen and twenty rounds (years) allowing for multiple revisions of the rules and a long enough period to conclude that the fishery is sustainable. Though the number of rounds could be reduced, a minimum of ten to twelve rounds is required. Instructors can be vague about the precise year the game will end, or inform students directly. However, if informed about the final year of the simulation students will often recognise that an incentive to cheat exists in the final year because no penalties can be assessed the following year. In other words, there is no cost associated with cheating, with a potentially tremendous benefit in increasing their net worth and winning the game. If students recognise this and collapse the fishery, the prior year's data is recognised as the final fishing year and the teams are assessed accordingly.

After the conclusion of the simulation, students are to write a two-page summary of the activity to be submitted the following class meeting. They are to reflect on the exercise and articulate key ideas about common property relations, what they found useful (or not) and interesting about the activity, and what they learned about rule making and common property relations. Students often highlight the difficulty of generating a consensus during the rule making process, the importance of rule adaptation, and the relevance of having graduated sanctions. Summaries are graded on a conventional 0%-100% scale. In the debrief portion of the commons exercise we discuss the simulation and the data recorded in *Fishbanks*. We also discuss the role of common property in enhancing the sustainability of the renewable resource.

Students' responses to the simulation reinforce the theoretical statements above concerning how role simulations can actively engage students in the learning process. The following student comments were recorded in their 'course evaluations'. While these were selected from a number of comments, they represent the overall tenor of the comments. In fact, there were no negative comments. One student wrote, "During the simulations… I felt very engaged and excited. The simulations helped connect the material in the classroom with real world applications and show[ed] us how different things had direct impact on the environment and sustainability". From another student, "This was a very enjoyable and engaging class. It was a first-hand experience into common property and related to many topics from class. Top 2 favorite class ever".

Students also remarked about the important lessons learned during the rule making process. "The rule making was also a good eye opener to how committees or large groups create rules/standards". Another student responded, "I felt the simulations were useful. The group work utilised great conflict resolution and negotiation skills. The material was current, relevant and interesting". Finally, one student commented concerning their favourite part of the class, "making our own rules to govern a sustainable fishery was awesome, hands on learning is the best".

4 Conclusions

The open-commons dilemma is an important misconception that many people in environmental instruction perpetuate, which unfortunately leads to incomplete conclusions regarding solutions to the tragedy of the commons. As a result, common property relations are seldom utilised as a solution. While Ostrom (1990), Dietz et al. (2003) and Hackett (2011) have made strides to counter this dilemma, more students and instructors need to be exposed to common property as a potential solution to mismanagement of common pool resources.

Utilising the *Fishbanks* computer simulation in the unique way articulated above is an effective vehicle for helping students internalise the concept of common property.[7] The debrief of the initial *Fishbanks* activity, the development of the common property regulations, and the testing of the regulations has been critical to the success of students' learning experience. The simulation has allowed students to become active participants in the learning process while actively engaging with complex systems. The simulation allows for interactions with common pool resource management that mirrors real-world renewable resource issues. Utilising *Fishbanks* in this way can potentially illuminate misconceptions, and reconstruct students' mental models. The fact that they find the activity enjoyable and engaging is an added advantage.

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Notes

1 As stated above, *Fishbanks* provides important insights into the collapse of an open access fishery. Having used *Fishbanks* in many of my environmental economics classes at Humboldt State University, I have yet to have a class that has not collapsed the fishery. This includes diverse classes comprised of environmentally conscious students from multiple disciplines including environmental studies, environmental science, business school and economics. The debrief portion of the class, following the simulation, is often extremely insightful and can be used to articulate important points. For example, asking students why they did not speak to each other; or is self-interest innate in humans or built into the institution (game)?

2 It should be noted that the supplemental material provided by MIT covers Ostrom and the importance of understanding common property. Access to the material requires establishing an account, but then all materials are freely provided, and can be accessed at: https://mitsloan.mit.edu/LearningEdge/simulations/fishbanks/Pages/fish-banks.aspx.

3 Because the class meets only once weekly, time is lost in getting the students to recall where they left off the week prior. In a longer class meeting, the rule making time would probably be greatly reduced.

4 Implementing a majority rather than consensus rule adoption process could reduce the time necessary for the exercise.

5 In one class where this game was played the rules were so rigid and penalties for violating the rules so strict that the game was not dynamic. The fishery was sustainable but there was no competition between fleets and every group had the same net worth at the end of 16 years (rounds) of fishing.

6 Although in real life, Ostrom notes that a central figure often knows little and it is the group that sanctions, rewards, and punishes; in the simulation only the instructor has access to the information on all teams and thus, only the instructor can ascertain if certain teams are violating the rules for allocating their boats.

7 Since the goals stated at the outset are to maintain a sustainable fishery in perpetuity and to maximise the net worth of the company, if the students have destroyed the fishery in the final season they have failed in their objectives. It is also not very realistic to have a 'final' fishing season where people are incentivised to take as many fish as they can without any regulations or penalties. The role of power and vested interests is not addressed in the game as each team is sanctioned simply according to the rules developed, and no team is able to acquire enough power to influence policy.

Appendix

Some rules students developed for governing the commons:

1 Boat cap – 50 boats freeze after cap.

2 One boat can be purchased at auction per year.

3 Year 1 – no restrictions on boats fishing

4 Year 2 – until revisiting the rules – maximum of 20 boats in deep sea, ten in coastal waters

   a Two boats in the deep, one in coast per team.

   b Extra spots – trivia winner takes all. Since there are extra spots not allocated to each team, trivia questions are asked and the winning team gets these extra spots to fish (two questions: one for boats in deep water, and one for boats in coast, winner of deep trivia gets a total of four boats in the deep, winner of coast trivia gets two total boats in the coast). Questions developed by instructor.

      - sign up for deep and coast question before hand
      - penalty for incorrect answer – for the deep – harbour two boats originally allocated to the deep; for the coast – harbour one boat originally allocated for the coast
      - rock paper scissors for tie.

5 Harbour all boats above the maximum boats allowed for each fishing region (note: this is necessary for teams that accumulate extra boats to be able to fish if they win the trivia questions).

6 Look at government statistics every year.

7 Revisit rules after year 3 (then every two years).

Student designated graduated punishments:

1 *First violation* – harbour all boats for the next year.

2 *Second violation* – harbour all boats for the next year; lose one designated fishing spot (deep or coastal); must harbour that extra boat indefinitely; *extra spots* (*allocated from abandoned spots*) – random team number from hat allocates that team with spot then rotates sequentially to next team number every year.

3 *Third violation* – harbour all boats indefinitely and assign remaining fishing spots according to the hat rotation.

   a Entire fishing slots moves to next set of teams that did not receive slots in previous year.

      - Skip any team that violated in that year but eligible for rotation in other years.