

Economics versus the environment: Promoting systems thinking, sustainability, and collaboration in a “commons” game

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We want students to grow up to be good citizens. Part of that is to care for the environment and collaborate with one another in allocating shared resources. At the same time, society often identifies success with short-term financial gain—and that often entails setting aside the common good. How can we help students navigate the balance between the ubiquitous drive for money and the need to save the planet? One strategy is to use simulation games in which students experience the phenomena we’re concerned about rather than simply endure explanations in class. In the games we present, students use data to see how to make a profit and preserve the environment simultaneously. These games were developed as a small part of the EduS4EL project, described in Martignon and Martinez (2026), in this volume. This paper focuses on the games themselves and on design and pedagogical considerations.

Many of the challenges we face as a society occur because of a collision between environment and economics. For the moment, however, let’s set aside the environment and begin purely in economics with a typical optimization problem:

You’re selling insurance for boats. The number of policies you can sell, $n(x)$, is a function of the premium price x . That function is $n(x) = 100 - x/10$. The chance that a boat will sink is 1% per year. You will have to pay €10000 for each boat lost. What price maximizes your profit?

The answer is €550...an exercise left to the reader. Students can figure it out using calculus, but that’s not really necessary. They can, for example, derive a function for the *profit*, which is income minus payouts, or $p(x) = xn(x) - (10000)(0.01 n(x))$. They can try different values of x to see what gives a large profit, or simply graph $p(x)$ in Desmos and see what price gives the maximum.

We like this problem partly because it has a whiff of the real world, but also because we can ask interesting questions such as, does the demand curve $n(x)$ make sense? What do the two intercepts of that $n(x)$ function *mean*? We also like it that the function you have to optimize does not appear in the problem statement; you have to use some algebra to figure it out.

Unfortunately, many of our students’ eyes will glaze over as they read the problem. It’s abstract and “mathy.” It’s boring, just another task. For us statistics educators, it also has no stats content, no data, no variability.

We can address the abstract boring mathiness of the problem by changing it from one that we present by *description* to one of *experience*. After all, the underlying situation, expressed by the sales function $n(x)$, is central to economics: with a low price, you sell a lot of policies, but you don’t get much revenue from each one—and you lose a lot in payouts. With a high price, you get a lot of money per policy, but you don’t sell very many. When a student sees this as a function, written out in symbolic mathematics, they may not recognize that essential relationship. But what if they have to decide on the policy price as part of their business, and they will gain or lose money depending on their decision?

That would give students *agency*: they will make decisions that affect how well they do.

Let’s turn it into a game.

GENOVA: AN ECONOMICS GAME

You are in Genoa at the birth of the insurance industry in 1347. You insure ships for 10000 lira each as they make the hazardous journey to Bruges. You will play this game for many years. You begin with 100000 lira. If your bank balance goes to zero, you lose; if it reaches 200000 lira, you win.

In the game, we do not tell students the function that determines the demand, or the probability of a boat sinking. Furthermore, the number of boats that are lost each year is not a straight percentage of the number of boats, but rather, each boat has a separate, independent chance of sinking. That is, the

number of payouts is binomially distributed. This means a student could be horribly unlucky. They have to deal with risk.

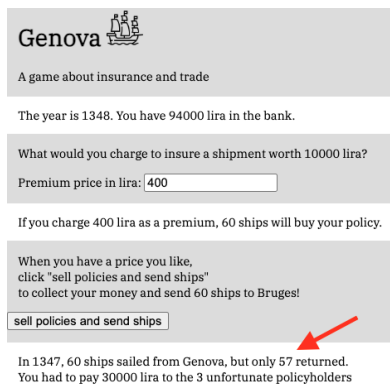


Figure 1. A screen shot of the “Genova” game in 1348. In the previous year, 1347, the player entered 400 lira as a premium price. They saw that, at that price, they would sell 60 policies. That gave them an income of 24000 lira, but they had to pay out 30000 to policyholders.

The game hides important information, but it also gives students superpowers: first, if they mess up and go bankrupt, they can just start another game. Second, because it’s on a computer, embedded in CODAP, they get data. The computer keeps track of what has happened, even across multiple games, so they can look back and see the consequences of all their earlier decisions. Of course, they could just play the game by the seat of their pants. But to do really well, they need to collect data and use it to help their decisionmaking. You can see how this works in Figure 2.

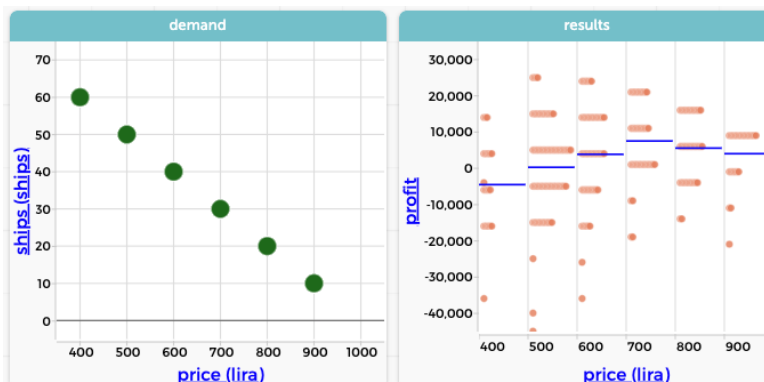


Figure 2. Data from 273 Genova game years, showing both the number of policies sold (“ships” on the left) and the profit (on the right) from each year, as a function of premium price in lira.

In Figure 2, the horizontal lines are the means (which are estimates of the expected value of the profit, right?). Notice how, in this dataset, it looks as if 700 is the best premium price. But you can also see the alarming variability among the years, a result of that binomial phenomenon. This shows the importance of data, the power of keeping track: although an individual year selling at 700 might be a disaster, and a year at 400 might be golden, in the long run the data don’t deceive: getting only 30 customers at 700 lira each (gross sales 21000 lira) is better than 60 at 400 lira (gross 24000 lira).

INTERMEZZO: EXPERIENTIAL LEARNING THROUGH COMPUTER GAMES

What is the consequence of basing this lesson on experience rather than on description? First of all, students develop a visceral sense of price and demand. And as you can imagine, making piles of even imaginary money is more motivating, in general, than deciphering algebra. On the other hand, students can succeed in the game without ever uncovering the underlying parabola or thinking about optimization. Depending on your curricular goals, that may be OK. But if your students must cover that topic, you could approach it from their game experience. With good questioning and their experience,

students can construct the mathematical model for themselves, discovering the critical parameters of that model through looking at data—through keeping track.

Now: what do we get out of this activity being a *game*? Games are supposed to be fun and therefore motivating. But the key here is that the player has a stake in the outcome (they want money), and also—since Genova is not entirely a game of chance—that they must make *decisions* that affect that outcome (they must choose the price of a policy).

Finally, what is the benefit of doing this on a computer? Speed, of course, and efficiency. And in this case, the computer also supports this activity being experiential rather than descriptive, because of what we just discussed. The computer code hides the relevant parameters of the problem—the probability and the demand function—and forces players to figure them out from experience. In addition, the computer makes it possible for the game to be *short*. That means students can play it many times, trying different strategies (and they do, quickly clicking through “on automatic”). A short game also means that you can limit the game part of a learning unit. Students benefit from the experience, but not to the exclusion of everything else.

MAZU: A COMMONS GAME

Genova was an economics game, but we promised a collision between economics and the environment. So let’s look at a new game that involves both: Mazu, named for a Chinese goddess of the sea.

Mazu is about fishing. As a player, each turn, each “year,” you decide how many fish to catch. You deliver them to the market, where they are sold. You have to pay some money (“subsistence”) every year to stay in the game, but you keep any profit.

The big change is that everyone else in the class is also fishing, with their own boats, in the same sea, trying to catch the same fish. That is, Mazu is a networked, multiplayer game.

The first time Alicia, Benjamin, and Cora play Mazu (Figures 3 and 4 show screen shots from the game), things start out fine. Everyone catches fish and makes plenty of money. The players might notice that the number of fish they can “see” is declining. Since the number of fish they can catch is limited by how many they see, their income also starts to decline. When that income falls below the subsistence, their bank balances fall and it becomes clear that everyone will go bankrupt.

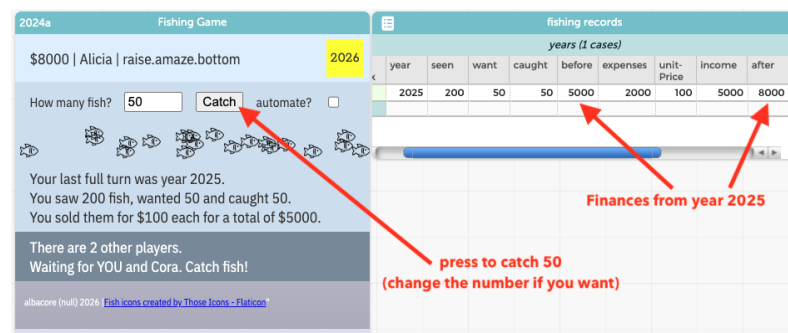


Figure 3. Alicia’s screen after the first move. She caught 50 fish in 2025, for a net profit of \$3000. She is ready to do the same in 2026. Note the column “seen” in her table, which shows that in 2025, she saw 200 fish from her boat. That “raise.amaze.bottom” is a code that identifies this game.

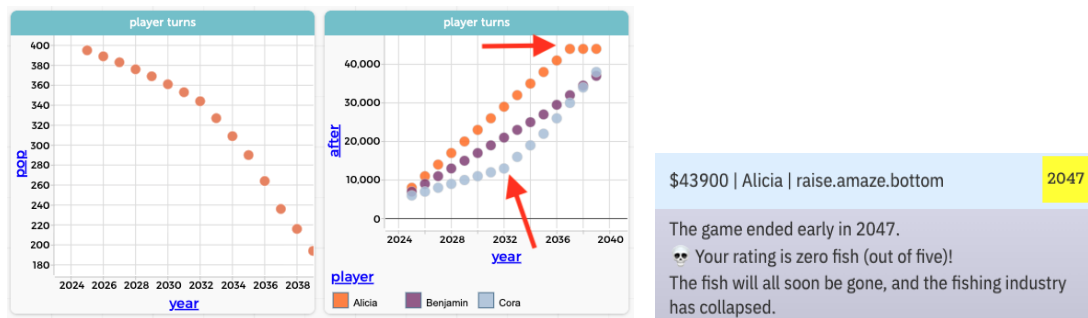


Figure 4. Same game as in Figure 3, three players. The two graphs on the left are from the teacher’s display in 2039. On the far left, the fish population (“pop”) has been falling. The rate increased in 2032 when Cora realized that everybody else had more money than she did, so she started taking 60 fish per turn instead of 30. (In the center graph, “after” is the bank balance at the end of the turn.) In 2037, Alicia noticed that the number of fish she “sees” had fallen by almost half, so she started taking only 20. On the far right, in 2047, is the message that the game is lost. Students can get positive ratings from 1 to 5 fish depending on the health of the fish population at the end of the game.

The students faced what we call a “commons problem.” The fish population is a common resource. It renews itself, but at a limited rate. Therefore, they cannot all take as many fish as they want; they must somehow regulate their fishing if the fishery is to survive.

The choices the players make are therefore not purely mathematical, but social as well. They need to collaborate with other players for their businesses to thrive. In practice, that is exactly what happens: the students discuss among themselves what they have to do and then try to implement their plan.

But to decide on a plan, they need information—data—that they have collected in previous, possibly disastrous plays of the game. For example, the subsistence payment is \$2000 per year, but they will only find that out if they read the data table. In the basic level of the game, the revenue from selling one fish is \$100. In most classes, someone (like Alicia in Figure 4) figures out that a “break even” strategy is to limit your fishing to 20 fish per year. Still, most players want a profit.

How much profit is OK? One way to figure that out is to perform experiments. Suppose that in the next game, Alicia, Benjamin, and Cora agree to limit their catch to 40. They play a few years and look at the data (Figure 5, left), and find that the number of fish they can see is declining. They should take fewer fish. They then agree to take 25, and see that the fish population is now increasing. Does it increase linearly? No! When they look closely, they see that it is concave up, perhaps even exponential—you know, like a growing population. This game ends with a win in 2051; they were awarded 5 fish for creating a sustainable population.

We have recreated that game in Figure 5.

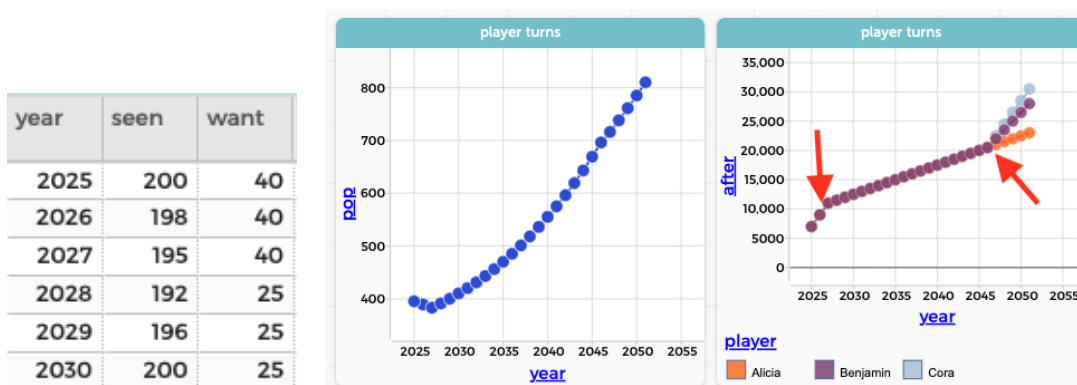


Figure 5. (left) Alicia’s table in 2030. After switching to 25 fish (“want”), the population looks to be rising. (center) Teacher’s data on fish population at the end in 2051. (right) Teacher’s data on player bank balances. Note how Cora and Benjamin both decided to increase their fish take in 2046.

DISCUSSION

We could say a great deal more about Mazu and its companion game, Forester, which is about trees and deforestation instead of overfishing. There are many details to share, many questions you might have. But you can play the game and learn more elsewhere; go to <https://codap.xyz/plugins/mazu> to try things out and read some documentation.

Our purpose here, however, is to encourage you to engage your students in experiential learning, possibly through games, ideally using contexts and problems that are especially relevant to your students and whatever the world's current problems demand. So we will devote our discussion to things to consider as you design lessons like these.

In the intermezzo, above, we have already discussed why we might present topics experientially as an alternative to description; how a game format can engage students by giving them a stake in the outcome and demanding that they take decisions to affect that outcome; and how doing so with technology supports discovery by hiding relevant information—making it discoverable rather than obvious—and keeping track of data, which support students taking a long view.

Now that we have looked at Mazu, a commons game with a social component, there is more to say. We like Mazu because it gives students a chance to develop empathy for the conflicting motivations in a conflict. We do want to save the fish. And we want—we need—to make money to be able to live. A game like Mazu lets us experience this viscerally and forces us to make our case to our colleagues in a low-stakes—but still engaging—setting.

Our interest in developing this empathy and in the seeds of cooperation is longstanding. One way to approach it is through research on risk education (e.g., Martignon & Hoffrage, 2019; Hoffrage & Martignon, 2025). Risk games also include the classic “Prisoner’s Dilemma” situation, named by Albert Tucker, explored by his student John Nash (1950) and brilliantly re-explored by Robert Axelrod (1984). The prisoner’s dilemma itself evokes the Tragedy of the Commons (Hardin, 1968), which inspired the game by Richard Powers (also 1986), which in turn inspired Mazu.

Some early research and observations using Mazu (e.g., Martinez & Martignon, 2025, Martignon & Martinez, 2026) suggest that students really do improve their attitudes about environmental issues and do in fact negotiate group solutions to the overfishing dilemma.

Comments on modeling

A game is a model, a summary and simplification of reality. In designing an educational game, we decide what aspects of reality we want to model, and which we will ignore. Some potential features might be fun or cool, but if they are irrelevant to our pedagogical purposes, they might needlessly complicate the game or our lessons, and should be omitted.

A simple example in Mazu is the cost of fuel for the boat. Why don’t you have to pay for gas? Because we don’t want to distract students with a real-life factor that would get in the way of learning about overfishing. So we exclude it from the model. It becomes part of the abstract “subsistence” cost.

A subtler example is in the first level of Mazu: the sales price of fish is constant. The number of fish for sale has no effect on price. So there is no optimization in Mazu, no finding-the-best-price that was an essential part of the insurance game, Genova. In fact, the first version of Mazu had that feature, but in early play-testing we noticed two things: first, the changing prices confused the players; and second, when we tried the game with constant prices, the social effect we wanted the game to generate—the commons problem—was still present. So we relegated the price function to a more advanced level...which people hardly ever play.

Another comment on modeling: the modeling in a computer-based game lives in the formulas in the computer code itself. We designers write those formulas, making choices about things such as how much things cost or how fast a fish population replenishes. That means that the “author’s message”—what we want students to take away—is embodied in some mathematics. The model shows our preferences, our values, and the ones we want our students to take on as their own. One could write a model that guided students to the opposite conclusion, so there is a legitimate concern whether the simplifications in a model are faithful to the more complex reality.

Game design choices

As you can imagine, many of the game design choices are precisely those we have just discussed under modeling. We have tried to make the game mechanics as simple as possible, both to make the programming easier and to make the games so that they can be learned quickly and played multiple times in a class period.

For additional comments on game design, please see the documentation.

Discussion and debriefing in class

Playing a game isn't necessarily educational. Students need to think about the game and what happened in order for learning to take place. We prefer that students come to their own understanding, so we advise against simply telling students what they should have learned. Instead, teachers can foster experiential learning by facilitating good discussions among the students.

For games like these, an essential "teacher move" involves not answering student questions. Instead, use what some call a "parking lot." The idea is straightforward and liberating. Students can begin playing these games almost without any instruction. But they will immediately have important questions, both about game mechanics ("How do I sell my fish?") and deeper, underlying principles ("What's the object of the game? How do I win?").

For the former, ask if another player can answer the question, get that answer, and move on.

For the latter, praise the question and the questioner, and record it: "How do I win? Sylvia, that's a wonderful question. Very important. Thank you! We'll get to that question a bit later, so to remember it, I want to write it here on the board [in the question parking lot]." Write it down, and move on.

Then, in a debriefing, often when a game is over, return to the parking lot. "Let's look at these questions. Can we answer any of them?" And lead that discussion *without giving any answers*. Sometimes you will need to prod: "This question from Juan—What's the probability that a boat will sink?—is another great question, but I don't know the answer. Do we have any information that will help us figure that out?" In this case, of course they do! They have data in CODAP that they can aggregate to get a good estimate of that probability.

You can also add questions of your own as follow-ups or probes: "What if you knew the probability? How could you use that to help you in the game?" This can lead to the use (or discovery!) of expected value.

Sometimes the questions are really about the game design. "Don't I need enough money to feed my own family? €2000 is not enough!" Ask the group to comment. How would they explain that €2000 subsistence cost? And sometimes, rarely, with a question like "Why can't I upgrade my boat?" if you don't want to spend the time in discussion, it's OK to blame the designer and drop my name: "For this version of the game, Tim decided not to allow upgrades."

With regard to the social aspects of the game, leading the discussion requires some skill that you can develop over time. One strategy is to highlight something that happened that you want to emphasize. You can do that by reporting your observation and asking for comments: "You all had a discussion about how to limit the number of fish you took. You started out suggesting 40, but wound up at 25. How did that happen? How do you feel about the way that turned out?"

And, of course, "if we were to play this again, what would you want to do differently?"

Finally, because you want to know, you can ask: "What do you think you were supposed to learn from this game? Did that work for you? Do you think this problem (for Mazu, overfishing) actually happens in the world? Where? How do they address the problem in real life? Why do you think the game involves money and not just fish? What other topics would you want a game on?"

FINAL COMMENTS

The first author (Tim) is grateful to the good people of EduS4EL for agreeing to include a game like Mazu in their project. Educational games have a long history and are seldom implemented very broadly. This paper is yet another attempt to encourage you to use educational games in the classroom.

The problem, I think, is that even if evidence suggests that games are powerful educational tools, actually using them goes against the grain. We have so much to cover in class. Games can use up so much time. Games are what you do outside of school.

I am here to ask you to set aside those reasonable objections and try one.

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