**The Externalities Game (TEG) Guide for INSTRUCTORS:**

For an introduction and/or summary of this teaching exercise as well as links to the referenced documents below, please visit: <http://serc.carleton.edu/introgeo/games/examples/62222.html>

**Pre-game activities:**

Depending on the goals of the instructor, students may be primed for TEG by reading assigned articles and/or discussing the problem of environmental externalities in class. The document entitled, “Game Theory, Collective Action, and Climate Change” is available online. This serves as an assigned pre-reading for students before playing the game. It gives a brief introduction about game theory, some theory on collective action, and describes how climate change is a collective action problem that can be modeled by game theory (the basis for TEG). Furthermore, it may be helpful for instructors to read and/or assign Ronald Coase's (1960) paper on social cost. It is a seminal piece that lays out some of the underlying concepts of the game:

Coase, Ronald H. 1960. The Problem of Social Cost. Journal of Law and Economics. Chicago IL, 1-23. October 1960.

There are also relevant and more recent papers by Elinor Ostrom focusing on collective action problems. In particular she discusses common-pool resource management issues:

Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action, Cambridge University Press.

Ostrom, E, et al. (1999). Revisiting the Commons: Local Lessons, Global Challenges. Science 284, 278-282.

In our own classes, we provide students with theory about collective action and game theory and ask them to hypothesize about what they think will happen during game-play. They are expected to apply the theory they have learned to explain their hypothesis. This also requires informing players about the game rules and possibly providing them access to the game-calculator ahead of time so that they may experiment with different strategies. Game rules and the game calculator may be downloaded by visiting the link provided above. It may be beneficial to give a brief lecture and explain the game rules in class and assign the readings and the hypothesis writing for homework, with the intention of playing TEG in the following class period.

Another option is not prep your students at all for the game. When they arrive to class, explain the rules and play right away. It makes the game more difficult because players don’t necessarily have the time to figure out an ideal strategy. Some instructors prefer this method because they feel that teaching the theory and talking about environmental externalities before the game changes the way they might normally react in a game-theoretic situation. In this case, most of the learning occurs through the reflection exercises that happen afterwards. If this method is preferred, the instructor could assign the above reading(s) after game-play and treat TEG as an activity meant to reveal the humanistic behaviors of your students. TEG might be a warm-up activity that you can refer back to in your lessons about environmental externalities and climate change issues. Instructors may want to offer students another chance to play TEG after class instruction as an opportunity to showcase what they learned.

**Game-play:**

**\*\*\***Note: A round of game play consists of two steps: 1) simultaneous production decisions by all players, followed up by, 2) simultaneous point-sharing decisions.

1. Randomly assign one of three production roles to each students: luxury, intermediate, and subsistence. About 15% of students should be assigned a luxury role, 30% should be assigned an intermediate role, and about 55% should be subsistence players. Each student should also be assigned a number so that they have a unique player code (e.g., S1 for subsistence player number 1, or L3 for luxury player number 3).
   * Logistically, we have found it helpful to write the player codes on index cards and hand them out randomly OR you can assign roles digitally, through e-mail for example. The roles should be kept confidential unless students choose to reveal them. Instructors should keep track of which student is assigned what role for grading purposes.
2. Allow students time to negotiate and strategize. They should have access to the excel spreadsheet so that they can try out different options. You may have to encourage students to get up out of their seats and talk to one another. Depending on how much time you have in class, you should tell your students how much time they have to talk before they must submit their decision. At least 15 minutes is recommended, but with smaller groups it may be less, larger groups may need more time.
3. When time is up, Students must make production decisions that result in points (for themselves) and externality costs (shared by everyone). Whereas points accumulate linearly with production, costs expand exponentially.

* Luxury players gain the most points per unit of production, but also emit the greatest amount of externalities. Intermediate players gain the second most points per unit of production, and emit the second highest amount of externalities. Subsistence players gain the least amount of points per unit of production, but emit the least amount of externalities.
* The units of production are constrained differently depending on the role assigned (these constraints may be adjusted by the instructor to change the power structure of the game):
  + - Luxury players may produce between *0 and 10 units*
    - Intermediate players may produce between *0 and 55 units*
    - Subsistence players may produce between *0 and 240 units*
* Players can only produce whole goods up to their maximum production capacity and not less than 0. (No negative production).
* Players can make deals during the game to share points or limit production for the greater good, however **the Instructor cannot enforce agreements**. Players may lie to each other about their behaviors, and in many cases these lies may go undetected.
* Players are allowed to experiment with various production choices. The consequences of their production choices may not be fully attained until after the first round has been played, and if the instructor chooses, the first round can be considered a “practice round”. Players will continue to experiment and try to make deals with each other to attain their wanted grades.
* When all players have come to a final decision, or when the instructor states that deliberation must end, the players will submit their final production value. \*THIS VALUE DOES NOT HAVE TO BE WHAT WAS AGREED UPON WITH THE OTHER PLAYERS.
* Students must simultaneously submit their production decisions, with the above constraints. If using index cards they can write their production decision on the card and submit to the instructor. If submitting online, give them a deadline that they must send you their decisions. The decisions should be kept confidential unless students choose to reveal their decisions to others.

1. When decisions are submitted, the instructor should input the players production decisions into the excel game-calculator. Make sure to record the decision in the red column, next to the correct player code.

* Grades are determined by the points that are produced individually, minus the social costs that are produced collectively.
  + Grades are automatically calculated when production decisions are entered into the Excel game calculator. Grades are not final until all the decisions are entered.
  + If you have more cells than players on the spreadsheet, leave the unused player code decision cell blank (entering a zero will impact grades).
  + Instructor may display the spreadsheet so that all players can see final results and/or the grades of each student may be recorded on the player’s index card and redistributed to students.

1. Students can share their grade points in the second part of the round. Give them some time to communicate about sharing.
   * Players do not have to share with anyone if they do not choose to. The people they share with and they amount they share is solely of their own discretion and will be kept confidential.
   * Negative scores must be overcome in the sharing round and not treated as a zero.
   * Players should resubmit their index cards simultaneously to the instructor or privately e-mail their sharing decisions.
   * Instructors can adjust grades based on the submitted sharing decisions by adding and subtracting points from the student’s initial grade in the blue column of the excel game calculator.
2. The grades are then calculated by the instructor’s program, and they are returned to the students. Another round may be played if the instructor so chooses. The instructor may assign a new random role to students or choose to assign roles in some other way, such as by the score they received in the previous round.
   * For final grades, players can earn above 100% for each round, but they can get no less than a 0.
   * When all rounds have been played, the grades are calculated based upon an average of all grades through all rounds.

**Post-game Activities:**

*Class discussion:* Instructors should lead a classroom discussion of the game-experience after playing. Feel free to design your own discussion points and questions based on your teaching goals and the experience you observed in your class. Keeping notes and recording observations of students’ behavior during game-play is helpful to lead an effective discussion. You may ask your students why they behaved in certain ways, why they chose to produce what they did, and how they decided upon a strategy. If you played multiple rounds of the game you can compare and contrast the game experiences with your students. You may also want to try and relate the game structure to real environmental problems, like climate change. Ask them how in the real world, their strategy might affect different countries, for example. Based on the game results, would the world have collectively mitigated anthropogenic climate change or not? Talking about the relation between player responsibility and country responsibility in the context of climate change may lead to some interesting discussion. You might also ask students if they had a different assigned role, would they have acted differently. In our classes we have asked students to think about two key questions: 1) What is their responsibility to their classmates? and 2) What are they willing to risk to fulfill those obligations? This can lead into a moral discussion about what responsibility the developed world has for underdeveloped countries in terms of mitigation and adaptation efforts.

*Reflective Essay*: Online there is a link to a “TEG Post-Game Writing Assignment” that asks students to read an essay by Dale Jamieson (2001) entitled, “Climate Change and Global Environmental Justice” published in a book called *Changing the Atmosphere: Expert Knowledge and Environmental Governance.* As a reflection exercise, students are asked to write an essay that relates the paper to the game experience.

**Other tips:**

Through administering these games, we have found it helpful to have one instructor or TA for data entry and another for moderating the game.

You should allow students time before submitting their production decisions to communicate, at least 15 minutes or so. You may have to encourage students to get up out of their seats and talk to one another. This may be difficult at first because it may be an unfamiliar task in traditionally structured classes.

We usually use index cards with player codes on them for students to write down their decisions and hand into the instructor. The codes correspond to the codes in the game calculator for data entry. This allows students to keep their decisions confidential if they desire.

After students hand in their decisions, it is fun to let students see the live data entry into the game calculator by using a projector hooked up to your computer.

If students fail to achieve their goals in the first try, it may be advantageous to play the game again after reflecting upon why the game outcome occurred.

Discussions of what an ethical outcome for the class should be is a great point for discussion. Instructors should be ready to adapt to changing circumstances and surprising reactions from students.

We have found that making the game count for a grade is critical for the non-cooperative tensions to occur. Students must feel like there is something at risk. In the past we make the game grade count as a quiz grade or homework grade.

Instructor’s should experiment and adjust the excel game-calculator as needed for their class. By changing the externality exponents for the different roles and/or adjusting the maximum production points that each type of producer can produce can make the game more difficult and change the power structure of the game.

Please contact [susan.spierre@asu.edu](mailto:susan.spierre@asu.edu) with concerns or questions. Good luck!