Using Non-cooperative Games to Simulate Ethical Tensions in Climate Policy Negotiations

Susan G. Spierre, Thomas P. Seager, Evan Selinger and Jathan Sadowski

***Abstract*—Successfully implementing a system of global compliance to mitigate climate change requires collective, social decision making that is unprecedented among people with radically different values and radically different needs. Our novel pedagogy in sustainability ethics teaches future professionals about complex moral problems in a way that leverages their interests in experiment and experience through the use of non-cooperative game theory. This approach emphasizes active, participatory, and experiential learning that is intended to more deeply immerse students in questions of fairness, justice, and equity in the context of sustainability. Through testing the games and preparing complimentary educational material, we have found that the developed non-cooperative games are particularly effective at replicating the ethical tensions surrounding the issue of climate change. This method of teaching ethics may prime students to participate in more effective group deliberation in real-world policy negotiations.**

***Index Terms*—Climate Change, Collective Action, International Climate Policy, Non-cooperative Game Theory, Sustainability Ethics**

I. Introduction

THE allocation of global CO2 emissions as a response to climate change is an intrinsically moral problem. Problems of justice exist both because highly industrialized countries bear greater responsibility for current CO2 levels, and because the consequences of increased global temperatures disproportionately harm some countries while advantaging others [1]. Furthermore, the availability of energy services, and pollution it creates, is often necessary for advancing many aspects of human development [2]. To address these complex issues, it is necessary to identify a system of global responsibility that allocates the benefits and shares the costs of fossil fuel consumption, which is the primary mechanism for development as well as the major cause of climate change. Nevertheless, negotiating the terms of an international system of cooperation in the context of climate change has been a challenge, to say the least. Experience with past international climate negotiations (e.g. Kyoto, Copenhagen, and most recently Cancun) have had little success at agreeing upon, let alone implementing, a large-scale commitment to controlling greenhouse gas (GHG) emissions.

Successfully implementing a system of global compliance requires collective, social decision making that is unprecedented among people with radically different values and radically different needs [3]. To deal with the increasing difficulties surrounding complex sustainability problems like climate change, a new approach in teaching deliberative and decision making skills to future professionals is critical. Questions of sustainability demand a greater level of complexity and broader scope than the typical professional ethics pedagogy provides. That is, sustainability is not reducible to a tractable definition that is amenable to traditional problem solving strategies.

Our project, funded by the National Science Foundation, is developing a new pedagogy in sustainability ethics that forces students to confront some of the salient issues of sustainability directly. Unlike a traditional liberal arts pedagogy involving reading about ethics, discussing the readings, and writing new analyses, this pedagogy uses games to position students in a series of potentially adversarial relationships that allows them to experience personal ethical decision-making. By framing sustainability issues in terms of non-cooperative game theory, in which the outcomes that impact each player are influenced by the actions of other players, the goal is to involve students in explicitly collaborative settings that require coordination of decision processes to ensure group success. We hypothesize that this approach will result in students that are actively engaged in the classroom exercises, and result in an improved ability to identify ethical problems, pose potential solutions, and participate in group deliberations with regard to complex moral problems. In particular, we postulate that the games are valuable tools for teaching the ethics of climate change. Preliminary results have exposed interesting parallels between classroom game play strategy and real-world climate policy

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S. Spierre is a Ph.D. Sustainability student at Arizona State University, Tempe, AZ 85287, USA (585-7091366; email: susan.spierre@asu.edu).

T.P. Seager is an Associate Professor in the school of Sustainable Engineering ans the Built Environment Arizona State University, Tempe, AZ 85287 USA (email: thomas.seager@asu.edu).

E. Selinger is an Associate Professor of Philosophy at Rochester Institute of Technology, Rochester, NY 14623, USA (email: eselinger@rit.edu).

J. Sadowski is a undergraduate student of Philosophy at Rochester Institute of Technology, Rochester, NY 14623 (email: jathansadowski1@gmail.com)

negotiations and proposals.

We begin by describing the theory of non-cooperative games that is used to structure the educational games in the new pedagogy. We then provide an overview of key approaches that have been offered as pathways for allocating CO_2 emissions in response to the need for climate mitigation. We continue by framing climate change as a collective action problem that can be modeled in terms on non-cooperative game-theory. In the final section we draw upon the discussed game theory and climate policy proposals to reveal how the structure of the non-cooperative games and the observed game-play experiences simulate ethical dilemmas that are characteristic of international climate policy.

II. Non-cooperative Games

Noncooperative game theory is a tool used to understand the strategic interactions among two or more agents, where what is best for one decision maker may depend on what the other is doing and vice versa. Studying noncooperative games allows us to understand the ethical ramifications of decisions players make. The lack of a third party enforcer (e.g. the police) forces the players to decide the best course of action on their own. That is, there is no government or authoritative figure guiding players to make responsible decisions. For example, in the classic non-cooperative game, called the *prisoner's dilemma*, two isolated suspects individually reason to either betray one another, by confessing to a crime, or cooperate with the other, by staying silent. Analyzing the payoffs for each potential decision (Table I), it becomes *collectively* rational for both suspects to cooperate, resulting in the least total prison time (quadrant I). In this case however, suspects are isolated from one another and reason individually. It then becomes *individually* rational for both to betray each other because it has the potential to result in the least individual prison sentence. The paradox is that if both suspects reason this way, both will end-up serving a lengthy prison sentence (quadrant IV). If each prisoner instead considered the effect that their decision would have on the other, together they would have been much better off and spend less time in prison. The advantage of studying the prisoner's dilemma and other non-cooperative games is that they model situations in which there is a conflict between the interests of individuals and the well-being of the group, also known as *collective action problems*. Collective action problems include challenges of sustainability such as managing common-pool resources, preserving biodiversity, and mitigating climate change.

TABLE I
Payoff Matrix for the Classic Prisoner's Dilema Game

	Suspect A Cooperates	**Suspect A Betrays**
Suspect B Cooperates	Each serves 6 months **I**	Suspect A: goes free Suspect B: 10 years **II**
Suspect B Betrays	Suspect A: 10 years Suspect B: goes free **III**	Each serves 5 years **IV**

Our pedagogy in sustainability ethics has developed four game modules that simulate the same type of tensions presented in the prisoner's dilemma and are characteristic of collective action problems. Each module consists of a game representing a salient moral problem in sustainability, including: 1) environmental externalities, 2) the tragedy of the commons, 3) weak versus strong formulations of sustainability, and 4) intra-generational equity [4].By framing sustainability problems in terms of non-cooperative game theory, in which the outcomes that impact each player are determined partly by the actions of other players, we position students in explicitly social settings that require coordination of decision processes to ensure group success. More specifically, students earn grades for their individual decisions during game-play, which also play a role in determining the grades of the other students in the class. Each game is designed to steer students towards two moral questions: "What are my obligations to my fellow classmates?" and "What am I willing to risk in my own well-being to meet those obligations?" We hypothesize that experiencing and experimenting with ethical problems in game-play will be more effective for teaching ethical reasoning skills than the standard liberal arts pedagogy in the absence of experience [4]. In addition, by immersing students in challenging decision-making situations they will be more skilled at participating in group deliberation, which is the primary setting for policy negotiations. This is a first step in preparing the next generation of professionals to be better equipped in effectively addressing complex sustainability problems, such as climate change.

III. Climate Change Policy

Climate change policy mitigation is confounded with varying viewpoints on who should reduce emissions from countries of different development status. Highly developed countries (e.g. Canada, United States, and Norway) assert that GHG reductions would devastate their economy, placing developed nations at a disadvantage economically. They appeal to the fact that developed countries are more efficient at using energy and that restricting energy use in developed world would lead to a less-efficient global economy. They also assert that the total GHG emissions of developing countries will soon surpass emissions from developed nations and therefore emission reductions need to be placed on developing nations. Conversely, developing nations (e.g. China and India) make the case that because developed countries have been responsible for historical emissions, they should be the ones to pay for climate mitigation. Another claim is that the developed nations have more available resources than the developing nations and therefore should lead in the response to climate change. Furthermore, a strong argument for the developing countries is that it is unfair to equate necessary emissions in developing countries with luxury emissions in the industrialized world [5].

In light of the climate mitigation dichotomy, proposals have been offered to reduce global GHG emissions. Past international climate change policy has been primarily focused

on the market-based mitigation system of cap and trade. This type of strategy seeks to lower global emissions by placing a cap on the overall concentration of GHGs in the atmosphere, and then allocates the resource of GHG emissions to the most profitable producers through the trade of emission permits. For example, Peter Singer (2004) and Dale Jamieson (2005) propose a cap and trade mitigation technique that distributes emission rights on an equal per capita basis. This strategy allows countries that require more than their per capita allowance to buy additional allowances from countries that emit less [5], [6]. International climate policy, such as the Kyoto Protocol, also use a cap and trade system that distributes emission rights based on a polluters pay principle, where developed countries (Annex I countries), who are most responsible for historical and current emissions, agree to reduce emissions to legally binding targets [7].

Another proposal, offered by John Baer (2009), is referred to as Greenhouse Development Rights (GDRs) which determines an individual's obligation to climate mitigation constraints based upon a right to development principle. That is, Baer argues that there exists a level of welfare below which people should not be expected to share the costs of the climate transition because those individuals have little responsibility for the climate problem and little capacity to invest in solving it. Under the framework, the concept of a development threshold provides the basis for calculating national obligations for mitigating climate change. Baer considers two options for operationalizing the national obligations, including a large global fund through which all mitigation and adaptation would be financed or a global system of national allocations as the basis for a global trading scheme (i.e. cap and trade) [8].

A student participating in the noncooperative games we've developed will struggle with ethical decision making that is comparable with the considerations that political leaders must contemplate within climate negotiations. In the same way students question their obligations to their classmates in the games, country representatives involved in climate policy inherently also consider, "What are my countries' obligations to other countries?" and "What are we willing to risk in our own well-being to meet those obligations?" Next, we try to clarify the tensions particular to climate change by using non-cooperative game theory to model the problem.

IV. Climate Change and Collective Action

In the context of climate change, the collective or shared resource at stake is the Earth's atmosphere, which has a limited capacity to store GHG emissions. Climate change is a problem of collective action because everyone has a common interest in preserving the atmosphere, but few individuals are willing to sacrifice emissions for the cause. Individuals are incentivized to free-ride on the altruism of others that do sacrifice, since everyone will benefit from decreased emissions regardless if they personally make the sacrifice. To expose these tensions, we frame climate change in terms of non-cooperative game theory and model it similarly to the prisoner's dilemma (Table II). The players in this case are those responsible for the GHG emissions: countries, institutions, companies, and/or individuals. The strategies of each player can be simplified into two categories: mitigate by decreasing emissions of GHG or continue to conduct business as usual. In this case, the players are referred to as Country A and Country B.

TABLE II
Potential Payoffs for Climate Change Mitigation Strategies by Two Countries

	Country B: *Mitigates*	**Country B: *Business As Usual***
Country A ***Mitigates***	**Both countries:** Neither has an economic advantage in the short term **Both countries:** benefit from long-term sustainable eco-system services, better human health, diversified and independent economies, as well as an improved sense for justice and the well-being of others **I**	**Country A:** disadvantaged economically in the short term due to conservation efforts including reduced industry and decreased production **Country B:** benefits economically by maximizing industry and production **Both countries:** over the long-term suffer from heightened GHG concentrations in the atmosphere **II**
Country A ***Business As Usual***	**Country A:** benefits economically in the short-term by maximizing industry and production **Country B**: disadvantaged economically in the short term due to conservation efforts including industry and production **Both countries:** over the long-term suffer from heightened GHG concentrations in the atmosphere **III**	**Both countries:** benefit economically in the short term **Both countries:** suffer from environmental and economic degradation in the long-term **IV**

Analyzing the payoff matrix (Table II) shows that it is collectively rational for both countries to cooperatively mitigate by restricting overall emissions. That is, each country prefers the outcome produced by everyone restricting pollution over the outcome produced by no one doing so. However, it is individually rational for each country not to restrict its own pollution. When each agent has the power to decide whether or not to restrict emissions, each (rationally) prefers not to, despite what the other decides to do [9]. Countries are incentivized in the short-term to conduct business as usual to maximize economic gain, but the consequences of not mitigating will be overall suffering in

terms of environmental and economic degradation over the long-term (quadrant IV).

Framing the climate change issue in terms of non-cooperative game theory helps to clarify the tensions that exist internationally between nations. Also, analyzing the issue in terms of a collective action problem highlights the urgency for a global responsibility system that enforces mitigation, preventing countries from ending up in the fourth quadrant. In the last section, we look more closely at how the new pedagogical game-play simulates ideas and operations that are characteristic of climate change policy tensions and negotiations.

V. Relating Non-Cooperative Games to the Ethics of Climate Policy

Through testing the games and preparing complimentary educational material, we have found that the developed non-cooperative games are effective at replicating the ethical tensions surrounding the issue of climate change, in particular. Here we provide a few examples of how the structure of the games and the experience of game-play simulate the existing pressures of the issue.

An important tension in the ethical games we've developed is the varying advantages of the randomly assigned player roles. For example, in the tragedy of the commons games (a/k/a the Pisces Game), students form groups based on their astrological zodiac sign, and the order of play is determined by the sequence of zodiac periods through the astrological year. Because this is a sequential game, students that happen to have a birthday early in the astrological year (i.e. Aries or Taurus) have an advantage in the game over students with later birthdays (i.e. Aquarius or Pisces). Assigning roles in this way simulates real-world injustices and global power structures between countries at varying development levels. Specifically, it simulates the dichotomy between developed and developing nations over climate mitigation issues. Industrialized countries have an advantage when it comes to climate negotiations because they have had the historic luxury to develop without restrictions and currently possess the wealth to adapt to climate change. Alternatively, developing nations are at a relative disadvantage because they are currently developing in an age of potential climate mitigation that may place a limit their future economic growth. In addition, poorer countries are more vulnerable to the worst impacts of climate change because a greater proportion of their economies are located in climate sensitive areas and have little resources to deal with those impacts, even though they have historically done the least to cause the problem [9]. Similarly, in the Pisces Game students who go last are at a great disadvantage in earning a good grade, even though they did nothing wrong.

Students earning grade points in the sustainability ethics games provide a way to simulate a country's development level in the real-world, which is largely determined by the level of a country's energy production and/or consumption and resulting GHG emissions. Specifically, a student's grade in a game can be used to represent a country's development score determined by the Human Development Index (HDI), which is a composite index used to rank countries based on their human development level. For example, in the environmental externalities game (a/k/a the Externalities Game), students earn grade points for their production decisions. A student with a grade of 90 or more could represent a highly developed country, and a student with a much lower grade could imitate a country with very low human development. This situation becomes important in the second part of the round because students have an opportunity to share points with less-fortunate classmates. Students must decide between acting selfishly by keeping points to earn a high grade and acting cooperatively by sharing points with peers who may be failing. In the international scene, this situation replicates tensions between countries on the subject of foreign aid; should the richer, developed nations be obligated to assist the poorer, undeveloped countries in adapting to climate change? Even more controversial; should the developed nations reduce their GHG emissions to provide developing countries an opportunity to obtain sufficient human development?

Another feature of the games that primes students to participate effectively in group negotiations is the importance of trust. In order to achieve group success, the students must develop a sense of trust in one another. For example, in the Externalities Game a solution that enables all students to earn an A is that the class allows one group of efficient players to produce all the grade points, and trust that they will share points with the rest of the class later in the round. The solution is analogous to the appeal that developed countries should not be restricted from emitting GHG because it would result in a less efficient global economy [5]. The game provides plenty of opportunities for students to lie, cheat, and steal from their classmates by not sharing points at all or by only sharing some points with their classmates. This can result in low grades for the students that act cooperatively with the group's strategy and high grades for the selfish actors. These selfish acts in one round prove to create a feeling of mistrust and hinder the collective cooperation potential of the class in the next rounds of play. In the context of climate change, countries will be unwilling to reduce emissions if they do not trust other nations to do the same. Also in the absence of collective action, countries that voluntarily curb GHG emissions will have the practical effect of incentivizing others to increase emissions. That is, the country that reduces emissions will be at a disadvantage compared to the countries that keep emitting as usual.

Game-testing experiences have resulted in emergent enforcement mechanisms, where students elect leaders to supervise the decision making process. Although most students behave cooperatively and follow the group's strategy, there are usually a few players that opt out of participating in the emergent enforcement and submit their decisions independently. Some students assert that they do not trust the strategy offered, while other players try to take advantage of the cooperative group. Students have also created ways to

punish delinquent players by not sharing points in the current or later rounds of game-play. Similar tactics can be observed in climate negotiations where enforcement might be accomplished by a representative third party, such as the United Nations, that develops the terms of international climate policy. For example, the United Nations approved the Kyoto Protocol which set binding GHG emission targets for industrialized nations. Like the independent students in the class, Kyoto was not ratified by all countries, including the United States, despite its large contribution to the climate change problem. Under Kyoto, the punishment for not complying with emission limitations is that a country is required to make up the difference plus an additional 30% and that country is suspended from making transfers under an emissions trading program. The United States however has not ratified the treaty and therefore is not required to comply with that particular punishment, but prohibiting trade of any kind with a country that does not ratify the international treaty may be an effective enforcement tool. The lesson to be learned is that without total cooperation from everyone, a global system of responsibility will not succeed in effectively stabilizing the climate system, just like a few selfish players in a classroom will keep the students in the class from all getting good grades.

Time and experience with game-play definitely proves beneficial to fostering cooperation in the classroom, as has been observed during game testing experiences. Students who have played the games so far have all eventually found a way to act cooperatively so that everyone in the class earns an A grade in the final round. For example, successful game-play strategy in the Externalities Game has involved the majority of students trusting a minority of students to produce at a maximum and share grade points later-on in the round. The opportunity to share and/or distribute grade points in all of the games becomes an important ethical statement and plays a vital role in grade determination. Distribution is also a very critical part of any climate change policy because it determines how much of a resource, such as the right to emit, goes to each individual [10]. Students who have played the Externalities Game and the Pisces Game so far have opted to follow the Singer (2004) and Jamieson (2005) ethic by distributing grade points on an equal per capita basis, so that everyone earns an A. Following Baer's (2009) ethic of development rights, students would have a right to at least a passing grade, and if they are not passing they should be exempt from sharing points. Another ethic that could be argued for is to give more points to players that received lower grades in the previous rounds of play in an effort to make up for historical injustices. Analogously, some nations may advocate for a system where developed nations provide developing nations with resources because of the historical inequality of emission contribution and the disparity in human development levels.

Many of the discussed parallels between game-play and international climate change policy are revealed in post-game reflective exercises. Students are asked about why they behaved the way they did and how they reacted to their classmates actions. They consider how their roles as players determined their fates and if they would have behaved otherwise if assigned a different role. Reflecting on how the games simulate real-world sustainability issues makes students appreciate the complexity of ethical dilemmas that can hinder effective group action. In particular they learn about the benefits of acting ethically as a group and the consequences of looking at the world through a narrow, one sided lens.

V. Conclusion

Our new pedagogy in sustainability ethics provides a method to teach students in a way that leverages their interests in experiment and experience. Preliminary test results have created an intellectual as well as entertaining experience for the students. In addition, educating future professionals about the tensions within climate change, and other complex moral problems, may provide a way to streamline the near impossible and tedious negotiating process within international policy-making. Furthermore, simulating the present ethical dilemmas and fostering group deliberation within classroom game-play is a likely remedy to the current generation of ill-prepared professionals, who have only been taught how to approach relatively tame and straightforward ethical problems.

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