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An Experiential Pedagogy for Sustainability Ethics

Abstract

While sustainability is increasingly recognized as an important ethical principle, *teaching* ethical reasoning skills appropriate for sustainability is problematic. While the classic approach in professional ethics education makes intensive use of behavioral codes and retrospective case studies, these approaches are limited in their ability to prepare students for the unfamiliar and forward-looking problems of sustainability. Moreover, the classic read-discuss-write pedagogical strategies typical of the humanities emphasize abstraction and reflection at the expense of two modes of learning more familiar to many professionals (e.g., engineers and physical scientists): experimentation and experience. This paper describes the results of a novel *experiential* approach to ethics education that employs non-cooperative game theory to position students in situations that model unfamiliar ethical tensions characteristic of sustainability problems, such as the Tragedy of the Commons. In this approach, students can only advance their own grade at the ultimate expense of other students. Whereas the Nash Equilibrium in our games predicts systemic collapse of student grades, the actual grade outcomes aligned with egalitarian ideals, despite evidence of conflict in on-line student communications.

Introduction

Sustainability is increasingly gaining the interest of professional engineering societies that consider adherence to the principles of sustainable development a fundamental ethical responsibility [1]. However, exactly what those principles are and how to teach them remains a vexing problem for existing engineering education [2]. Traditional, case study approaches are problematic in matters of sustainability. In part, this is because case studies are by necessity retrospective, while problems of sustainability are forward-looking. Specifically, the Brundlant Commission's definition of sustainable development stresses the importance of limitations and/or restrictions to maintain the environment ability to meet both present and future needs [3]. For example, our current experiences with global climate change (e.g., changes in precipitation, melting polar ice, and frequent hurricanes) are insufficient to inform us of the full *moral* dimensions of the problem, which include our obligations to unborn generations. In fact, James Hansen and others [4] show that the majority of impacts from GHG emissions will take place 25 to 50 years in the future. Case studies that can capture such prospective aspects of sustainability and the views or preferences of future people are, by definition, non-existent.

Additionally, the classic liberal arts pedagogy of read-discuss-write limits students to learning about ethics via abstract, fictionalized examples that students may fail to identify with. For example, in the presentation of the classic case study of the space shuttle *Challenger* disaster, students are encouraged to confront the potential conflict between holding paramount the health, safety, and welfare of the public, and serving as a faithful agent to their employers [5]. According to the ethical norms of the engineering profession, where duty to the public overrides duty to an employing organization, the engineer should become a *whistleblower.* While most students cognitively understand what their Instructor's claim is the "right" thing to do, they may nevertheless fail to understand the difficulty of *acting* in accordance with that understanding in a professional setting. That is, the case study approach may fail to resonate with engineering and physical science students who invariably consider themselves to be morally exceptional in the sense that they would either never confront a similar issue, or would consistently perform admirably in similar cases. This phenomenon is so familiar that is has a name in moral philosophy called the "Moral Saint Fallacy", in which outside observers overestimate their own moral fortitude – at least until they are actually confronted with a real moral dilemma [6].

Lastly, professional ethics typically involves a code and/or a set of fundamental canons, such as the NSPE Code of Ethics for Engineers [7]. Such rules are enacted to achieve predictable results as well as to provide a clear account of what behavior is considered ethical or correct in various circumstances. However, lists of rules are difficult to apply toward the broad systematic lens through which sustainability challenges are viewed. Sustainability problems can be unfamiliar, high-risk with highly unpredictable outcomes [2]. To effectively operate under these uncertain and unanticipated conditions, future engineers and scientists need to be able to handle surprising situations and be equipped to evaluate appropriate action where conflicting interests are at stake.

For example, Freeman et al., describe how the occurrence of natural disasters and extreme events, like flooding of the Mississippi, may become more frequent and more intense, not to mention more costly in the future as a result of both climate change and increasing populations in vulnerable areas [8]. For example, record water flows in the Mississippi River from Illinois to Louisiana in Spring 2011 overtaxed the levee systems designed in the 1930s to manage river flows and control flooding. When water levels on the Ohio river were projected to exceed 61 feet above at the Cairo, Illinois river gauge, the US Army Corp of Engineers (USACE) ordered the detonation of explosives that would intentionally flood farms in Birds Point-New Madrid Floodway, but spare Cairo from sure destruction. The induced breach and flooding of the 53,824 ha of Missouri farmland resulted in the loss of 2011 crops (i.e., wheat, corn and soybeans) and caused damage to future soil productivity [9].

While the floodway was originally constructed in 1928, it had never been activated until 2008, despite earlier extreme flood events. Taken in isolation, the floodway decision faced by the USACE in 2011 has elements of the classic utilitarian thought experiment known as the "Trolley Problem" (http://en.wikipedia.org/wiki/Trolley_problem). However, the channelization and levee construction enacted by the USACE that was intended to protect communities may have perversely increased systemic flood risks [10]. To the extent that the Mississippi River system acts as a complex system, the consequences of any single engineering action may be unpredictable and uncontrollable – i.e., resulting from hidden or multiple, interdependent causes – that undermine utilitarian reasoning. It is therefore imperative that students preparing for sustainability-related careers possess moral reasoning capabilities that are adaptive to unfamiliar and unexpected situations. We argue that without experiential learning, existing ethics education is insufficient for preparing students to employ adaptive strategy techniques required for forward-looking sustainability problems. Here, we outline an alternative educational approach that will strengthen the student's ability to learn, experiment, and adapt to such unforeseen circumstances.

The game modules supplement traditional teaching approaches to complete the Kolb Learning Cycle. According to Kolb, a successful learning experience contains both active and passive styles of learning, these include: 1) abstract conceptualization; 2) active experimentation; 3) concrete experience; and 4) reflective observation [11]. These learning components occur sequentially, transitioning from one learning style to another as displayed in the classic representation of the cycle in Figure 1 below. Each game in our pedagogy is designed as part of an entire lesson module that moves students through the entire Kolb cycle.

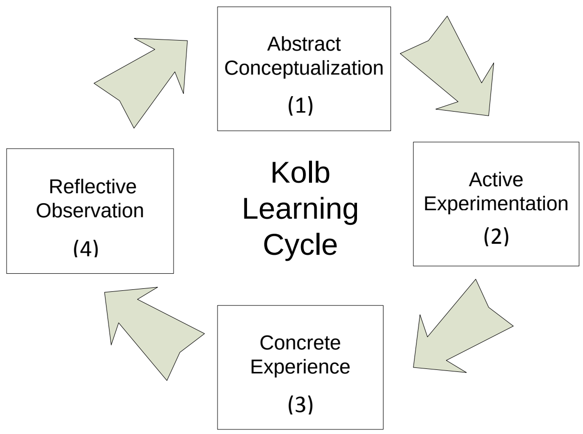

Figure 1.The Kolb Learning Cycle includes both active and passive components.

A Novel Pedagogy

Our project in sustainability ethics, funded by National Science Foundation grant #1134943, is developing a new pedagogy in ethics education that uses experiential learning techniques to confront the salient, forward-looking moral problems of sustainability. Unlike the traditional liberal arts approach, this pedagogy uses educational games to position students in a series of potentially adversarial relationships that allows them to experience ethical decisions directly. This experience provides students with personal knowledge to draw from when confronting future moral problems. The games focus on four key sustainability concepts: environmental externalities, the Tragedy of the Commons, weak vs. strong sustainability and intra-generational equity [12]. These salient sustainability issues are inherently characterized by their forthcoming consequences and the moral complexity related to impacts of current decisions on future generations. In each game, students must ask themselves the question, "What are my obligations to my fellow students?" and "What am I willing to risk in my own sense of well-being to meet these obligations?". Thus, students have the opportunity to *experiment* and *experience* with real-time ethical decision-making that results in authentic impacts on others in the classroom. We hypothesize that teaching ethics through games will result in students that have an improved ability to participate in group deliberations with regard to complex moral problems. Additionally, they will be more actively engaged in the classroom, have an improved ability to recognize moral problems and pose solutions, as well as be more comfortable and confident in making decisions that affect other people.

The games are based upon non-cooperative game-theoretic tensions and structure, such as the classic prisoner's dilemma, that position the students so that they can only unilaterally advance their own interests at the expense of other students. In game-theory terms, non-cooperative games simulate 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. Non-cooperative situations are effective at examining the ethical ramifications of decisions players make when confronted with the tension between their individual interests and group benefit that is characteristic of sustainability *collective action problems* [13]. In the games, this tension is created through grade points that are earned through individual or team decisions during game-play, but also play a role in determining the grades of the others in the class. In our games, there is no government or authoritative figure (i.e., a third party enforcer) guiding players to make responsible decisions. While a successful group will cooperate to coordinate the actions of the entire class, the games are structured so that the Nash Equilibrium, where no student can unilaterally improve their own position, will result a systemic collapse in all grades.

The general module format starts by priming students for game-play through assigned readings, PowerPoint style lectures, and on-line videos. This provides the background information (such as the professional engineering codes of ethics) and theory for the particular sustainability issue and allows students to *conceptualize* the problem and possible solutions in an abstract way. Understanding of theory may be assessed through graded writing assignments such as formal essays or less formal entries online (wikis, tweets, or blogs). Next, students are encouraged to *experiment* with game calculators to become familiar with how the game works and to determine possible game strategies. Before playing with the entire group, students must hypothesize what will happen during game-play, and predict the level of cooperation they expect from their peers. This serves as an assessment tool for experimentation, as they apply theoretical solutions to their knowledge of the game. During actual game-play, students *experience* ethical tensions directly, as they make decisions that impact themselves and others in the class. By observing the interactions among students, tracking individual/team decisions, and through the communication record of online chat boards, instructors may assess the quality of discourse. The resulting game grades of each player will quantitatively express the level of coordination obtained. That is, a large variation in scores suggests a competitive environment in which decision-making is unilateral, whereas low variation implies successful class collaboration. After game-play, the class participates in a series of class-wide and individual *reflection* exercises, including discussions, debates, and writing assignments. Table 1 outlines how the specific components (objectives, activities, assessments, and expected outcome) of each learning stage are addressed.

Table 1. Specific components of our pedagogy are organized to bring students through the complete Kolb Cycle.

	Kolb Learning Cycle Stage			
Stage Specifics	**Abstract Conceptualization**	**Active Experimentation**	**Concrete Experience**	**Reflective Observation**
Objectives	Provide background for sustainability issues Introduce related theory and general ethical codes of conduct	Learn how the game works Determine effective strategies Identify successful outcomes	Directly experience ethical decision making with classmates Sharpen deliberation skills Practice discourse ethics	Develop realizations of individual moral fiber Confront discrepancies between what they say they would do and what they actually did
Activities	Assigned readings PowerPoint lecture Educational videos	Experiment with game calculator Discuss possible outcomes of various strategies and thought experiments Students may take a trial and error approach to game-play	Navigate non-cooperative situations Role playing Negotiating & deliberating with classmates Opportunities for leadership and teamwork	Compare hypothesis to results Relate to real-world collective action problems Debate the actions of classmates Classroom discussions Completing reflective writing assignments
Assessments	Graded writing assignments such as essays, wikis, tweets, and discussion board entries	Students apply theory by publically hypothesizing about expected behavior	Individual and average grades Communication record Observation of game-play interactions Sharing of game points	Graded reflection essays on their experience and/or how they might redesign system for more cooperation
Outcomes	Students develop interpretations and conceptualizations of sustainability problems	Game strategy Some students emerge as group leaders at this stage	Relationships and trust between classmates Heightened emotions and memories Teamwork skills Improve ability to improvise A sense of accountability to classmates	Group tacit knowledge Students alter their perceptions and interpretations of theory and conceptualizations

The Pisces Game Example

The most widely adopted of the four games we have developed and tested is called the Pisces Game. It has been tested at six different institutions, including graduate, four-year undergraduate and community college settings. It is designed to introduce the concept of the Tragedy of the Commons. As an illustrative example, we outline the complete game module below.

Theory--Originally formulated by Hardin in 1968, the Tragedy of the Commons has explicit moral implications[14]. The basic premise is that there is no technical solution to what amounts to a game theory problem, in which individual incentives are in conflict with collective outcomes. The concept has subsequently been applied to a wide variety of problems in ecology and economics such as overfishing, in which individual incentives to catch as many fish as possible are at odds with the desirable outcome of sustainably managing the fish population. As the problem is modeled in non-cooperative game theory, there are two possible resolutions: collapse of the fishery resulting from unrestrained competition or a sustainable fishery resulting from self-restraint. Hardin's theory predicts that only the collapse scenario is attainable without third-party enforcement, which could come in the form of government action or cultural norms. On the other hand, more recent work by Ostrom describes case studies where groups have successfully managed common-pool resources without government intervention when specific characteristics of group dynamics and enforcement mechanisms are present (i.e., small groups of people relying on shared norms)[15].The Pisces Game allows students the opportunity to experiment with both Hardin's and Ostrom's theories of managing the commons in the context of fishing for survival on a shared Lake.

Pre-game activities- Prior to game-play students are primed for the exercise by reading Garrett Hardin's *The Tragedy of the Commons* (1968)[14] as well as Elinor Ostrom et al's later response entitled *Revisiting the Commons: Local Lessons, Global Challenges* (1999)[15]. This period of abstract conceptualization is necessary for students to understand the thought and theory behind managing common resources, as well as the potential solutions proposed in the literature. A PowerPoint lecture has also been developed that reviews the theory described above and explains the biologically-based reproduction function used within the Pisces Game. Students are provided with game rules and encouraged to actively experiment with game strategies using the game calculator, which is available online, and asked to provide a hypothesis of what they think will happen when the class plays. They are expected to apply the theory and concepts they learned in class to justify their hypothesis.

Game-play-- The actual game-play experience occurs in class and takes about 60-90 minutes, depending on the number of players and how long the teams are allowed to deliberate between decisions. The Instructor administers the game and records the team's decisions in the game calculator. The game can be played once or multiple times, depending on time availability and at the discretion of the Instructor. The game starts by dividing students into teams based on their individual zodiac signs, which determines the teams and the order of play. The Pisces team is placed at the ultimate disadvantage in this game, since they are the last team to harvest in each round, and often suffer from a lack of available resources. The tension between teams that can harvest early in each round with those harvesting later fosters discussions of fairness and responsible decision-making during play.

The focus of the Pisces Game is on resources (i.e., fish) and all students (or teams) who act as resource extractors (i.e., fisherman). The teams proceed to harvest fish sequentially following a few limiting rules (i.e., boat capacity, fish needed for survival), until all teams have harvested once each round. Each team must decide how many fish to harvest that directly increases their grade and how many they wish to invest in building a private fish farm, which has higher reproduction rates but requires capital investment. (Capital is raised by selling fish taken from the Lake). The remaining population of fish in the Lake is calculated and announced after each round of play, allowing for the fish to reproduce. If teams harvest fish in the Lake to extinction, the game can continue only for teams that have enough fish in their private ponds. The game ends for each team in the round when they cannot make their survival harvest quota, up to eight rounds. Grades are assigned based upon only the resources gathered up to that round.

Post-play--After game-play, the instructor facilitates a reflective discussion. In particular, students are asked to comment on why they made particular decisions, if/how they were influenced to make certain choices, and how they might play differently under different circumstances. Discussion often focuses upon questions of responsible management (by sustaining the common lake of fish) or individual well-being (by consuming fish for grade points). Students are asked to compose a reflective essay on their individual experience of game-play. We have found that the Pisces Game module is best administered over multiple classroom sessions, and if the class fails to achieve cooperation for the group's success, students may ask to repeat the game after a period of reflection.

Results

At first, students can be intimidated and resistant to the unfamiliar and interactive classroom structure that these games nurture. Engineers in particular often find it difficult to articulate their ideas, including emotional or moral appeals, to the class. However, the unstructured class structure allows leaders to emerge. Activities are characterized by peer deliberation and conflict, signs of emotional investment, and extremely active participation from a few individuals, with most others following along. In general, we observe that moving from a traditional pedagogy to the game-based pedagogy fosters a transition in students from spectators to players, from passive to active, from apathetic to emotionally invested, from narratively closed to experimentally open, and from predictable to surprising.

All four game modules have been piloted in sequence at Rochester Institute of Technology and at Arizona State University as part of a new undergraduate course called "Sustainability Ethics" in which students from many disciplines enroll. Our experience demonstrates that when the complete set of modules is delivered in series, students gain communication, deliberation, and team-work skills in addition to moral reasoning. For example, while playing the first game of the series (*The Externalities Game*) students often do not know one another's names and they demonstrate difficulty in coordinating their actions as a group. This failure demonstrates the lack of skills necessary to find a cooperative solution to a problem of collective action. Erden et al. (2008) might blame the lack of coordination on low levels of *group tacit knowledge* (GTK)[16]. At low levels of GTK groups are characterized by loose assemblages without group identity or self-knowledge and may have difficulty even following instructions or taking orders. By the fourth game of the series (*Intra-generational Equity Game*) students become conditioned by their previous experiences and display an improved ability to adapt by establishing strong lines of communication and constructive dialogue among players and teams. In later game modules students are able to effectively resolve difficulties of cooperation by instituting self-designed governance structures to ensure formation and enforcement of rules that instantiate a collective strategy. This behavior indicates an improved quality of GTK that allows them to improvise unique and effective solutions to unfamiliar, complex problems [17].

Online Game-play-A recent development that has been tested with the Pisces Game has been to allow students the opportunity to play the games with and/or against other classes at other universities. By recruiting additional Instructors and through the use of EthicsCORE, a collaborative online communication platform (www.nationalethicscenter.org), we can now offer a blended course structure, both online and in the classroom. Students are encouraged to communicate via EthicsCORE, where they can strategize, deliberate, and inform each other of what is occurring in multiple classrooms. This online play has added a new dimension to game-play, in that decisions made by an individual student, or a small group of students, will impact the grades of those present in the same classroom and also the grades of students located at distant geographical locations. This allows game-play among students with potentially very different experiences, cultures, and educational backgrounds to collaborate in ethical decision making and creates a much more realistic yet unfamiliar ethical situation for the students to experience. There is also the opportunity for players present in one class to make decisions that affect others who are absent from the deliberation and/or students continuing to play the game at a later time. Thus, playing the games across universities allows Instructors to simulate both *inter*generational as well as *intra*-generational ethical considerations. Instructors can also use EthicsCORE as a tool for cooperative teaching and for reporting their game-play experiences to other game administrators.

A recent test of online game-play was administered with the Sustainability Ethics class at Arizona State University (ASU) and two introductory Engineering classes at the nearby Mesa Community College (MCC). The first MCC class (MCC1, about 24 students) played the first four rounds of the Pisces Game in isolation and passed the resulting shared lake of fish and group resources to students in the later, but simultaneously scheduled MCC (MCC2, about 24 students) and ASU class (ASU, about 70 students). Groups MCC2 and ASU thus inherited resources from MCC1 and had to complete the final rounds of play through online communication between classrooms.

MCC1 obviously had a simpler task (less students playing in a single classroom), and came to class prepared with a "master plan" of action. Two students in particular emerged as group leaders and explained the plan to the entire class. As a result, there was a concerted effort to earn equal grades through class-wide trust and effective communication. Although MCC1 students could have acted rapaciously, given the abundance of fish in the Lake available to their generation, they all agreed to scores of 80% with little conflict and felt pleased with the resources they would bestow on the next generation, MCC2 and ASU. In fact, MCC1 left a message online for the future students explaining their strategy and enabling continuation of the 'master plan".

MCC2 and ASU struggled much more than MCC2, as they were trying to organize larger, geographically separated teams to coordinate a synchronized group effort. In MCC2, many students seemed unaware of the 'master plan' or even the rules of the game. ASU, on the other hand, had students that were more prepared and were able to build upon the 'master plan' provided. Leaders emerged from ASU and their solution to the coordination problem was to suggest to the MCC2 students that they delegate all decision-making authority to ASU -- a suggestion that some MCC2 students resented.

A simplistic dynamic between ASU and MCC2 may have prevailed, however, a clerical error in data entry committed during the last round of MCC1 play resulted in the "death" of thousands of fish, and drastically reduced grade expectations in the MCC2 and ASU groups. The students' immediate response to discovery of the error was to appeal to the Instructors to correct the clerical error. The Instructors refused, reasoning that fish surveys might be unreliable, and that moral reasoning requires confronting conditions that are unexpected, and even unfair. Further, game play had already advanced past the point of the error, and attempting to roll back play would have interrupted the game flow, implied that the authority of the Instructor superseded a principal of student autonomy (even when that autonomy results in damaging errors), and undermined the veracity of the emotional experience that surely would become a critical aspect of reflective discussion.

The common lake was exhausted of fish halfway through the MCC2 and ASU play, but the leaders in ASU kept the class on track and committed themselves to ensuring the best possible outcome for the overall group -- a grade of 78 for all players. In this case, cooperation and egalitarianism prevailed, despite the errors, communication difficulties, and grade incentives for selfish play. That is, despite the lack of familiarity with each other, and the fact that students at MCC and ASU were enrolled in different classes, at different institutions, the students succeeded at coordinating a group outcome that reflected a unanimous consensus (at least in action) of a normative ethical view – that all students should get the same grades. However, the uniform outcome belies the conflict represented in on-line communication between MCC2 and ASU via EthicsCORE. Figure 2 shows a time sequence of communication quality represented by level of conflict expressed in the chat room, among different teams during the through the game-play experience.

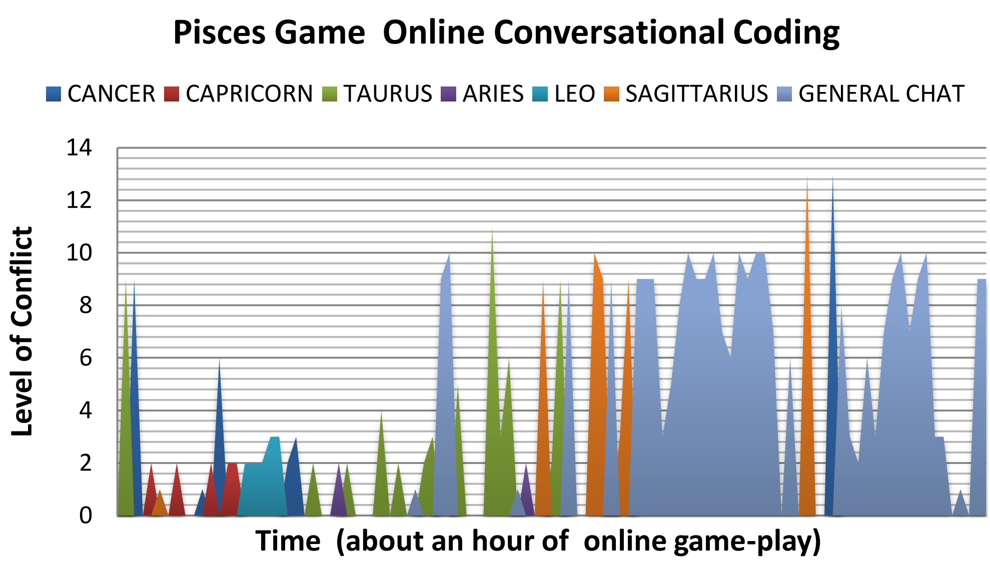

Figure 2. Online chat messages for the game were coded using the Conversational Argument Coding Scheme by Daniel Canary [18]. This coding highlights levels of conflict within conversations using 14 different codes which can be arranged by increasing levels of conflict. The bright colors indicate level of conflict among members of zodiac teams, whereas the light blue represents conflict in the general chat across teams.

Some individual teams recorded little to no conflict among themselves, which may be the result of smaller teams, effective leadership, and/or greater adaptability. Other teams contributed little communication at all to the online forum. Most statements within teams were non-argumentative and were mere attempts to reach out to other team members in the other classroom. However, in the general chat (where players could communicate between teams) a different story emerges. Most contributions to the general chat began when the mistake in the game calculator was discovered. There was obvious conflict among students concerning the error, with some students explaining it to others to pacify the situation.

While some students claimed that the mistake originated with MCC1, this fact was openly contested by others who thought of this as unfairly passing the blame onto earlier players. The mistake resulted in an unforeseen event for the students to struggle with and experiment with adaptive strategy. At the close of the game several players expressed their frustrations in their game-play experiences in the online chat. Students from MCC2 generally felt that they were not as involved in the game as they should have been, and made statements about the disorganization and unwillingness to communicate by ASU members. The arguments within the general chat confirm issues of trust, communication, power, and threats that peak near the end of the game (Fig. 2). Although there was evident conflict between MCC2 and ASU players, the students were able to operate under almost complete cooperation in *action* to achieve the highest grade that could be earned by all players evenly

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