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AGENT-BASED SIMULATION FOR TEACHING ETHICS

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ABSTRACT

The present work discusses the use of NetLogo, an agent-based simulation software, as a tool to teach ethics modeling as part of an ethics course. It allows students to define and describe the behavioral rules of agents under different ethical theories through agent-based simulation and learn and assess the consequences of such ethical behaviors. Several simulations developed by the students along with their principal findings are presented.

1 INTRODUCTION

Ethical decision making refers to the process that a person follows to arrive to a decision when facing an ethical dilemma. This process goes from identifying the dilemma, the facts and the stakeholders involved, to evaluating different options and making a decision considering ethical principles. This decision depends on an individual's set of moral values which underlie his attitudes and affect both his acceptance or rejection of norms, and affects his personality (Schwartz 2012). People have different set of moral values as a result of their life experiences and cultural and societal influence. Human relationships are complex and specially when interacting with others of different morality when facing an ethical dilemma.

Agent-based simulation is an effective means for modeling ethical behaviors of individuals, observe their complex interactions, and identify outcomes that could be considered atypical thinking. First of all because us, people, are agents who have different and individual characteristics or attributes and interact with others according to a set of behavioral rules based on our set of moral values. An agent-based simulation is a model of a system that operates over time, where individuals are represented as agents. These agents, who can be persons, animals, entities in general, have individual characteristics and logic rules that set their actions and reactions. Second, because we make decisions on our own, and interact constantly with others. Agent-based simulation is more flexible and efficient in modeling interactions among agents, rather than discrete-event simulation, for example, where the simulation models interactions among processes within a discrete-event system (Chan et al. 2010). Agent-based simulation allows the user to observe agents interacting dynamically with other agents and the environment, and the effect of individual decisions on the system dynamics (Macal and North 2010).

There are several agent-based simulation software packages commonly used nowadays. They differ on their primary domain, license, operating system, user support, among others. NetLogo is the package used for this work primarily because it uses a general-purpose language simple to understand since the syntax is similar to natural language where students do not need a programming background. In addition it is free, and runs on Linux, Windows or Mac OS. It has an excellent documentation (Railsback et al. 2006) and provides a models library where users could search and study already built models. It is a multi-agent modeling platform powerful enough to develop medium to high scale level simulation models, yet with a model development effort cataloged as simple or easy to learn and use (Abar et al. 2017). NetLogo has been used for a variety of applications in both the social and natural sciences as well

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as for teaching and research purposes in general. Railsback et al. (2009) found NetLogo very suitable for use in education because of its easiness of use.

Very little has being found in the literature regarding the use of agent-based simulation as an educational tool for teaching different areas than simulation itself. There are some applications in fields such as in science (Okanoto et al. 2011, Hayse 2007) , economics (Kvasnicka 2014) and business (Baptista et al. 2014, North and Macal 2017). In these applications, agent-based simulation is being used as a teaching tool in two ways: for modeling and building a simulation to gain deeper knowledge of a system, and for interaction of students with a simulation already built to understand the different outputs of the system under different conditions. To the best of our knowledge, there are no applications of agent-based simulation as a tool for teaching ethics.

Simulation for teaching ethics has been discussed in business for the last two decades (LeClair et al. 1999) and in health care for the last decade (Buxton et al. 2014), but it usually refers to case-studies, role-play or games. No work has been found that uses simulation for modeling ethical behaviors and gain deeper knowledge of the rational process an individual follows to arrive to a decision.

2 ETHICS COURSE

The ethics course was designed as a 14-week academic semester course as a result of a National Science Foundation (NSF) award on "Educational Simulation for Computing and Information Ethics" (Fleischmann et al. 2009). It covers topics related to ethical issues, with a particular focus on those issues related to the introduction of information technology into society, such as communication over the Internet, exchange of intellectual property, privacy, vulnerability of networked computers, software and computer reliability, workplace monitoring, telecommuting, and globalization. During the course, students are presented with a wide range of theories of ethical decision-making, including their advantages and disadvantages in a variety of decision- making situations (Murrugarra and Wallace 2015). Students apply these theories in discussing and confronting ethical dilemmas through cases and to understand and simulate ethical behaviors using an agent-based simulator. Although the course was not designed specifically for undergraduate students nor with a particular major in mind, it is mainly being taught to senior students with a major in Industrial Engineering.

The content or skills the students are taught in the course are:

1. Ability to design models and conduct simulations, as well as to analyze and interpret data.
2. Ability to identify, formulate and solve engineering problems.
3. Ability to communicate effectively.
4. The broad education necessary to understand the impact of engineering solutions in a global and societal context.
5. Knowledge of contemporary issues.

Upon successful completion of this course students are able to (outcomes):

1. Model aspects of a target phenomenon and use this model to simulate activities for this target phenomenon.
2. Use ethical principles to assess motivations, processes, or the related consequences.
3. Integrate the application of these two knowledge areas and model, ethically.
4. Identify key problems in the ethics of modeling and propose solutions to these problems.

Skill number 1 is related to learn how to build a model using agent-based simulation. We believe that the introduction of agent-based simulation as an educational tool helps achieve outcomes 1 and 3.

2.1 Course educational impact

The evaluation of the educational impact of agent-based simulation for teaching ethics is a work in progress. As the first step towards it, we just started measuring the level of confidence that students had regarding the four outcomes. Table 1 shows results from the survey students filled at the end of the last semester the course was taught, where 53% of the class felt very or moderately confident on modeling and simulating activities of a target phenomenon, and 82% of the class felt very or moderately confident on integrating ethical principles into their simulation to assess consequences.

Table 1: Results of level of confidence.

Ability to	Very confident	Moderately confident	Somewhat confident	Only a little confident
Outcome 1	7	8	11	2
Outcome 2	17	11	0	0
Outcome 3	10	13	5	0
Outcome 4	12	14	2	0

In over the five years we have been offering this course using NetLogo to develop agent-based simulations, with approximately 30 students each Fall semester, we have had only one case where a group failed to produce a running problem, and failed the project. Although we do not have quantitative assessment that separates out the impact of the NetLogo simulations, our course evaluations have always been well about average and our anecdotal evidence very positive.

3 AGENT-BASED SIMULATION PROJECT

The ethics course includes one modeling and simulation project that students grouped in teams of four members perform throughout the semester. NetLogo projects are an important part of the course and corresponds 30% of the final grade. The project includes four deliverables, but only one final grade.

The first deliverable is a one-page project proposal, due to the fourth week of classes, which represents 5% of the total project grade. Its primary purpose is to ensure that every team is choosing an appropriate project before they begin working in earnest.

The project proposal should include the following:

1. A problem statement that includes:
   (a) Relevant facts
   (b) Stakeholders involved
   (c) Ethical issues raised
2. Ethical Dilemma(s) to decide on
3. Possible Outcomes to measure the consequences of different decisions
4. Modeling ideas

The second deliverable is a poster project proposal, due to the seventh week of classes. Each team has 10 minutes to present their poster and answer questions about the proposed simulation from the instructor and the class. This presentation represents approximately 10% of the total project grade, and provides an opportunity for students to get feedback from the instructor and the class regarding improvements they can make to their simulation. The poster is the presentation of the revised project proposal and should include:

1. A problem statement that includes:
   (a) Relevant facts
   (b) Stakeholders involved
   (c) Ethical issues raised

2. Ethical Dilemma(s) to decide on
3. Simulation plan
   (a) Description of agents and their interactions
   (b) Ethical theories to be used
   (c) Outcomes

The third deliverable corresponds to the pseudo code of the NetLogo simulation, due in Week 9. This pseudo code represents approximately 10% of the total project grade, and its primary purpose is to ensure that each group is on track to successfully create a working simulation by the end of the semester. In the pseudo code students outline the general structure of the simulation code; they describe what the simulation model would do. It does not need to be written in NetLogo programming code, rather than in natural language.

The final deliverable is the NetLogo simulation, due to the end of the academic semester. Each team has 15 minutes to run and explain their model, as well as answer questions from the instructor and the class. The simulation must run in order to receive a passing grade. This presentation represents approximately 75% of the total project grade, and the grade is based on the content and form of the presentation, as well as the quality of the simulation itself.

3.1 Project evaluation

NetLogo presentations are evaluated twice during the semester. The first evaluation corresponds to the project proposal and the second evaluation corresponds to the final project. The rubric for the project proposal includes a presentation format part as well as a presentation content part. Table 2 shows the rubric in detail.

Table 2: Project proposal rubric.

Presentation format (25%)			
Organization (5%)	Audience cannot understand presentation because there is no sequence of information.	Audience has difficulty following presentation because students jump around.	Students present information in a logical sequence which the audience can follow.
Delivery (5%)	Students do not speak clearly, do not make eye contact, and/or present significantly under or over 5 minutes.	Students mostly speak clearly; make some eye contact, and/or present noticeably under or over 5 minutes.	Students speak loudly and clearly, make frequently eye contact, and deliver the presentation in 5 minutes.
Group (5%)	One member of the group participates in the presentation.	Two members of the group participate in the presentation.	All member of the group participate in the presentation.
Presentation content (75%)			
Objective (15%)	Objective is poorly defined and unclear.	Objective is somewhat defined but is unclear.	Objective is clearly and specifically defined.
Problem statement (20%)	Students do not clearly describe the ethical dilemma or identify the relevant stakeholders.	Students partially describe the ethical dilemma and identify some relevant stakeholders, but miss key issues or provide unclear descriptions.	Students clearly describe the ethical dilemma and identify the relevant stakeholders.
Outcomes (20%)	Students do not clearly identify the possible	Students partially describe possible outcomes, but	Students fully and clearly describe the possible

	outcomes.	description is incomplete or unclear.	outcomes.
Simulation plan (20%)	Students do not clearly describe the planned simulation or how it will be carried out.	Students describe the planned simulation but do not provide details on how it will be carried out.	Students clearly describe the planned simulation and how it will be carried out.

The rubric for the final project presentation includes also a presentation format part as well as a presentation content part. The presentation format part is the same as for the project proposal presentation. Table 3 shows the rubric in detail.

Table 3: Final project rubric.

Presentation format (25%)			
Organization (5%)	Audience cannot understand presentation because there is no sequence of information.	Audience has difficulty following presentation because students jump around.	Students present information in a logical sequence which the audience can follow.
Delivery (5%)	Students do not speak clearly, do not make eye contact, and/or present significantly under or over 5 minutes.	Students mostly speak clearly; make some eye contact, and/or present noticeably under or over 5 minutes.	Students speak loudly and clearly, make frequently eye contact, and deliver the presentation in 5 minutes.
Group (5%)	One member of the group participates in the presentation.	Two members of the group participate in the presentation.	All member of the group participate in the presentation.
Presentation content (75%)			
Simulation code (40%)	Simulation does not run, and/or students cannot explain how the code operates.	Simulation runs but with some error, and students can mostly explain how the code operates.	Simulation runs as intended, and students can explain the code clearly and thoroughly.
Simulation outcomes (15%)	Students do not clearly explain the outcomes and results from the simulation.	Students partially describe the outcomes and results, but description is incomplete or unclear.	Students fully and clearly describe the outcomes and results from the simulation.
Simulation applicability (10%)	Students do not explain how the simulation addresses the ethical dilemma.	Students partially explain how the simulation addresses the dilemma, but miss key issues.	Students clearly explain how the simulation addresses the ethical dilemma.
Resolutions and decisions (10%)	Students do not explain how the outcomes assist with finding a solution to the dilemma.	Students partially explain how the outcomes assist with finding a solution, but miss key issues.	Students clearly explain how the outcomes assist with finding a solution.

4 SAMPLE PROJECTS

This section provides examples of simulations models developed by students, along with their principal findings.

4.1 Return to offending after leaving jail?

This model explores the social reintegration of ex-prisoners into the community and the possibility of returning to offending. It includes two type of agents; civilians and police officers. Civilians are divided in two types, ex-prisoners and civilians with no criminal records.

Civilians and police officers are created according to a certain density and located randomly throughout the view window. Police officers move along the system; if they run into a civilian committing a crime, he is sent to jail where he remains for a period of time before coming back to the system. Each civilian, while moving along the system, can make the decision to either commit a crime or not. This decision depends on whether the individual is an ex-prisoner or has no criminal records, if is unemployed or not, their level of education, proximity to people committing crimes, and proximity to police officers.

Under the ethical theory of utilitarianism, a utility function was built upon all the factors mentioned before. For each civilian, if the value of his utility function is greater than his value of risk, he decides to commit a crime. Under the social contract theory, since it is illegal to commit a crime, a civilian would not do it under any circumstances. In the simulation model, each civilian makes their decision to commit a crime or not depending on the assigned ethical theory.

Students found that ex-prisoners tend to return to offending if close to other ex-prisoners committing a crime. In time, ex-prisoners committing a new offense tend to group together.

4.2 Plundering or not after a natural disaster

This model seeks to understand the behavior of civilians after being suffered a natural disaster and explores the significance of different variables that surrounds the issue of plundering. Students came up with this idea after the occurrence of a massive fire in Valparaiso, Chile and the issues of plundering that increased the chaos.

This model includes passive and active agents. The passive agents represent houses that are randomly placed throughout the view window according to a certain density; each house has a particular amount of resources. The active agents are civilians and police officers. These active agents are placed randomly throughout the view window and move through the whole system. If a civilian runs into a house with resources, he decides to either plunder or not. When plundering, the civilian keeps the resources with him. This decision is based on different characteristics such as, income level, number of people that is plundering in their surroundings, and proximity of police officers. If a police officer collides with a civilian who has plundered, the civilian is being removed from the system and the resources returned.

Under the ethical theory of utilitarianism, a utility function for the civilian was built upon all the factors mentioned before. For each civilian, if the value of his utility function is positive, he decides to plunder since he will gain some benefit from it. Under the ethical theory of Kantianism, under the second formulation of the Categorical Imperative, to treat humanity as an end in itself, civilians would not plunder since they would benefit from someone else´s tragedy. In the simulation model, each civilian makes their decision to commit a crime or not depending on the assigned ethical theory.

Students found that the most significant variable is proximity of police agents. Hence, they concluded that an efficient police deployment would reduce significantly plundering.

4.3 Vehicle-cross actions in an unsignalized intersection

This model simulates the behavior of vehicles at an all-way-stop intersection; it does not include pedestrians. Each vehicle moves through the roads from its origin to its particular destination and when at the intersection it makes the decision to cross or not based on whether there are other vehicles at the cross-section and the ethical theory they follow to make their decision.

Under the theory of ethical egoism, vehicles cross the intersection as soon as they get there if there is any available space at the intersection. If not they wait until there is some space available at the intersection. Vehicles do not care if as a consequence of them trying to cross they block other vehicles from crossing. Under the ethical theory of Kantianism, they do not cross if another vehicle got to the cross-section before them or if there is no space available on the road they are going into.

The students assess the consequences of vehicle behavior in terms of travel times and number of accidents. When the decisions of all vehicles are completely egotistic, traffic jams occurs very rapidly and also car accidents. When all vehicles use Kantianism to assess their decisions, no car accidents occur, and also no traffic jam. When there is a mix of egotistic and Kantian vehicles in the system, traffic jam could occur depending on the percentage of egotistic vehicles.

5 CONCLUSIONS

Importance and utilization of simulation as an educational tool for teaching other areas than simulation itself is being increasing during the last decade. In particular, simulations for teaching ethics are being used as a training tool on how to react under different ethical dilemmas.

This work is innovative in the sense that we are using simulation for modeling ethical behaviors and gain deeper knowledge of the rational process an individual follows to arrive to a decision. Even more, we are using agent-based simulation, which is a type of simulation that, to the best of our knowledge, has not been used before for teaching ethics.

In terms of the utilization of NetLogo as the agent-based simulation platform used by the students to build their models, we found that the students did not consider using NetLogo to be a hindrance in modeling their particular ethical situations. However, the instructors did have to help them conquer their natural aversion to learn “another language”.

Although we do not have quantitative assessment that separates out the impact of the NetLogo simulations, our course evaluations have always been well about average and our anecdotal evidence very positive.

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