Online Game-enhanced teaching in Game Theory

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1. ABSTRACT

Introducing digital educational games into class lessons can generate engagement, interactivity, and motivation. It can also result in an active participation of the students in the classroom.

To achieve this goal, one teaching strategy is to use online digital games in teaching and learning situations. In our case, we wanted to test this strategy in an economics course, especially in a Game Theory lesson.
We set up an experiment in two different lessons: the “Economie expérimentale” (Experimental economics) lesson with L3 students and the “Introduction à l’analyse économique du droit” (Introduction to law economics analysis) with M2 students.
For these two experiments we decided to use an online n-player “Chicken” game, proposed on the free educational games website Economics Games, http://economics-games.com (Gruyer and Toublanc, 2013).

Our paper will present these innovative experiments carried out in economics courses about Game Theory at Paris Descartes University. It will also explore the pedagogical and motivational value of online economics games on student learning in economics education and especially in Game Theory teaching.

2. INTRODUCTION

Several publications reported that educational games are useful tools to actively involve students in their learning. For instance, *The Journal of Economic Education* offers original theoretical and empirical studies dealing with the analysis and evaluation of teaching methods, learning attitudes and interests, materials, or processes. One of the aims of this journal is to identify exemplary material for teaching and learning economics that is interactive.

According to Whitton (2012), educational games have the potential to create active and engaging environments for learning and for supporting problem-solving, communication and group activities.

So, this reinforces our will to test the use of online economics games to teach Game Theory, because of their motivation potential.

As a result, we investigate in this paper an innovative experiment carried out in an economics course about Game Theory at Paris Descartes University. It is innovative because it makes use of an online economics game (that we consider as a game-enhanced learning teaching approach) within a classroom experiment.

Game-enhanced learning refers to “a branch of serious games that deals with applications that have defined learning outcomes. Generally they are designed in order to balance the subject matter with the game-play and the ability of the player to retain and apply said subject matter to real world" (Ott et al., 2013). Moreover, according to Van Eck (2007), "One of the central challenges of integrating [game-enhanced] learning in formal learning settings is helping learners and teachers make the connections between the knowledge learned in the game and the knowledge learned at school".

The other component of our pedagogical strategy, which will be addressed in section 5, is the classroom experiment. It can be defined as an experiment, which generally takes place in a classroom with a pedagogical purpose (Eber, 2003). Moreover, experiments can introduce a topic in an accessible way to students from many different backgrounds and skills, in particular to those with weak mathematical skills (Kaplan and Balkenborg, 2012).

To understand the scope of this new way of learning, we need to clearly define what a game is. So, according to Kapp (2012): "A game is a system in which players engage in an abstract challenge, defined by rules, interactivity, and feedback, that results in a quantifiable outcome often eliciting an emotional reaction".

One of the most important aspects that we have retained, like Whitton (2012), is that games can provide playful spaces in which learners can make mistakes in a safe environment, free from external consequences, in which failure is a recognized and accepted part of the process.

This paper is structured as follows: in section 3, we will show that teaching Game Theory with a digital educational game is an innovative approach. Then, section 4 will insist on the technological tool we selected to set up the experimentation. In section 5, we will describe our pedagogical approach, characterized by the combination of an educational game and a classroom experiment. Section 6 will review the main milestones of the experiment and section 7 will show the usefulness and benefits of our experiment. Finally, the main conclusions will be drawn in section 8.

3. INTRODUCING A GAME TO ENHANCE GAME THEORY TEACHING: AN INNOVATIVE APPROACH

Game Theory is a branch of Economics, which is a relevant topic for an educational game. Indeed, as Binmore (2007) says: "Game Theory provides useful mathematical tools to understand the possible strategies that individuals may follow when competing or collaborating in games".

This branch of applied mathematics is used nowadays in the social sciences (mainly economics), biology, engineering, political science, international relations, computer science and philosophy.

The following definition from Aumann (1987) explains why Game Theory is now applied to a wide range of domains: "Game theory is a sort of umbrella or "unified field" theory for the rational side of social science, where social is interpreted broadly, to include human as well as non-human players (computers, animal, plants)" (Aumann, 1987).

There are three kinds of non cooperative static games with complete information: "Prisoner's dilemma" games, where a unique pure strategy Nash equilibrium exists, "Matching pennies" games where a pure strategy Nash equilibrium does not exist (but there is a mixed strategy Nash equilibrium), and "Chicken" games, where multiple Nash equilibria exist.

In our situation, we wanted the students to consolidate their knowledge of the "Chicken Game".

The story behind the classical two-player "Chicken" game is well known. Two car drivers drive straight at each other on a road. Each driver has two alternatives to choose between: to swerve or not to swerve. If neither of them changes the course, mutual destruction is inevitable. If they both veer off, the worst case is prevented. If one of the drivers swerves before the other, he is the chicken. In such a two player game, there are two pure-strategy Nash equilibria and a mixed-strategy Nash equilibrium.

We suggest defining the principles of this game: "the game of chicken is an influential model of conflict for two players in game theory. The principle of the game is that while each player prefers not to yield to the other, the worst possible outcome occurs when both players do not yield[1]".

The following definition insists on the interactions: "The game of chicken […] appears to be a realistic description of strategic interactions, which is particularly suitable for describing relations between individuals, firms, institutions, social groups, political parties, and countries that wish to coordinate for mutual benefit" (Cabon-Dhersin, Etchart-Vincent, 2011).

In our case, the game was used to illustrate mixed-strategy Nash equilibria (Binmore, 2007, Eber, 2013).

Our aim was that the students would discover the following three key points (see, *e.g.*, Osborne, 2004):

First, when there are several Nash equilibria in a game, as the n-player "Chicken" game, Nash equilibrium loses much of its appeal as a prediction of play. The pure-strategy Nash equilibria are asymmetric. If the members of the group do not differ significantly, there is no way for them to coordinate.

Second, a symmetric equilibrium, in which every player uses the same strategy, is more compelling. The mixed strategy Nash equilibrium of the n-player "Chicken" game is symmetric. Therefore, this equilibrium is compelling. In such settings, all possible issues can be obtained.

Third, the larger the group, the more likely the mutual destruction will occur. The condition defining a mixed strategy equilibrium is responsible for this result. For any given player to be indifferent between yielding and not yielding, this condition requires that the probability that no one else yields be independent of the size of the group. Thus each player's probability of not yielding is larger in a larger group, and hence, the probability that no one yields is larger in a larger group.

4. THE CHOICE OF A TECHNOLOGY: AN ONLINE EDUCATIONAL GAME

We decided to adopt and apply the methodology proposed by Ott et al. (2013). This helped us to choose a relevant game for introducing game-enhanced learning in a Game Theory lesson.

This methodology gives us three steps:

- Choosing a Suitable Game;
- Aligning the Game with the Curriculum;
- Aligning the Game with the Content.

It appeared that the games website "Economics Games" designed by Nicolas Gruyer and Nicolas Toublanc (2013) matched our pedagogical objectives.

In fact, this is a free educational games site for teaching macroeconomics, industrial organization and game theory. There are twelve different economical games available on the website.

The games proposed on the site are well and professionally designed, and they offer an instructional scenario for each notion. This makes them applicable to a large number of economical concepts. Moreover, the students can easily handle the games interfaces, which proposed them simple interactions "with relatively simple inside games scenarios compared to those in the real world economic activities" (Van Wyk, 2013).

According to the subject of our lesson and to the pedagogical objectives, we selected the repeated n-player "Chicken" game (illustrated in Figure 1).

[1]Chicken Game. (n.d.). In *Wikipedia*. Retrieved January 27, 2014, from http://en.wikipedia.org/wiki/Chicken_(game)

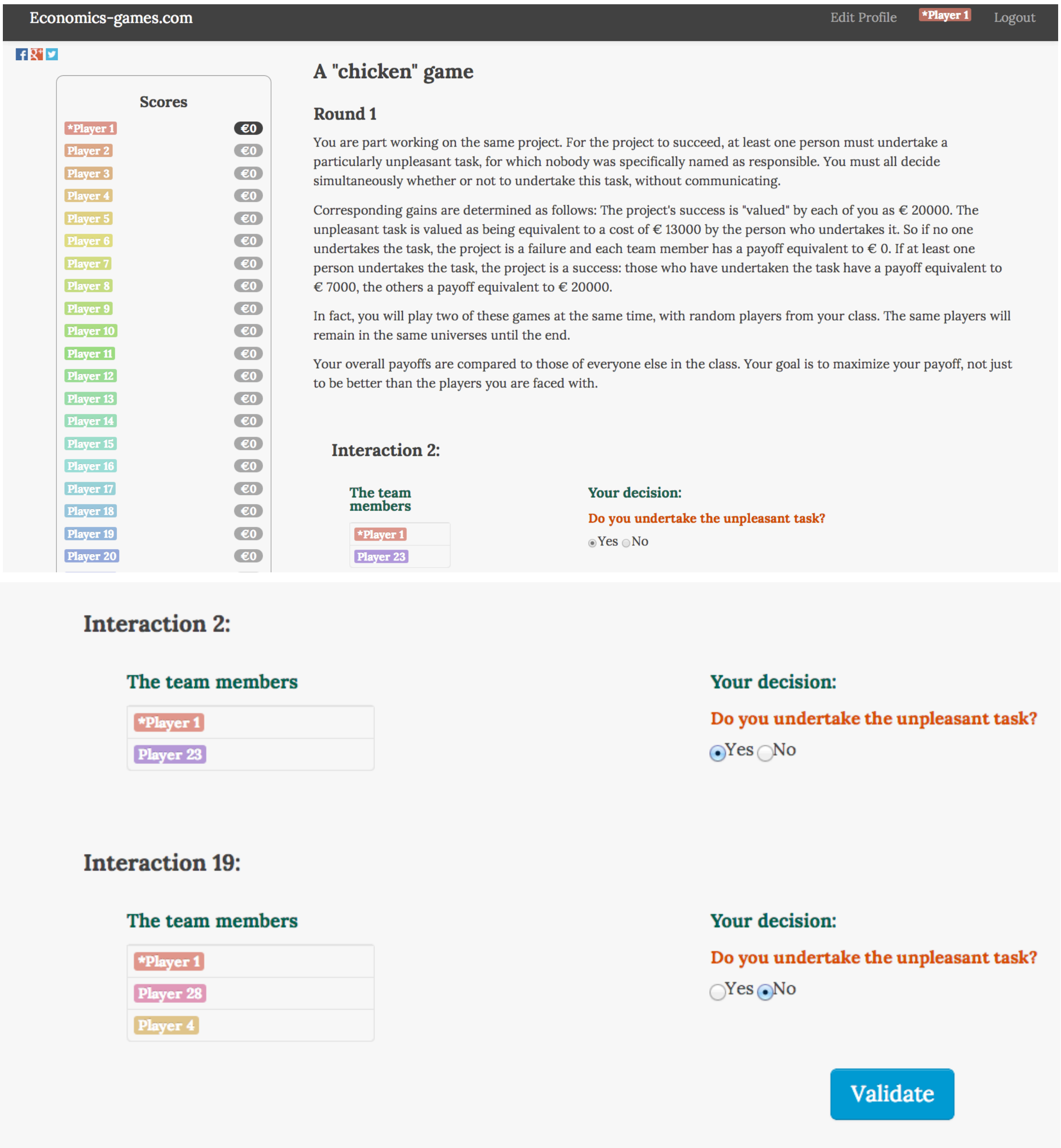

Figure 1. Interfaces of the online n-player "Chicken" Game[2]

4.1. Set-up of the game

To use one of these games, the teacher needs to:

- choose a game;
- fill out a form to determine the name of the game, the number of players, the universe for the first experiment, the universe for the second experiment. Then it is possible for him to get logins (illustrated in Figure 2).

[2] source: http://economics-games.com

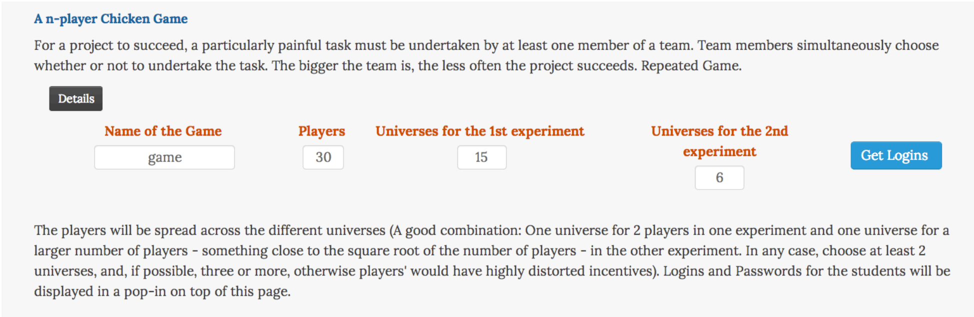

Figure 2. Parameters of the game[3]

4.2. Game presentation and rules

In this game, students are invited to act as members of a team working on a project. One condition of the success of the project is that one of the members accepts to undertake an unpleasant task. The players are performing in a particular environment where they cannot communicate and collaborate. The players are invited to play this game repeatedly and gains are determined as follows. If the project is a success, it is valued as 20000 €. The unpleasant task is valued as 7000 € (for the person who undertakes it). The project is a failure if no one undertakes the task: it is valued as 0 €. All payoffs are systematically compared to those of every student in the classroom. The goal of this game is to maximize players' payoffs (according to Gruyer and Toublanc, 2013).

5. OUR PEDAGOGICAL STRATEGY: COMBINATION OF A DIGITAL GAME AND A CLASSROOM EXPERIMENT

According to Kaplan and Balkenborg (2012), economic classroom experiments are an excellent way to increase students' interest and curiosity. This assumption is reinforced by Charles Holt's (1999) thought, who claimed that classroom experiments have become "the most exciting new development in teaching economics".

So by adding the use of an online economics game, we can easily affirm that we have an efficient combination to propose a challenging and engaging teaching.

Linking classroom experiment and educational games is a relevant combination.

We choose this combination because it places students directly into real economics situations where they will be required to make choices based on specific incentives.

This experiment provided a strong link between the economics theory of game theory and direct experience.

The notion of "engaging" learning environment often occurs in publications related to game-enhanced learning. Engagement can be defined as "the degree to which participation, interest and continuity are maintained as it relates to an activity or project" (Dyer, 2013).

Pedagogical objectives

We wanted the students to check and apply taught notions in specific situations to understand the game and define a strategy to address a problem. The role of this game is to support the

[3] source: http://economics-games.com

experimental approach used by the teacher. In this context it is used as a reminder, a consolidation and an application of theoretical concepts of the chicken game. The experimental approach provides a very efficient pedagogical tool that allows a more intuitive and comprehensive presentation of theoretical concepts without necessarily implying a less rigorous conception of teaching (Eber, 2003).

6. REVIEW OF THE CLASSROOM EXPERIMENT

6.1. Preparation

We need to highlight the importance of the collaboration between teachers and Instructional Designers. These experiments would not have been possible without a common thought. In fact, it is essential to guide teachers, because as DeWitt (2012) says "[..] they do not always understand how to handle the concept".

The two experiments were prepared beforehand. The teacher worked narrowly with the Instructional Designer, especially on the instructional design and scenario of the session. We decided to follow the scenario proposed by the team who developed the website.

We performed the following process:

1) The students play the game;

2) The teacher debriefs the results and explains the notions;

3) The students perform an additional exercise about game theory. This exercise is proposed in the game scenario.

During the session, the engineer who animated the lesson with the teacher presented the game, and helped the students for the participation in the game. The teacher brought his knowledge of economics theory and his explanations, and demonstrated them on the blackboard during the debriefing.

6.2. Set-up of the experiment

The experiment lasted one hour and 6 L3 students (13 M2 students) took part in the game.

The process was the same one for both experiments. The teacher prepared ten pieces of paper. On each piece a number was written to indicate the number of rounds and to limit the game duration. The teacher randomly picked up one paper, which indicated the number of rounds. Students were told that each number of rounds was equally likely to be chosen. They were not told however the number of rounds in advance.

For the first session with M2 students, there were 9 rounds and 7 rounds for the second one.

6.3. Equipment

The students were well equipped and brought their own equipment in a BYOD (Bring Your Own Device) mode (Bouziane et al., 2013).

For the first session, 13 M2 students (the entire promotion) attended the lesson, with 8 personal computers, 1 tablet and 2 smartphones. For the second session, 6 L3 students attended the lesson, with 3 PCs and 3 smartphones.

6.4. Experiment proceeding

Rules, criteria and outcomes of the game were clearly communicated to students at the beginning of the session.

The students played two of these games at the same time, with random players from the classroom. The same players were to remain in the same universes until the end.

After the game session, the teacher guided the students towards understanding related theoretical concepts that have been developed and taught during the previous lessons.

The game played during this session provided opportunities for students to explore, like Van Wyk (2013) says: “how in-class economic games [can be] a social laboratory providing opportunities to contextualized learning experiences. [The students] experienced that through their own actions and observed reactions of other participants in the in-class games help them to learn collectively by advancing their economic knowledge and skills”.

7. RESULTS: USEFULNESS AND BENEFITS OF THE EXPERIMENT

We could observe active participation and interaction of the students during the experiment. In fact, game based learning “engages players in learning activities, usually by means of […] serious games” (Burguillo, 2010). In our case, the use of online games allowed us to create active and experiential learning environments. We observed an improvement of the students’ motivation because the game used in classroom (repeated n-player “Chicken” game) proposed compelling challenges that favored teamwork. Moreover, the use of this game provided the students with a safe playful environment in which they could make mistakes without serious consequences (Whitton, 2012).

Students were positive and motivated by the introduction of the game during the lesson: we indeed collected their feedback with a live oral opinion poll just after the experiments.

How to bring more significant evaluation evidence concerning the advantages of introducing serious games into class lessons for student learning?

Achieving this objective implies meeting two requirements.

Firstly, we need to have two different courses: in one of these courses (the "experimental" group), all the students participate in the chicken game; all the students attending the other course (the “control” group) receive a traditional lecture-oriented presentation of the chicken game. The price to pay to meet this first requirement is high: we deprive some students of the opportunity of participating in the chicken game.

Secondly, we need to implement multiple-choice tests specifically devoted to the chicken game three months after the end of the session. Indeed, according to Eber (2007), the right question to answer is the following one: do classroom experiments really improve the long-term retention of knowledge? This is not an easy task to achieve: three months after the end of the session, L3 students (if they are still in the university) have many other concerns.

Building on this simple cost-benefit analysis, we have chosen not to incur both these substantial costs involved in the quantitative evaluation process.

8. CONCLUSION

In this paper we presented an innovative experiment based on the use of an online game in a Game Theory lesson.

The aim was: 1) to talk about a successful experiment to foster and generate a more effective online and digital games use in educational situations (both learning and teaching situations), 2) to provide an insight on the introduction of an economics game in a Game Theory teaching lesson, 3) to show that the use of educational games can impact students' motivation and improve their participation in the course.

In fact, according to Oblinger (2004): "Games also offer advantages in terms of motivation. Oftentimes students are motivated to learn material [...] when it is required for successful game play – that same material might otherwise be considered tedious."

By playing this game, students have experienced a kind of "competition" in an experiment based on the "Chicken" Game, but the main goal was for them to see how theory works in action, depending on their individual choices and actions. Moreover, it allowed them to explore new concepts and ideas without fear of consequences.

Finally, this experiment has been successfully reproduced with the L3 students (12 students) of Paris Sorbonne Abu Dhabi University (http://www.sorbonne.ae/).

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