The Game Academy: Learn while playing, and play while learning!

Demonstration Track

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ABSTRACT

We present game-academy.org, an online platform hosting interactive games that can be used for both teaching and outreach activities to illustrate concepts from game theory and related fields.

KEYWORDS

Game Theory; Gamification; Education; Outreach

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1 INTRODUCTION

The *Game Academy*, available at game-academy.org, is an online platform hosting a range of interactive games that can be used to bring to life some of the core concepts in game theory and related fields, such as the notions of *strategy*, *rationalisability*, *equilibrium*, or *backward induction* [9]. The games hosted include both well-known classics, such as the Centipede Game, and games developed by us, such as a particularly simple variant of Poker.

The platform grew out of an introductory course on game theory taught by the second author since 2017. The idea is to let students actually play some of the stylised games typically discussed in such a course, to then review the strategies they end up using in class. We later found that some of the games developed for the course can be used equally well during outreach events, including events aimed at children (e.g., during a "University Open Day").

An instructor who wants to use the Game Academy can register at game-academy.org, which will allow them to create *sessions*, each corresponding to an edition of a course or an outreach event. Others then can register as players for a session and play the associated games. Especially for outreach events, players can also enter as *guests*, without prior registration on the platform. Each game comes with a results page presenting insights about the strategies submitted, creating opportunities for in-depth discussion.

Our experience with this approach in general and the use of the Game Academy in particular has been very positive. These findings are consistent with broader trends towards gamification in educational contexts [5, 7]. We stress that the idea of letting students play games in a game theory class is not new. For instance, Ariel Rubinstein has been doing this since the 1990s and also made the website he and his collaborators developed for this purpose available to others [13]. He recommends asking students to submit answers to game-based exercises ahead of class, for the instructor to then discuss those solutions in class. The Game Academy can be used in the same way, but it also allows students to play directly in class (using a smart phone) and the instructor to immediately present the results. Another advantage of the Game Academy is that it is highly customisable and, due to being an open-source project, easily extendable.

In the remainder of this brief paper, we first provide some more details on the inner workings of the Game Academy and then review the games implemented on the platform and discuss how they might be used for specific educational purposes.[1]

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2 IMPLEMENTATION OF THE PLATFORM

The platform is implemented as a Django project, an open-source Python web framework for developing complex websites. It is an open-source project; the code is available as a GitHub repository.[2]

The code is organised as a collection of several Django applications. The core application implements the general mechanism of the website, and each game is developed as a separate application on top of this. It is easy to add, modify, or remove games as they are independent components handled by Django mechanisms. We do not wish to delve any deeper into the implementation here. The code is duly documented in the GitHub repository, where detailed explanations are provided for the interested developer.

3 AVAILABLE GAMES AND USE CASES

At this point, the platform includes implementations of six games, most of which can be customised to the needs of a given class or outreach event. Next, we briefly describe these games and sketch how they might be used to illustrate and discuss relevant concepts from game theory, mechanism design, and social choice theory.

3.1 The Numbers Game

In the *Numbers Game* [2] each player submits a number between 0 and 100. The player who submits the number that is the closest to 2/3 of the average of all numbers submitted wins the game.

This game can be used to illustrate concepts such as *Nash equilibrium* or *k-level reasoning*. When played in a classroom with a few dozen students, it is common to see clear peaks around 33 (best response under the assumption that others use 0-level reasoning, i.e., choose a number uniformly at random), 22 (best response under the

[1] A short video presenting the platform is available at youtu.be/zvdSuEkjzjM.
[2] github.com/COMSOC-Community/Game-Academy

assumption that others use 1-level reasoning, i.e., choose a number around 33), and 0 (everyone's strategy in the game's only Nash equilibrium). This offers a great opportunity to discuss rationality concepts as defined in the game theory literature and to contrast them with real-world human behaviour. When the same game is played a second time (maybe a week later), the winning number tends to go down, which can be related to notions such as *iterated elimination of dominated strategies* and *rationalisability*.

3.2 Iterated Prisoner's Dilemma Tournaments

The *Prisoner's Dilemma* is the classical two-player game in which each player must choose between two actions (*cooperate* and *defect*). In its iterated version, the players repeatedly play the game for a fixed (but unknown) number of rounds, their final payoff being the sum of their payoffs for each individual instance of the game.

In the late 1970s, Robert Axelrod [1] famously organised a round-robin tournament where game theorists as well as hobby programmers were invited to submit strategies to play in the Iterated Prisoner's Dilemma, with *tit-for-tat* emerging as the most successful strategy. Our implementation of this tournament was directly inspired by Charles Pence's Oyun platform for evolutionary game theory [12], where players can submit their strategies for how to play the iterated game in terms of simple finite state machines that specify the action to be played in the next game based on the current state and the opponent's move in the most recent game.

3.3 The Centipede Game

The *Centipede Game* [11] is a classic example of an extensive game in which two players take turns to decide whether to pursue the game further or whether to stop. The payoffs are such that each player has an incentive to stop the game at an early stage, even though the sum of their payoffs increases with every round.

This game lends itself to illustrating the method of *backward induction* to analyse an extensive game, as well as the solution concept of *subgame-perfect equilibrium*. Similar to the Numbers Game, it provides an excellent opportunity to discuss both the power and the limitations of solutions concepts studied in game theory to analyse real-world behaviour by human players.

3.4 Simplified Poker

Our *Simplified Poker* game is a severely simplified version of Poker, even simpler than Kuhn Poker [8]. There are two players and three cards: King, Queen, and Jack of Hearts. Each player is dealt one card and pays $1 to participate. The standard rules of Poker then apply: players can either bet a further $1 or fold; if both players bet the one with the higher card wins. Players need to submit a mixed strategy for this game, both for the situation where they are the first to play and the one where they go second.

This variant of Poker is difficult enough so that almost nobody without prior experience with analysing imperfect information games will be able to come up with the perfect strategy (i.e., the strategy played in the only Nash equilibrium). Yet, it is simple enough to fully analyse the game in class in under 30 minutes.

On `game-academy.org`, participants can see how their own strategy fares agains the Nash-equilibrium strategy, and how it fares in a round-robin tournament against all other participants. While nobody will beat the Nash-equilibrium strategy, there might very well will be a participant strategy that does better than the Nash-equilibrium strategy in the tournament, as some theoretically non-optimal strategies might be better attuned to exploiting the weaknesses of other non-optimal strategies. Both of these observations offer valuable starting points for in-class discussion.

Simplified Poker can also serve as a starting point for a class dedicated to algorithms for solving full instances of Poker [3, 4].

3.5 The Auction Game

Our *Auction Game* lets participants experience the difficulties associated with bidding in a first-price sealed bid auction [10]. Each player is assigned a valuation for the item on auction—sampled from a distribution that is not necessarily disclosed to the players. Players then are asked to submit a bid for the item. The player with the highest bid wins the auction, unless someone bids higher than their assigned valuation, in which case there is no winner.

When playing the game in class, we have given *the same* valuation to all players, without disclosing that fact in advance.[3] This allows for a direct comparison between the different strategies used.

3.6 The Good/Bad Game

In our *Good/Bad Game*, players are presented with a list of questions. For each question, several possible answers are proposed and the goal is to identify the correct one. The questions can be text-based, but also image-based. For example, we had very good engagement during outreach events with an instantiation of the game where you have to pick out the correct logo for several well-known companies.

In the results page of this game, the average performance of participants is compared to the performance that would have been obtained by selecting for each question the most popular answer. This can be used to illustrate the concept of the *wisdom of crowds*, i.e., the idea that group decisions usually are better than individual decisions [14]. In a class on epistemic social choice, this observation could be linked to results such as the *Condorcet Jury Theorem* [6].

4 OUTLOOK

We have used the Game Academy and its precursors successfully for teaching and outreach for several years (and in the case of teaching, this positive impression is supported by formal student evaluations). It could also be used to run experiments in behavioural game theory. Due to the modular architecture of the code base underlying the Game Academy, it would be relatively easy for others to add new games to the platform. We note that the current set of games is tailored to courses on noncooperative game theory. While we found it challenging to conceive of similar games that would lend themselves for use in a course on cooperative game theory, to illustrate concepts such as *core*, *Shapley value*, or *deferred-acceptance algorithm*, we believe that doing so would be very valuable.

[3]When using this approach it is important to discuss with students the ethics of experiments: in other circumstances, lying to an experimental subject can be problematic.

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