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Using Squid Game to Teach Game Theory

This paper uses Netflix's dystopian Korean-language drama series *Squid Game* (2021) to illustrate an active learning technique to support the teaching of game theory in undergraduate courses. The series is chosen because it demonstrates different games with which the characters have to engage as part of the narrative. Geerling, Mateer and Addler (2020) show that using popular films in class is an effective way to introduce and motivate the deeper learning of core game theory concepts. We build on this work by providing instructors with a menu of quick teaching scenes and extended teaching guides, from which they can freely select and adapt to their particular needs. These resources provide summaries of the scenes, links to the clips, key concepts, and assessment questions. This teaching material is suitable for use in both principles-level courses, where game theory is first introduced, and advanced-level courses.

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1. Introduction

Game theory is one of the most engaging topics taught in undergraduate economics courses, typically first introduced to students in the context of market structures. The applications of game theory, however, extend beyond the treatment applied to duopolies and can be applied to decisions in politics, social interactions, business, and everyday life. Dixit (2005) was one of the earliest proponents of changing the way game theory should be introduced in an introductory curriculum to highlight the varied ways in which students make interdependent decisions. Of particular relevance to this paper is that Dixit suggested using media to teach game theory. Since Dixit's publication, there have been attempts to highlight game theory's applications to everyday life (Fisher, 2008; Gambetta, 2009), literature (Chwe, 2013), and even superhero storylines (O'Roark and Grant, 2018).

Despite the growth in available teaching resources, and the ability for educators to integrate innovative teaching practices into their curriculum more easily, the vast majority of educators continue to teach using a traditional lecture. The only meaningful difference in the way economics was taught 20 years ago compared to the way it is taught today is that the majority of educators have introduced presentation software (like PowerPoint) into their lectures (Asarta, Chambers, and Harter, 2021). While the median professor still reports delivering a traditional didactic lecture quite frequently, there has also been a reported increase in the amount of student-to-student discussions occurring in class, but relatively the same amount of instructor-to-student discussions. While educators may report an increased focus on active learning in the classroom, the actual amount of active learning may be overstated (Sheridan and Smith, 2020).

For those educators not using active learning techniques in class, one explanation often given is that the investment cost associated with identifying and implementing various forms of active learning is too high (Goffe and Kauper, 2014). This paper bridges the gap between Dixit (2005) and Goffe and Kauper (2014) by identifying a number of scenes from the highest-rated Netflix series of all time that can be used when teaching game theory.[1] By identifying particular scenes from a popular Netflix series, we extend Dixit's call for the use of pop culture in the classroom by focusing on more current pop culture references compared to their original recommendations. In an effort to address the cost of implementing a new approach for some instructors, we have provided assessment questions and teaching guides for multiple scenes from the series and we have uploaded these scenes to Critical Commons. This eliminates the need for an educator to acquire the source media, identify the relevant time clips, and queue those particular segments for the classroom presentation. In addition, many of these assessment questions can be administered with classroom response systems, but we also provide more in-depth teaching guides that can be adopted (and adapted) as required by the instructor. These teaching tools are suitable for both introductory-level courses and advanced-level courses, where clips can be utilized as supplementary material to motivate deeper student interest, engagement, and discussion.

All of the quick teaching scenes and extended teaching guides presented below use scenes from the popular Netflix series *Squid Game*. The South Korean survival drama debuted in September 2021 and immediately achieved critical acclaim. It has already won several awards, including a People's Choice Award for Bingeworthy Show of the Year.[2] This paper also builds on the work of previous educators who have introduced ways to integrate Korean culture into the economics classroom (Wooten et al. 2021b; Geerling et al. 2021).

[1] https://variety.com/2021/digital/news/squid-game-all-time-most-popular-show-netflix-1235113196/
[2] https://www.votepca.com/tv/the-bingeworthy-show-of-2021

2. Literature Review

The economics profession has been notorious for its continued reliance on 'chalk and talk' lectures, but a significant amount of recent work focuses on innovative ways to teach economics concepts (Wooten et al. 2021a). A subset of these resources often includes specific examples of ways to teach game theory in a more innovative manner. The most radical recommendation is to change at what point in a course game theory is introduced to the curriculum. Some have called for game theory to be taught at the start of a principles course (Dixit, 2005) while others have advocated for teaching game theory in conjunction with other concepts often covered in the first few lessons (Friesner & Axelsen, 2009). More subtle recommendations include altering the presentation of concepts or introducing differentiated assessments associated with the game theory lesson.

Dixit's earliest call for changing how game theory is taught included several scenes from television shows and movies that could be used to illustrate particular concepts. Those early recommendations, however, relied on educators acquiring physical copies of the media. In addition to the cost of acquiring the discs, educators needed access to a space that had a DVD player, and then had to spend time (either prior or during the class) cueing up the show to the right chapter and time for the appropriate clip. Improvements in digital technology and webhosting services has allowed for these scenes (and many more) to be hosted online through sites like the Economics Media Library (Wooten, 2018) or Dirk Mateer's Media Library (Mateer, 2012). These sites have reduced the cost to using relevant media for instructors by placing the sources in an accessible location. The scenes below are available to educators through a similar repository service known as Critical Commons.

More specific resources have also been developed to improve the teaching of game theory, including the introduction of classroom simulations and experiments targeting particular concepts (Shubik, 2002; Kaplan and Balkenberg, 2010; Rousu et al., 2015) and complete websites with resources for students and educators (Shor, 2003). Each of these resources vary in the amount of guidance provided to educators looking to implement new teaching methods, with some providing detailed guidelines and others just summarizing a particular media example. Relatively few of the previous resources provide detailed lesson plans or assessments for their associated work. The lesson plans presented below provide educators with relevant scenes, easy access to a digital source of the scene, and assessment questions to ease the implementation process.

Teaching guides that focus on game theory concepts have been created for popular movies like *The Hunger Games* (Burke, Robak, and Stumph, 2018) and *Crazy Rich Asians* (Geerling, Mateer, and Addler, 2020). Geerling et al. (2021) have also used the popularity of Korean pop music (K-pop) to introduce the ultimatum game, while Hobbs and Wooten (2021) have developed a brief in-class activity that introduces game theory using the former British television show *Golden Balls*. Each of the resources already developed follow a similar structure proposed by Wooten (2020) in which educators introduce discussion between relevant clips.

3. An Overview of Squid Game

Netflix's dystopian drama Squid Game has proven a global sensation, smashing ratings records and becoming the platform's most-viewed program in nearly 100 countries since its release in 2021.[3] The premise of Squid Game is simple: a group of 456 people who are heavily indebted, and have nothing left to lose, are offered the opportunity to compete to win a large cash prize by playing deadly versions of traditional children's games. The players are taken to an unknown location and made to wear green tracksuits, identified only by a three-digit white

[3] https://variety.com/2021/digital/news/squid-game-all-time-most-popular-show-netflix-1235113196/

number on their backs and on the left side of the front of the jackets. A group of masked guards in pink jumpsuits arrive and explain that the players are all heavily indebted, but will be given billions of South Korean ₩on (millions of dollars) in prize money if they can win six games over six days. The games are overseen by the Front Man, who is masked and dressed in black. The players soon discover that losing a game results in their death, with each death adding ₩100 million to the potential grand prize. The reward for the winner is ₩45.6 billion (c. USD $38 million). For everyone else, the consolation prize is death.[4]

Squid Game is the latest in a long line of cultural exports from South Korea. While K-pop has been at the forefront of the Korean Wave (*Hallyu*), Korean dramas and movies were primarily consumed in other Asian countries until recently. Korean entertainment now reaches the mainstream Western film industry through mediums such as Netflix, a global pioneer for streaming movies and television shows. In 2019, Bong Joon-Ho directed the movie *Parasite*, a black comedy thriller, which made history in 2020 by becoming the first non-English language film to win an Academy Award for Best Picture, along with three other awards: Best Director, Best Original Screenplay, and Best International Feature film.[5] South Korean films and dramas are now all the rage in the West, leading to a new term to describe the Korean-language entertainment and film industry: *Hallyuwood* (a portmanteau of *Hallyu* and Hollywood).[6]

Themes which frequent Korean dramas and movies include the abuse of power; the differentiation of the 'haves' and the 'have nots'; and the role and responsibility of parents (especially fathers) to their families. Given South Korean household debt levels were 106.6% of the country's nominal GDP in December 2020[7], *Squid Game* is seen as an allegory for South Korean capitalism and provides insight on economic inequality, debt, poverty, and more generally, the human condition.[8]

4. Squid Game and Game Theory

Much like any other real-world interaction, parts of *Squid Game* can be viewed from the perspective of game theory. As such, it provides students with a number of compelling and stimulating examples of important aspects of strategic behavior. Our belief is that the resources presented in this paper serve two overarching purposes: (i) to help students intuitively grasp some of the key concepts in the field and (ii) to motivate them to explore the intricacies of game theory more deeply. There are moments in the series when some of the aspects of *Squid Game* do not correspond strictly to the formal rules of game theory. The series is, after all, a drama designed to entertain audiences and is not strictly an academic study!

For example, most players are not initially informed regarding the likelihood of death in the games. The participants in *Squid Game* are also not provided any information about the games they are playing during the preparatory phase, where they are instructed to work alone, pair up, or work in groups.[9] In lab experiments and the formally constructed games found in specialist texts, this would typically not be the case. As a result, given the information asymmetry present in *Squid Game*, it is difficult for the players to work out their optimal strategies in each game and coordinate with other players to maximize their chances of staying alive.

We contend that this and other deviations from the formal rules of game theory, however, should not distract from the educational opportunity of the material presented

[4] https://www.bbc.co.uk/sounds/play/p09zsls9
[5] https://www.oscars.org/oscars/ceremonies/2020
[6] https://theface.com/culture/south-korea-hallyuwood-kim-jee-woon-dr-brain-hellbound-squid-game
[7] https://www.ceicdata.com/en/indicator/korea/household-debt--of-nominal-gdp
[8] https://www.news9live.com/art-culture/netflix-squid-game-korean-behavioural-economics-psychology-characters-decisions-125504
[9] https://blogs.cornell.edu/info2040/2021/09/23/netflix-squid-game-and-game-theory/

in the paper. Our intent in the following sections is to develop teaching material that will stimulate and motivate a deeper engagement with the topic. We argue that using clips from the highest-rated Netflix series of all time is an excellent vehicle for this purpose. Moreover, whilst acknowledging the clips' inherent limitations, we would hasten to add that once the key concepts have been intuitively understood by students, instructors in game theory courses can lead classes in discussions on how the program deviates from how games are normally presented in the literature, thereby deepening and reinforcing student comprehension and critical thinking (Kearney, 2022).

5. Quick Teaching Scenes

There are a variety of low-cost methods of introducing *Squid Game* into the game theory curriculum, including as questions used in conjunction with classroom response systems or posted to a learning management system as part of a formal or informal assessment. Each scene identified below includes a brief moment from the series that can be used to highlight a key game theory concept. These scenes are suitable for an introductory level course, where instructors may only have one lecture to cover the basics of game theory. No prior knowledge of game theory is required. These particular scenes involve less class time than the extended teaching guides outlined in the following section.

Each scene below includes a link to a brief segment of an episode from the series, the associated topic, the length of the scene, a summary, and an appropriate multiple-choice question. The answer to the question has been bolded.

Scene #1: Rules of the Game

Scene Link: https://criticalcommons.org/view?m=1lgWnd1w3

Topic: Game theory, interdependence

Length: 2 minutes and 46 seconds

Summary: One of the rules that the players agreed to follow was that if the majority of remaining players voted to end the games, then they could go home. This particular scene occurs right before all of the players cast their vote, but it's helpful in framing interdependent decision making by recognizing there are players, actions, and payoffs in every interdependent decision.

Follow-up question:

Which of the following statements about interdependent decision-making is correct?

A. The people in the detention hall represent the players.

B. Their actions are whether they should continue playing or quit the game.

C. The payoffs to the decision depend on the collective results of the player's actions.

D. All of these statements are correct.

Scene #2: Everyone's Desperate

Scene Link: https://criticalcommons.org/view?m=yLA0Z1xZz

Topic: Dominant strategies

Length: 2 minutes and 29 seconds

Summary: Nearly everyone playing in these games has been selected because they are heavily indebted. After the first game, the players call a vote on whether to stop playing the games. In the middle of voting, one player reminds everyone why they have all been selected and that life outside isn't better. Despite this, the majority of players vote to end the game. They are given the chance to come back later, but only if the majority of remaining players decide to come back. While on the outside, Player #001 and Player #456 meet and discuss how bad life is on the outside. At least inside the game, they had a chance at redemption. Out of 201 surviving players, 187 decide to come back. Without participating, the players don't really have any way to pay off their debts. Some of them would return to a brutal life that may not be worth living. The players who return realize that playing the game is the dominant strategy.

Follow-up question:

Why is playing the game a dominant strategy for the 187 players who return?

A. Each player has a high probability of winning the jackpot.

B. Without playing the game, these players have no chance of paying off their debts and life would be miserable.

C. Participating in the game allows each player to feel like they are in a dominant position.

D. It creates a situation where all of the other players must surrender.

Scene #3: Sharing Secrets

Scene Link: https://criticalcommons.org/view?m=szsyuSExh

Topic: Noncooperative behavior

Length: 2 minutes and 19 seconds

Summary: It turns out that one of the players (#111) is working outside the official games to help some of the masked workers sell body parts. In exchange for his medical services, he is given information that will help him in the upcoming game. He must then decide whether to share that information with his fellow players or keep it to himself. If he behaves cooperatively then it increases the chance that everyone he tells will live, but if he does what's in his own best interest (behaves noncooperatively) then it limits the number of players at the end of the game and increases his potential payoff.

Follow-up question:

Why does player #111 decide to behave noncooperatively by not passing on the information about upcoming games to all players?

A. He wants to maximize the number of players at the end of the game and increase his potential payoff.

B. He does not believe that the information will be useful to the other players.

C. He wants to limit the number of players at the end of the game and increase his potential payoff.

D. He is waiting to see if the information is correct before deciding whether to tell the other players in the future.

Scene #4: Pick Your Marbles Game

Scene Link: https://criticalcommons.org/view?m=zk8qbFVa2

Topic: Simultaneous vs. sequential games

Length: 2 minutes and 47 seconds

Summary: In the fourth game in the series, players must select a partner and then play a game against each other using marbles. Each pair must decide what type of game is played. Some pairs choose simultaneous games while others pick sequential games. Some even start with simultaneous games and then switch to a sequential game.

Follow-up question:

Two games were played in the scene: (I) odds and evens and (II) marble tossing. Which of the following statements is true?

A. Both I and II are simultaneous games.

B. Both I and II are sequential games.

C. I is a simultaneous game while II is a sequential game.

D. I is a sequential game while II is a simultaneous game.

Scene #5: Collusion at Night

Scene Link: https://criticalcommons.org/view?m=BCdxlUWte

Topic: Collusion

Length: 51 seconds

Summary: The players have not been fed very much food in an effort by the Front Man to expedite the game. One of the guards informs Player #111 "we gave you less food on purpose to make you all fight each other and weed out the weaklings before the next game begins (tug-of-war)." The players recognize what is about to happen once the lights are turned off and decide to work together to ensure the other members of the group live.

Follow-up question:

Why does Sang-Woo (#218) suggest to members of his group that they should collude in this scene?

A. He is worried that rival players are planning to attack them at night.

B. He wants to ensure that food rations are raised.

C. He wants to put pressure on the Front Man to end the game.

D. By joining forces with other players, he wants to maximize his potential winnings.

Scene #6: To Kill or Not to Kill

Scene Link: https://criticalcommons.org/view?m=nN1BOiS6s

Topic: Prisoner's dilemma

Length: 2 minutes and 2 seconds

Summary: The players have not been given very much food in an effort to motivate them to attack each other. The masked leaders admit to one of the players that it was done on purpose to eliminate weaker players. The players aren't required to kill each other since it isn't an official game, so they must decide: go to sleep or attack other players. If all players go to sleep, no one will be killed, and all can play the next official game. If someone gets out of bed to attack others, then the players who go to sleep will likely die and the attacking player(s) may be more likely to live. By eliminating players, it makes it more likely the attacking player will win the final jackpot. This scene represents a prisoner's dilemma since it's in each person's best interest to attack (fewer future competitors), but cooperation will yield a great collective outcome (no one dies).

Follow-up question:

How does this scene represent a prisoner's dilemma?

A. It's in each player's best interest to cooperate, but attack will yield a greater collective outcome.

B. It's in each player's best interest to attack, but cooperation will yield a greater collective outcome.

C. It's in each player's best interest to attack, but cooperation will yield a lower collective outcome.

D. It's in each player's best interest to cooperate, but attack will yield a lower collective outcome.

Scene #7: Going First or Last

Scene link: https://criticalcommons.org/view?m=XIMrgW9GL

Length: 2 minutes and 40 seconds

Topic: Risk-Averse Behavior

Summary: Players in the upcoming game must select a numbered vest that will determine their playing order. Initially, players pick numbers in the middle of the order because it isn't clear whether it's beneficial to go first or last. When there are only two players left who haven't selected a number, their choices are to go first or last. Eventually, we learn it's better to go last in this game, but the players don't know that when selecting the numbers.

Follow-up question:

Why are most players reluctant to choose a numbered vest?

A. Players don't know the rules of the game.

B. Players don't know the implications of their choice.

C. Everyone wanted to play the game first or last because these were the safest options.

D. Both A and B are correct.

6. Extended Teaching Guides

Whereas the previous section provided a series of quick teaching scenes covering the basics of game theory taught in a single lecture, the extended teaching guides in this section are designed for lecturers who might devote a second lecture to game theory or as a refresher in an advanced level course.

Squid Games focuses on six games. In this paper, we have selected two of those that serve as vivid and entertaining appetizers for students learning some of the key concepts of game theory. The series of games presented in the extended teaching guides below include (1) Red Light, Green Light and (2) Marbles. We segment these games into 3 shorter clips, ranging in length from 4 to 11 minutes. Each of these clips are available on Critical Commons as an open access resource for any instructor. Each teaching guide is accompanied by an overview of the scene so that instructors and students do not need to watch the entire sequence to appreciate the economic content (Wooten, 2020).

Each teaching guide begins with a short summary of the game, economic concepts, and one includes a warm-up activity, which is a suggestion for an actual in-class activity and not part of the TV show itself. The clips for each teaching guide have been split into shorter scenes, each focusing on a particular concept which has its own sub-heading, follow-up questions and answers, and interactive activities. The teaching guides have been constructed in a way to provide the instructor with the greatest possible freedom. Each scene can be used as a standalone, in a sequence, or taught as part of a full teaching guide in face-to-face, hybrid, or online classes. The questions range from easy to intermediate level, making this ideal for an instructor teaching a lecture on game theory in a principles-level course or as a refresher at the beginning of a standalone game theory course.

Game 1: Red Light, Green Light[10]

Summary: Behind the start position, players stand at the far edge of the pitch, while a mannequin stands on the opposite side of the field. The participants' goal is to cross the field to the opposing side. The players are allowed to move forward while the mannequin sings (the equivalent of shouting 'Green Light'); they must stop and be motionless when the mannequin turns back and stops singing (the equivalent of shouting 'Red Light'). If movement is detected afterwards, they will be eliminated from the game. At first, the players don't realize that 'eliminated from the game' means being shot dead on the spot. If the players behaved strategically (cooperated or colluded), they would have had a better chance at survival, but at the start of the game, a wave of panic overcomes most players and those that try to flee are shot dead. With help from another player, Gi-Hun (Player #456), the main protagonist and narrator of the series, survives the game.

Length: 3 minutes 48 seconds

Critical Commons URL: https://criticalcommons.org/view?m=vufgXphCO

[10]It is important to note that when players sign up, they are told the following by the guards overseeing the games: "Everyone here will participate in six different games over six days. Those who win all six games will receive a handsome cash prize." When "Red Light, Green Light" starts, 456 players are given 5 minutes to cross the field. They are not told the types of games they will play or given any details about the amount of prize money, or how it will be allocated. Only at the conclusion of this game do the players discover that there is a jackpot.

Concepts: collusion, dominant strategy, irrational behavior, Nash Equilibrium, pareto optimal, payoffs, player coordination, rational behavior, strategic behavior.

A. Rules of the Game

Play the clip above from 0:00 to 1:05 when the rules of the game are being explained to the players. Divide students into smaller groups and ask them to discuss the following questions:

1. What information is known in a typical game?
2. What assumptions do we make about a player's behavior?
3. Is this a game of strategic interaction at this point?

Suggested Answers:

1. In game theory, we know the number of players, their strategies, and their payoffs. The game is usually represented by a payoff matrix that shows those players, strategies, and payoffs. We assume that players act simultaneously or without being able to observe the actions of others.
2. We assume that players within the game are rational and will strive to maximize their individual payoff in the game.
3. No. Each player wants to win by crossing the field within the 5-minute time limit, but it's not clear whether strategic behavior is possible or even desirable at this stage.

B. Importance of remaining rational

Play the clip above from 1:08 to 2:50 where players first realise that elimination from the game means being shot on the spot. A wave of panic overcomes the group and hundreds of players are shot trying to flee the game. Pose the following questions for students to discuss:

1. How can we use the concept of game theory to understand the actions of some of these players?
2. Have you ever been in a situation where you would have benefitted from colluding or acting cooperatively, but instead you may have acted to benefit only yourself?
3. Are there methods of increasing cooperation in situations where people act in their own self-interest instead of cooperating?

Suggested Answers

1. Some players don't fully understand the rules and payoffs of the game. In the standard version of the game players are sent back to the start or eliminated – not murdered – when they move at the wrong time. Once players understand the consequences of breaking the rules in *Squid Game*, panic takes over. Players would be better off putting their emotions aside and playing in accordance with the rules. One useful strategy might be to cooperate (signalling or protecting others), as working together more may survive the game.
2. Some examples of situations when people act in their own best interest instead of the group's best interest include:

- Co-workers agreeing to remain silent about a minor theft or damage in the workplace and not telling the manager, but then one worker informs the boss.
- Siblings agreeing to collude not to tell a parent about misbehavior, then one sibling turns the other in.
- A group of students agreeing to remain silent about homework that a teacher has forgotten to collect, which none of them have done, but one student reminds the teacher.

3. Some examples of ways that people can behave more cooperatively may include:

- Communicating with others.
- Punishing those who do not cooperate.
- Revealing every person's contribution.

C. Strategic Behavior

We see a few instances towards the end of the game where players begin to act strategically by signalling, hiding behind, and even helping other players. Play the following scene from 2:52 to 3:48 which shows how cooperative behavior in game theory can be beneficial. Gi-Hun (Player #456) is saved by Ali (Player #199), who prevents him from falling after the players have been ordered to stop ('Red Light').

In the payoff matrix below, Player #199 is the row player and Player #456 is the column player.[11] Have students use this payoff matrix to answer the questions that follow.

		Player 456	
		Act Individually	Cooperate
Player 199	Act Individually	**-1**, **-1**	**-1**, **2**
	Cooperate	**2**, **-1**	**5**, **5**

1. Do either of the players have a dominant strategy? If so, what is their dominant strategy?
2. What is the Nash Equilibrium?
3. Is the Nash Equilibrium pareto optimal?

Suggested Answers:

1. Both players have a dominant strategy to cooperate.[12]
2. Both players cooperating is the Nash Equilibrium, i.e. (Cooperate, Cooperate). They end up in the bottom right corner and earn 5 each.
3. Yes, the Nash Equilibrium in this game is pareto optimal. Acting cooperatively offers

[11]The payoff matrix is created by the authors to show that both players have a dominant strategy to co-operate and that the Nash equilibrium is pareto-optimal. The payoff matrix is not known to the players in the TV show, thereby deviating from the simple game theory model.
[12]A detailed reasoning is provided in the appendix.

the highest set of payoffs and neither player can improve their payoff by unilaterally deviating.

Game 2: Marbles

Summary: Players are told to pair up, but given their prior game experiences they try to choose a partner strategically. The players soon discover that instead of working as a team, they will have to play against their partner in a marble-based game of their choice. No pre-determined rules are given to the players on which game to play with the marbles; instead, players are free to establish their own rules or play their favorite games. Each player is given a bag containing 10 marbles. Whoever acquires all their partner's marbles within 30 minutes is the winner.

Several groups play odds and evens (*holjjang*) with their marbles. Both players grab a random number of marbles – holding it hidden in their hand – and present this to the other player. They take turns guessing if the number of marbles held by the other person is even or odd. Based on the guess – the 'winner' will acquire the other's marbles they held hidden. The interaction between Ali (Player #199) and Sang-Woo (Player #218) is a good example of a 2-person zero-sum game with imperfect information.

Length: 4 minutes 40 seconds

Critical Commons URL: https://criticalcommons.org/view?m=jvCncY4Zj

Concepts: coordination, dominant strategy, imperfect information, mixed strategies, Nash Equilibrium, simultaneous move, zero-sum game.

Warm Up Activity: It's important that students understand the concept of a zero-sum game before you show them scenes from the "Marble Game". To help them understand this, play Rock, Paper, Scissors. Announce "we are going to play 5 rounds of Rock, Paper, Scissors. Please find a partner. Each round is worth +1 point to the winner; -1 point to the loser; zero points for a tie. Record your results, then answer this question: What is the total change in wealth at the end of 5 rounds?"

Suggested Answers: Rock, Paper, Scissors is a 2-person zero-sum game with imperfect information. Players move simultaneously but do not know the other player's move. There is no dominant strategy. Rock crushes scissors; paper wraps up rock; and scissors cuts paper. There are three possible outcomes: Player 1 wins; Player 2 wins; or there is a tie, if both players choose the same object. For the five rounds, the payoffs sum to zero.

A. Incomplete Information

Players in the game are told to choose a partner before they are told the rules of the game. Play the clip above from 0:00 to 3:22 and then pose the following questions to students:

1. What assumptions did the players make when choosing a partner?
2. When players learn that this 2-person game is a zero-sum game, how does this affect their strategy?

Suggested Answers:

1. Players believe they will be competing against other teams, so they choose their friends or allies. They were likely hoping to work cooperatively and survive together.
2. When the players learn that the game is a zero-sum game, they know that cooperation

is no longer possible: only one member of the team can survive.[13] They must play to win or sacrifice themselves to allow their partner to win. Their strategy shifts from close cooperation to ruthless competition.

B. Zero-Sum Game

In this scene, it is Player #199's turn to hide marbles. Player #218 must guess how many marbles he has hidden in his closed fist. We can model, in theory, the possible strategies and payoffs in the payoff matrix below where *X* represents the winnings or losses. Player #218 is the row player and Player #199 is the column player.

		Player 199 (X_1 = Player 199's bet)	
		Has Odd	**Has Even**
Player 218 (X_2 = Player 218's bet)	**Guess Odd**	$+X_1, -X_1$	$-X_2, +X_2$
	Guess Even	$-X_2, +X_2$	$+X_1, -X_1$

Play the scene above from 3:24 to 4:40 and use the payoff matrix above to answer the following questions:

1. How many marbles did Player #199 hide in his hand? How many marbles did Player #218 bet? Did Player #218 choose odd or even?
2. Fill in the game table above with numbers based on the video clip.[14]
3. How can we show that this game is a zero-sum game?
4. After Player #199 wins this game, Player #218 only has 1 marble left. How should Player #199 play the next round of the game?

Suggested Answers:

1. Player #199 hid 3 marbles and Player #218 bet 2 marbles. Player #218 chose even.
2. The completed payoff matrix is presented below. Player #199 won 2 marbles and Player #218 lost 2 marbles.

		Player 199	
		Has Odd	**Has Even**
Player 218	**Guess Odd**	**+3, -3**	**-2, +2**
	Guess Even	**-2, +2**	**+3, -3**

[13]Hypothetically, it is possible to see a negative-sum game: if neither player wins the game by securing the other's marbles, they are both eliminated, but we don't observe this in Squid Game.
[14]This payoff matrix corresponds to the actual scene where Player #199 hides 3 marbles, Player #218 bets 2 marbles, and Player #218 chose even.

3. For each cell in the payoff matrix, the summation of the payoffs equals zero. The gains in the payoff matrix are opposite for each player (-2, +2) and sum to zero.

4. In the next round, Player #199 will guess the number of marbles in Player #218's hand. He knows Player #218 only has 1 marble left, so calling odd is now a dominant strategy.[15] Notice that Player #218 knows this and tricks Player #199 into giving up his marbles and wins the game! If we assume that Player #199 was going to bet 2 marbles, the last round could be represented as follows.

	Player 218	
		Has Odd
Player 199	**Guess Odd**	**+1, -1**
	Guess Even	-2, +2

7. Conclusion

Game theory is one of the most challenging topics in economics to teach. Many students struggle to think in a strategic manner when the material is taught through traditional mathematical methods alone. Dixit (2005) was one of the first proponents of changing the way game theory is taught, demonstrating that pop culture could be used as an effective medium to break down barriers to learning. In the period since, several articles and online repositories of pop culture have been created, but few provide instructors with detailed teaching guides.

Squid Game is an obvious extension to this literature because the premise of each game is based on strategic behavior and interdependence. This article provides instructors with a variety of quick teaching scenes and extended teaching guides, from which they can freely select and adapt to their needs. The quick teaching scenes are suitable for principles level courses, where game theory is first introduced, while the extended teaching guides are best suited for more advanced-level courses, where vivid and entertaining illustrations of key concepts may serve to refresh students' memories and stimulate more active discussion and engagement.

[15]As an extension in an upper-level course, it might be worth mentioning how a player could contemplate some of the possible future subgames. For instance, if you gamble all but 1 marble, then you could be stuck with a known number (1) that would be commonly known to be odd. This also might be a point where teachers could introduce risk concepts. Does a player want to wager big? This game could also connect to some of the experimental evidence about whether or not people are good at randomizing, versus whether they might exhibit patternistic choices. We are grateful to an anonymous referee for the suggestion.

References

Asarta, C. J., Chambers, R.G., & Harter, C. (2021). Teaching methods in undergraduate introductory economics courses: Results from a sixth national quinquennial survey. *The American Economist*, *66*(1), 18-28.

Brauer, J., & Delemeester, G. (2001). Games economists play: A survey of non-computerized classroom-games for college economics. *Journal of Economic Surveys*, *15*(2), 221-236.

Briguglio, M., Acchiardo, C. J., Mateer, D., & Geerling, W. (2020). Behavioral economics in film: Insights for educators. *Journal of Behavioral Economics for Policy*, *4*(1), 17-28.

Burke, S., Robak, P., & Stumph, C.F. (2018). Beyond buttered popcorn: A project using movies to teach game theory in introductory economics. *Journal of Economics Teaching*, *3*(1), 153-161.

Dixit, A. (2005). Restoring fun in game theory. *The Journal of Economic Education*, *36*(3), 205-219.

Fisher, L. (2008). *Rock, Paper, Scissors: Game Theory in Everyday Life*. New York: Basic Books.

Friesner, D., and Axelsen, D. (2009). Using game theory to teach principles of microeconomics. *Journal for Economic Educators*, *6*(1), 1-14.

Gambetta, D. (2009). *Codes of the Underworld: How Criminals Communicate*. Princeton, New Jersey: Princeton University Press.

Geerling, W., Mateer, G.D., Addler, M. (2020). Crazy rich game theory. *International Journal of Pluralism and Economics Education, 11*(4), 326-342.

Geerling, W., Nagy, K., Rhee, E., & Wooten, J.J. (2021). Using K-Pop to Teach Indifference Curve Analysis, Behavioral Economics and Game Theory, Journal for Economic Educators, 21 (1), 40-56.

Goffe, W. L., & Kauper, D. (2014). A survey of principles instructors: Why lecture prevails. *The Journal of Economic Education*, *45*(4), 360-375.

Hobbs, K., & Wooten, J.J. (2021). Teaching principles of microeconomics with the economics media library. *Applied Economics Teaching Resources*, *3*(1), 37-57.

Kaplan, T.R., & Balkenborg, D. (2010). Using economic classroom experiments. *International Review of Economics Education*, *9*(2), 99-106.

Kearney, M. S. (2021). What does critical thinking mean in teaching economics?. *The Journal of Economic Education*, 1-3.

Mateer, G.D. (2012). Econ 1-0-What?. *The Journal of Economic Education*, *43*(4), 440.

O'Roark, B., & Grant, W. (2018). Games superheroes play: Teaching game theory with comic book favorites. *The Journal of Economic Education*, *49*(2), 180-193.

Rousu, M.C., Corrigan, J.R., Harris, D., Hayter, J.K., Houser, S., Lafrancois, B.A., & Hoffer, A. (2015). Do monetary incentives matter in classroom experiments? Effects on course performance. *The Journal of Economic Education*, *46*(4), 341-349.

Sheridan, B.J., & Smith, B. (2020). How often does active learning actually occur? Perception versus reality. *AEA Papers and Proceedings*, *110,* 304-308.

Shor, M. (2003). Game theory.net. *The Journal of Economic Education*, *34*(4), 388.

Shubik, M. (2002). The uses of teaching games in game theory classes and some experimental games. *Simulation & Gaming*, *33*(2), 139-156.

Siegfried, J.J. (2021). Trends in undergraduate economics degrees, 2001–2020. *The Journal of Economic Education,* 1-4.

Wooten, J.J. (2018). Economics media library. *The Journal of Economic Education*, *49*(4), 364-365.

Wooten, J.J. (2020). Integrating discussion and digital media to increase classroom interaction. *International Review of Economics Education*, *33*, 100174.

Wooten, J.J., Al-Bahrani, A., Holder, K., & Patel, D. (2021a). The role of relevance in economics education: A survey. *Journal for Economic Educators*, 21(1), 11-34.

Wooten, J.J., Geerling, W., & Calma, A. (2021b). Diversifying the use of pop culture in the classroom: Using K-pop to teach principles of economics. *International Review of Economics Education*, 38, 100220.

Appendix

Game 1: Red Light, Green Light

C. Strategic Behavior

Q1. Do either of the players have a dominant strategy? If so, what is their dominant strategy?

Suggested Answers: Both players have a dominant strategy to cooperate.

- Step 1: Let's think from player 199's perspective. Player 199 has two strategies: Act individually and cooperate. When player 456 acts individually, player 199 can earn -1 by acting individually or can earn 2 by cooperating. Since 2 > -1, when player 456 acts individually player 199 will cooperate. When player 456 cooperates, player 199 can earn 1 by acting individually or can earn 5 by cooperating. Since 5 > 1, when player 456 cooperates, player 199 will cooperate as well. Regardless of what player 456 chooses to do, player 199 will choose to cooperate, because it offers a higher payoff. Therefore, player 199's dominant strategy is to cooperate.
- Step 2: Let's think from player 456's perspective. Player 456 has two strategies: Act individually or cooperate. When player 199 acts individually, player 456 can earn -5 by acting individually or can earn 2 by cooperating. Since 2 > -5, when player 199 acts individually, player 456 will cooperate. When player 199 cooperates, player 456 can earn -5 by acting individually or can earn 5 by cooperating. Since 5 > -5, when player 199 cooperates, player 456 will cooperate as well. Regardless of what player 199 chooses to do, player 456 will choose to cooperate, because it yields a higher payoff. Therefore, player 456's dominant strategy is to cooperate.

Game 2: Marbles

C. Matching Pennies

Q3. What is the pure Nash Equilibrium in this game?

Suggested Answers: There is no pure-strategy Nash Equilibrium in this game.

- Step 1: Let's think from Player 1's perspective. Player 1 has two strategies: Heads or tails. When Player 2 chooses Heads, Player 1 can earn 1 by choosing Heads or can earn -1 by choosing Tails. Since 1 > -1, when Player 2 chooses Heads, Player 1 will also choose Heads. When player 2 chooses Tails, Player 1 can earn -1 by choosing Heads and can earn 1 by choosing Tails. Since 1 > -1, when Player 2 chooses Tails, Player 1 will also choose Tails. Player 1 does not have a dominant strategy. What Player 1 chooses depends on what Player 2 chooses.
- Step 2: Let's think from Player 2's perspective. Player 2 has two strategies: Heads or Tails. When Player 1 chooses Heads, Player 2 can earn -1 by choosing Heads and can earn 1 by choosing Tails. Since 1 > -1, when Player 1 chooses Heads, Player 2 will choose Tails. When Player 1 chooses Tails, Player 2 can earn 1 by choosing Heads and can earn -1 by choosing Tails. Since 1 > -1, when Player 1 chooses Tails Player 1 will choose Heads. Player 2 does not have a dominant strategy. What Player 2 chooses depends on what Player 1 chooses.
- Step 3: In this game, for each cell there is a player that has an incentive to deviate. Therefore, we do not have a pure Nash Equilibrium.