Teaching Design of Game Theory under Limited Faculty Constraint

Yifan Xiong

School of Economics and Management, Anhui Normal University, Wuhu, Anhui Province, China.

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Abstract

Game theory plays a vital role in the teaching of economics. Because of its highly abstract characteristics, this course has high requirements for teachers' professional knowledge. In ordinary colleges, the faculty of this course is usually limited, while the backgrounds of students that took the course are diverse, which leads to a contradiction between limited faculty and diversification of teaching contents. This paper puts forward two paths: modularization of teaching content and stratification of teaching content, and makes a specific analysis by using the teaching example of p-beauty contest.

Keywords

Teaching of Game Theory, Limited Faculty, Teaching Design, Modularization, Stratification

1. Introduction of Game Theory course

Game Theory is the main course of economics majors, which studies the interactive decision-making problems among people in certain situations. The famous economist David Kreps has made a very precise summary of game theory: "Game theory is the knowledge of situations. By its very nature, game theory is the study of human decision making, and we are faced with decisions all the time. The basic premise of game theory is that the correctness of a decision, what is the optimal choice, does not depend only on one's own actions, but also on the context in which it is made." Robert Aumann, winner of the 2005 Nobel Prize in Economics, has similarly argued that "Game theory is the science of interactive decision making. By interaction I mean that the actions and decisions of the participants in this situation affect each other. Thus to make optimal choices, we must consider the actions and reactions of our opponents,

the interdependence of subjects, and the interactions." In short, what participants in a game need to do and should do depends on who their opponents are and what those opponents are doing and will do. The main goal of teaching "Game Theory" is to give students a deeper understanding of how people make decisions under mutual influence and the relationship between competition and cooperation in human society through the study of game theory and examples, aiming to make students understand the basic concepts of game theory, master the basic methods of game theory analysis and be able to use the knowledge of game theory to solve some problems encountered in real life. Further, students can gain a new way of dealing and thinking from this course - to make decisions not by examining dogmas, but by knowing their opponents, understanding the logic of each other's actions, and learning to consider problems from other people's point of view if they want to achieve their own goals, which is often said to think differently.

2. The main problems in the teaching of "game theory" course under the conditions of faculty constraints and solutions

The object of the course "Game Theory" is not only the undergraduates and postgraduates of economics, management and other business majors, but also economic theorists, business operators, theoretical and practical workers in law and politics, etc. Different audience groups mean that the learning targets not only differ in their learning bases and knowledge backgrounds, but also in their learning purposes. For example, many economic and management colleges and universities cover the knowledge of game theory in their professional courses for entrance exams, and one of the important motives for undergraduates to study game theory is to cope with entrance exams. Part-time MBA students, whose main sources are economic theorists, business operators, theoretical and practical workers in law and politics, study this course more to enlighten their minds and use the knowledge of game theory to solve practical problems. For full-time academic students, the knowledge of game theory is used as an analytical tool for conducting scientific research.

The difference in the learning purpose of the audience groups determines that the teachers cannot teach Game Theory in a single move, but must choose the appropriate teaching content according to the learning situation. In order to meet the different purposes of different audiences for the course of game theory, higher education institutions usually set different hours for the course according to different teaching objects. In non-specialized institutions, the number of teachers who can teach this course is relatively limited. Usually one teacher needs to teach game theory to all three groups of students at the same time. This is a huge challenge for faculty preparation for the course. In this paper, we believe that the curriculum design of the course "Game Theory" should be based on the following two points.

First, the overall content modularization. Usually applied in modern economics, management game theory according to the game in the action of the participants in the classification of the time sequence can be divided into static games and dynamic games. The so-called static game is a game in which all participants make decisions at the same time, while the dynamic game is the participants make decisions successively. And according to the information available to the participants can be divided into complete information game and incomplete information game. Complete information is both the "common knowledge" of the participants' benefits from each strategy combination (sometimes complete information is also described as the "common knowledge" of the participants' types of information, which determines their benefits from the game), and incomplete information is the "common knowledge" of some participants. Complete information means that some participants' gains are not "common knowledge" (or some participants' types have private information - only they know their own types, but not the other opponents). Therefore, the game theory course can be divided into four modules: module 1) Static game with perfect information; module 2) Dynamic game with perfect information; module 3) Static game with incomplete information; module 4) Dynamic game with incomplete information. These four modules have a high degree of independence from each other. On the premise of ensuring the completion of module 1, one or several of the remaining three modules can be taught according to the length of class time without affecting the integrity of the course content too much. In contrast, the concepts of complete information games are more intuitive and examples are more common in practice, while incomplete information games involve knowledge of probability theory on the one hand, and the concept of equilibrium on the other hand is more abstract. Therefore, for short courses or for part-time students, only the first two modules can be chosen. For long courses, especially for academic students, all four modules can be taught. If the instructor is only prepared to go deeper in the static game, he or she can also choose modules 1 and 3 to organize the course.

Second, the knowledge is stratified. The content of the game theory course has a great span in terms of difficulty. Game theory is a branch of mathematics at the earliest, and its basic theories and concepts are characterized by a high degree of abstraction in the discipline of mathematics. With the introduction of game theory into economics in the 40s and 50s of the last century, it has gained great development and is widely used in explaining economic phenomena and predicting the results of the development of economic problems. This provides a large number of examples of real economic problems for the teaching of this course. In addition, many real-life games, activities and competitions are essen-

tially games between people. For example, the game of “rock, paper, scissors”, chess or go, and the game between the penalty kick taker and the goalkeeper in soccer. This makes it possible for teachers to use examples to teach students to grasp the basic elements and ideas of game theory even if they do not pursue the rigor of basic theoretical knowledge. Therefore, teachers can divide each knowledge point into the following three levels of increasing difficulty: Level 1 understand the idea of game theory, be able to identify whether a situation is a game, and furthermore, what kind of game it is, and use the concept of equilibrium to predict the possible results of a game; Level 2 redescribe the basic concept of game equilibrium mathematically, and use the relevant concepts to analyze the equilibrium of a specific game. Level 3 understand and master the general principles and concepts of game theory, and deeply understand the correlation between different concepts. In the teaching of theoretical knowledge, the required stratification can also be further subdivided for the students’ knowledge background. It is easier to teach mixed strategy Nash equilibrium in the framework of a two-player game than in a general multi-player game. It is more intuitive to teach subgame perfect Nash equilibrium in a two-phase dynamic game than in a general multi-stage dynamic game. Depending on the background of the students, the instructor can choose whether to choose examples and explain the basic concepts in a special or general framework.

3. Teaching Case

The following paper further illustrates how to stratify a knowledge point through a specific teaching case. The “P-perfect race game” is a game that has been extensively experimented with in behavioral economics. The game consists of the following: n participants simultaneously choose an integer from 1 to 100, and the number chosen by all participants is averaged and multiplied by P (where the constant $P < 1$ is usually taken as two-thirds), and the resulting value is denoted Z. The participant who chooses the number closest to Z among all participants is the winner, and the winner receives a certain prize, and if there is more than one winner, the prize is divided equally among the If there is more than one winner, the prize is divided equally between the winners. This is the reason why the game is called a P-perfect contest - instead of choosing the participant closest to the equilibrium, the participant closest to the mean P times wins.

The game is generally used to explain the entire thought process of “repeatedly eliminating strictly inferior strategies” [1]. A strictly inferior strategy is one in which a participant can always choose another strategy to obtain a higher payoff than that strategy, no matter what the other participants choose, and that strategy is called a strictly inferior strategy for that participant. A rational participant (with the goal of maximizing returns) must not adopt a strictly inferior strategy. Further, if each participant is aware that other participants are rational, then each participant should expect that other participants will not adopt strictly inferior strategies, and these strictly inferior strategies are eliminated from the participant's strategy set. Once some of the opponent's strategies are eliminated, new strictly inferior strategies may arise for the other participants. If the rationality of the participants is strong enough (rationality is common knowledge), then the process of proposing strictly inferior strategies can be repeated until all participants have no strictly inferior strategies.

In the “P-perfect game”, all rational participants should realize that the choice greater than or equal to 67 must be strictly inferior, because no matter how the other participants choose, two-thirds of the average number of choices of all participants must not exceed 67, so the choice above 67 must be strictly inferior to the choice 66 (although 66 is not necessarily the optimal choice). And if participants are aware of this, then they will further infer that everyone’s choice should not exceed two-thirds of 66, that is, 44, and if all participants are rational enough (not only are they rational in making their own choices, but they expect that other participants are also rational, and furthermore, they expect that other participants can expect all participants to be rational, and so on), this process of each participant This is the theoretical outcome of the game, but in practice people are not as perfectly rational and they have sufficient information about the degree of rationality of others. Therefore, it is almost impossible for people to choose 1 when they participate in this experiment.

This experiment is very easy to conduct in the classroom and is highly tractable. And in the author’s experience, this experiment can have very good classroom results. Instead of explaining the results of the theoretical analysis of the game, the instructor can have each student play the game as a participant in the game. The teacher can ask all students to independently write an integer between 1 and 100 on a prepared paper (or enter a number between 1 and 100 on the teaching terminal if using a digital teaching terminal), collect the numbers written by all students, count the results, calculate the mean value, and then determine the winner according to the rules of the game and provide a prize. At the end of the game, the teacher can ask the students who made different choices to explain how they thought about the choices they made. The teacher then evaluates the students’ answers and finally introduces a theoretical analysis of the process, thus deepening the students’ understanding of the whole process of repeatedly eliminating strictly inferior strategies. Generally speaking, the first level of instruction is basically completed here, and the teacher can make minor adjust-

ments according to the learning situation. At the second level, the teacher should not only teach the students the thinking process of the game, but also use mathematical language to rigorously prove the result of the game's repetitive rejection of strictly inferior strategies. Compared to the first level, the second level provides more training for students' logical and abstract thinking skills. The third level of instruction for this game should be designed to further abstract from this example to the general rule. This leads to the "repeated rejection of strictly inferior strategies" and the "Nash equilibrium" between this leads to the relationship between "Nash equilibrium" and "Nash equilibrium" - all Nash equilibrium strategies are not eliminated by repeatedly eliminating strictly inferior strategies. After the example of the "P-perfect game", it is easier for students to appreciate the intuition behind the mathematical construction of the proof than to explain the proof of the proposition directly.

These three levels are progressive in terms of difficulty and demands on the students. When class time is sufficient and students have a good foundation, instructors can follow these three levels in a progressive manner. If the class time is not sufficient, but the students have certain foundation (for example, academic graduate students in some majors, but "Game Theory" is not a core course, and the number of class hours arranged is less), then the first level can be abandoned, and only teach around the second and third levels. If there are sufficient class hours, but students have a relatively poor foundation (e.g. undergraduates), then the third level can be dropped and only the first and second levels can be taught. If the class time is short, and the purpose of teaching is only to quickly convey the basic ideas and thinking of game theory to students (for example, the target audience is part-time MBA, and game theory is generally used as a chapter in some courses such as management economics), then the instructor can also achieve good results by choosing only the first level for classroom teaching [2].

4. Conclusion

In this paper, we have briefly introduced the objectives and content of the course "Game Theory" and presented the problems that may exist in general institutions when conducting this course - limited faculty and the contradiction of offering different courses of different duration and difficulty for different backgrounds at the same time. Using the intellectual features and knowledge structure of game theory itself, this paper proposes two ways to solve this contradiction: modularization of the teaching content and stratification of the teaching content. Both on the one hand, the game theory is divided into four teaching modules according to the content of the course and taught selectively according to the object of instruction; on the other hand, each module and each knowledge point is stratified according to the degree of mastery of knowledge, and the level reached in teaching is chosen according to the class time arrangement and students' background. This paper is an exploration of the teaching design of the course "Game Theory", and the author hopes that this paper can provide a solution to teachers who are engaged in teaching game theory when they face similar contradictions.

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