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A NEW APPROACH FOR ASSESSING TEACHERS' TEACHING METHODS USED IN LESSONS: GAME THEORETIC ANALYSIS

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Abstract: The choice of instructional strategies, methods and techniques used by teachers is important in terms of establishing an effective learning environment. The purpose of this study is to examine the most common methods teachers use in their lessons and the factors that influence their choice of methods by using game theory. Game theory has different applications such as social sciences, politics and economics. A questionnaire is prepared by the researchers in this study, which is conducted with forty-seven teachers working in different branches and at different levels. The two most preferred teaching methods are considered to be players: direct instruction and problem solving method. The characteristics of these methods are compared with game theoretic approach according to the survey results. Two separate game problems are revealed in the study. The first game problem is a zero-sum game representing the state of the two teaching methods, which are considered as rival to each other. With the non-zero-sum game, the characteristics of both teaching methods are analyzed. According to results, direct instruction method is superior in terms of usage properties in accordance with problem solving method. The advantages and disadvantages of the two teaching methods are discussed for further research.

Key words: game theory, teaching methods, teachers, survey research

1. Introduction

During the past decades, game theory has been applied to social sciences to solve some problems in a competitive environment (Charilas & Panagopoulos, 2010). When it comes to education, game theory can provide clues to teachers about which teaching method is more effective in their learning environment.

Investigations on the effectiveness of instructional methods and techniques have shown that there is no one best teaching method (Gönen & Kocakaya, 2006; Jia et al., 2017). However, the effectiveness of method-techniques varies according to the characteristics of the teacher, the characteristics of the students, the subject matter, the aims to be reached and other variables of classroom environments. For this reason, it is very important for teachers to know the teaching methods and techniques very well and to choose the most appropriate method for the situation they will use (Erden, 1997). In this respect, it is aimed to investigate and find out the method-technical preferences of teachers and the reasons of these preferences in this research.

In the phase of choosing teaching strategies, methods and techniques in the direction of teaching objectives, student's intelligence areas, learning styles, perception styles, readiness, targets to be reached, contents to learn, time, physical and economic possibilities, classroom availability and teacher characteristics should be considered (Tok, 2007). For a desired behavioral change through effective teaching, a teacher should choose a technique that will be used according to the content of the course, the subject area, the level of readiness of the students, and the number of students, school

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administration, and parents. In order to use the chosen method and technique efficiently for the teacher, he must have sufficient knowledge about the method or technique and should be able to use the technique or method according to the aims and principle (Tan et al., 2002).

Each teacher may have different preferences and predispositions in choosing a method that may be relevant to their professional background, experience and skill. Some teachers do not want to make changes in a way they are accustomed to (Şahan, Uyangör, & Isıtan, 2012). For example, some teachers are happy when they are discussing in classes. For some, the direct instruction method is the best method.

Time and physical facilities are effective in the choice of teaching method. In cases where time is short, more classical methods are preferred by teachers. Contemporary, student-centered methods require more time. These methods also require different physical materials. For example, in order to use the group discussion method in the class, the classical chairs must be fixed (Görücü, 2015).

The nature of the subjects within the course is often the strongest determinant of the teaching method. Some subjects in Physics-Chemistry courses may require direct laboratory work. In literary lessons, it is necessary to read some literary works and prepare them as homework, or sometimes to read and explain the old texts. If the topic can be taught in the best way with a given method, this method should be used (Özdaş, 1997).

Teachers should choose the most appropriate method-technique by taking into account the student characteristics in their class and go through the necessary changes with the feedback they have received from the class again (Küçükahmet, 2004). For example, lecture (direct instruction) method is reasonably effective for auditory learners (Tan & Erdoğan, 2005).

Researches examining the teaching methods used by teachers are available in the educational literature (e.g., Demirezen, 2001; Saracaloğlu & Karasakaloğlu, 2011; Yeşilyurt, 2013; Güven Yıldırım, Köklükaya, & Aydoğdu, 2016). However, in this study the most used teaching methods and factors affecting the choice of the methods when teachers are teaching their lessons will be evaluated with a different point of view by using game theory as an alternative. This study is also important since it is the one of the first research on the application of game theory to the education field.

In education, strategy is a general approach that leads to goal and method selection (Saracaloğlu, 2003). The concept of strategy is the determinant of which methods and techniques to choose (Snowman, 1986). The method is a regular path, which is chosen deliberately to teach a subject (Demirel, 2004).

In this study, the factors affecting the teaching methods used by the teachers during the determination of the strategies have been classified under four headings. Factors affecting the teaching methods selection are the readiness of students, the willingness of students, the developmental characteristics of students, the teacher's skill in the method, the methods used by the other teachers, the ease of use, physical facilities, time, and cost, the number of students, school administration, parents, and classroom environment. The strategy X is evaluated in terms of students, strategy Y is in terms of teachers, strategy Z is in terms of usage, and strategy T is determined as external factors.

The main purpose of this study is to determine two most common teaching methods used by the teachers in their lessons, to compare the various features of them and to determine the priorities of the teachers on these methods. For this purpose, the criteria that the teachers can take into consideration in their teaching method preferences are established within the scope of the study, these criteria are grouped according to the relevant fields and strategies are determined. According to survey results, opponent players have been identified as direct instruction and problem solving methods. While in the first game problem (zero-sum game), two teaching methods' properties are compared, the second game (non-zero-sum game) problem investigates the teachers' priorities about the usage of the teaching methods by comparing their different features.

Teachers who participated in this study stated that they use the most direct instruction (lecture) and problem solving methods in their lessons. In the light of the information in the literature, direct instruction and problem solving methods have superior and weak points to each other. One of the teaching methods that teachers use most is the method of lecture (direct instruction). This method is

used in the definition of general terms and concepts, and presentation of samples and making comparisons (Sönmez, 2008; Arıcı, 2006). Courses can be carried out with larger groups. It is highly effective when time is limited for teaching (Savaş, 2007). Instead of transferring information directly with the problem solving method, the development of problem-solving skills is targeted and children are directed to think creatively (Kılıç & Samancı, 2005). Hiebert and Wearne (2003) state that problem solving approach helps students to develop deep and rich understandings of mathematics. Students are active in the problem solving method. Since students are active in the teaching-learning process, permanent learning outcomes can be provided. It raises interest in learning and teamwork carry out by small groups (Gök, 2006). However, the problem solving method as a teaching method is a time-consuming method. It is not possible to apply to all disciplines. It may be cost to obtain a number of material resources that will be necessary in problem solving (Çoban, 2012).

With game theory viewpoint, these two methods are compared to each other in terms of superiority and weakness. Comparisons with the literature are made in the discussion part of the paper. The following research questions are searched:

1. What are the advantages and disadvantages of direct instruction method compared to problem solving teaching method?

2. What are the priorities of the teachers on learning process with these two separate teaching methods?

1.1. Basic concepts of game theory

Game theory is a mathematical branch based on decision-making in social relations. Three main properties are available in game in the terminology of game theory: players, strategies and payoffs (Colman, 2013).

Two or more decision makers called "players" are available (Morton, 1997) and each player has a choice of two or more ways of representation, called "strategies" (Colman, 2013) in a game. Decision makers use strategies against each other in order to achieve the highest outcomes in every possible case (Cinemre, 1997). The result of the interaction depends on the strategy preferences of all the players. A strategy is a complete plan of action, involving the choices of the players for all situations that may arise during a game (Doğan et al., 2015). Therefore, the concept of strategy in game theory is different from the concept of strategy in education. A game composes of a finite set of players each of which selects a strategy with the aim of maximizing his expediency (Charilas & Panagopoulos, 2010). There are well-defined preferences of players between the possible outcomes. Numerical "payoffs" reflect these preferences and can be assigned to all players for all outcomes (Colman, 2013). A game is generally presented as a rectangular matrix of payoffs to first player. The rows and columns are referred to as "strategies". The payoff is at the intersection of the row chosen by first player and the column chosen by second player (Washburn, 2014).

Two types of games are distinguished: two-person zero-sum game and two-person non-zero-sum game. Games in which the players' preferences are mutually opposed are defined zero-sum games (Colman, 2013). In zero-sum games, the gains or losses of a player are equal to the sum of the gains and losses of the other players (Doğan et al., 2015). Games such as checkers and arm-wrestling are examples of two-player zero-sum games, because at the end of the game, there is a single winner and a single loser with the winner being and the loser being (McDonough, 2011).

If the gain of a player does not necessarily mean the loss of another player (and vice versa) then the situation becomes more complicated. These types of games are called as non-zero-sum games, because the sum of the gains and losses in the game is not always equal to zero. A classic example of a non-zero-sum game is the Prisoners' Dilemma. In this game, both players act in their own interests to achieve the best possible outcome, but the winnings of a player are not balanced equally with the loss of the other. Many cases in the real world are best modeled by non-zero-sum games (McDonough, 2011). A zero-sum game is definitely a competitive game (Bacharach, 1989).

A two-person zero-sum game is called to be a finite game if both strategy sets are finite sets. One

solving method of zero-sum games is the minimax theorem. The solution process is carried out via payoff matrix in this method (Ferguson, 2000).

In game theory, firstly the mathematical model of the game is created. Then, what is the optimal strategy in the given game is determined (Guseinov, Akyar, & Düzce, 2010).

The first step for solution is to begin with the choice of the player. When the player that represents the rows of the payoff matrix is to be implemented, the maximin method is carried out. If the player representing the columns is to be applied, the minimax method is performed (Von Neumann & Morgenstern, 2007).

In the maximin method, the smallest element of each row of the payoff matrix is selected. Then the largest of these values is determined. The found value is the expected value of the player who represents the rows in the payoff matrix (Maschler, Solan, & Zamir, 2013). From the perspective of the players representing the columns, the highest value will be selected. Because the player representing the column knows the strategy of the other player's maximin and plays the game with the minimax strategy. The player representing the columns checks the elements and chooses the maximum value of each column. For this player, the result of the game is the smallest of these values (Taha, 2000). The value of any game is at a point between maximin and minimax values of the game (Öztürk, 2001). The fact that the game's maximin value and minimax values are equal to each other means the game is at its peak. The games with the peak are in equilibrium and this is the best result for each player (Taha, 2000).

2. Method

This study is a descriptive study and based on survey research. The survey model investigates specific characteristics of a group (Büyüköztürk et al., 2011). A questionnaire is prepared by researchers to determine which teaching methods teachers in various branches and grades in their classes generally prefer. In addition, teaching methods properties are compared from different angles via the developed data collection tool. According to the results obtained from the questionnaire, two different game problems are created and two most used teaching methods are accepted as players. The game matrices are formed using the data obtained through the survey. The obtained data are analyzed quantitatively with a statistical program.

2.1. Participants

The sample of the research is composed of 47 teachers who work in different branches and in different levels (middle and high school). The questionnaire prepared on the internet is delivered to the participants via an e-mail. Participants are teachers who are able to reach researchers by mail, so an easily accessible case sample is used. In this type of sample, also called the appropriate case study group, the researcher selects the people or groups to which the data can be easily collected (Sönmez & Alacapınar, 2014).

2.2. Data Collection Tool

By the questionnaire, it is aimed to determine two teaching methods, which are opponent in accordance with the basic idea of game theory.

In the first part of the prepared questionnaire, demographic information (gender, branch, teaching experience, graduated faculty, pedagogical formation status) of the teachers are included. In addition, various teaching methods (direct instruction, discussion, problem solving, cooperative learning, demonstration, case study) are given and the participants are asked which teaching method they prefer most. In the second part of the questionnaire, the factors (the readiness of the students, physical facilities, time, cost, etc.) that are effective in the selection of teaching methods are included. This choice of teachers as factors in what degree is effective “not important, somewhat important, important, very important” as 4-way through a Likert-type items are examined. The Cronbach’s alpha coefficient obtained for the survey is 0.71 and the questionnaire is adequately reliable (Fraenkel, Wallend & Hyun, 2012).

A questionnaire consisting of nine questions is prepared (see Appendix 1). While the first five questions in the questionnaire contain demographic information, the other four questions are about the

purpose of the study. The criteria that teachers consider when choosing the methods they use in their lessons are given in Table 1.

Table 1. *Criteria considered in the selection of teaching method*

Number	Criteria
1	The readiness of students
2	The willingness of students
3	The developmental characteristics of students
4	Teacher's skill in method
5	The methods used by other teachers
6	Ease of use
7	Physical facilities
8	Time
9	Cost
10	Number of students
11	School administration
12	Parents
13	Classroom environment

Of the 47 teachers who participated in the questionnaire, 37% use "direct instruction method", which is the highest rate. Later, 34.8% of them came up with "problem solving method". Considering these values, opponent players have been identified as method of direct instruction and problem solving.

2.3. Data analysis

In order to establish the mathematical game model and to construct the solution, the data are obtained via the prepared questionnaire. Two-person zero-sum and two-person non-zero-sum game problems are proposed. For this purpose, the strategies to be used in these games are determined and a mathematical model characterizing the game with a matrix is created. Factors affecting the teaching methods used by teachers during the determination of strategies are grouped under 4 headings. The strategy X is students' properties, strategy Y is teachers' properties, strategy Z usage properties, and strategy T is determined as external factors. The numerical values of the strategies are obtained through participants' responses.

In the first game, evaluation scores are calculated according to the factors stated in the methods used by the teachers who used the teaching methods which are opposed to each other. With the help of these scores, the state of the two teaching methods is formulated as a zero-sum game. In the second, the priorities of the two teaching methods are evaluated in terms of teachers. This game problem is established as a non-zero-sum game.

3. Results

3.1. Analyzing Teachers' Teaching Methods Selection by Game Theory

In this study, two most commonly used teaching methods are handled as two opponents. The first game problem is a zero-sum game, which the teaching methods determined as competitors in line with the opinions of the teachers. The second is a non-zero-sum game that analyzes how well both methods meet the priorities of teachers in their lessons.

Strategies in the game problems created in the study correspond to the determined criteria. For both game problems, the criteria in Table 2 are considered as the strategies of the players and the situation of the two players against each other according to their preferences is investigated. Assessment scores of teachers that use the direct instruction method and the problem solving method are calculated according to the specified criteria. Using these scores, the situation of the players (teaching methods) against each other in terms of the preferred criteria is expressed as a zero-sum game.

On the other hand, their situation is considered as the second game problem in terms of the criteria the

teachers consider while preferring teaching methods. This problem is established as a non-zero-sum game. For each of the game problems, game matrices are created to investigate the loss-gain situations of the players according to each other and the preferences of the teachers.

3.1.1. Determination of the Strategies

The thirteen criteria in Table 2 are summed up in four main headings. These generated titles determine the strategies and X strategy is in terms of students, Y strategy is in terms of teachers, Z strategy is in terms of usage and T strategy evaluates the methods teachers use in their lessons in terms of external factors. The determined strategies and the criteria included are given in Table 2.

Table 2. *Strategies and Criteria Grouped According to These Strategies*

Strategies	Criterion
X strategy: Students' properties	The readiness of students
	The willingness of students
	Developmental characteristics of students
Y strategy: Teachers' properties	Teacher's skill in teaching methods
	The methods used by other teachers
Z strategy: Usage properties	Ease of use
	Physical facilities
	Time
	Cost
	Number of students
T strategy: External factors	School administration
	Parents
	Classroom environment

3.1.2 Establishment of Game Matrices

3.1.2.1 Establishment of Zero-Sum Game Matrix

In the first game, the zero-sum game, the game matrix is constructed according to the responses to the seventh question in Appendix 1. Since 37% of the teachers participating in the study preferred the direct instruction method and 34.8% preferred the problem solving method in their lessons, these two teaching methods are determined as game players. Teachers who use the direct instruction method and problem solving method get scores of the related strategy by collecting scores for the criteria grouped under each strategy. Since the numbers of the criteria grouped in each strategy are different from each other, it is worked with rates instead of numbers. Percentages of scores given to each strategy compared to total score are computed and the percentage for each player meets the expectations of each strategy is obtained. These values are summarized in Table 3 for the first and second players.

Table 3. The scores of players for each strategy

Strategies	Problem Solving Method		Direct Instruction Method	
	Scores	Percentage scores	Scores	Percentage scores
X	180	0.2521	173	0.2625
Y	98	0.1372	98	0.1487
Z	282	0.3950	259	0.3930
T	154	0.2157	129	0.1958
Total	714	1.0000	659	1.0000

The direct instruction method is considered as the first player, and the scores obtained from all the strategies of the direct instruction method are evaluated according to the scores of the first player. According to Table 3, the score obtained by the first player in strategy X is 0.0104 higher than the other player is. The scores of the second player are subtracted from the scores of the first player and the values in the game's payoff matrix are obtained. The zero-sum game matrix obtained according to the first player is given in Table 4. The values in this matrix show the situation of the direct instruction method against to the problem solving method for each strategy. Negative values can be thought of as loss for the direct instruction method and gain for the problem solving method.

Table 4. *Payoff matrix of zero-sum game*

		The Problem Solving Method (Second Player)			
Direct Instruction Method (First player)		**X**	**Y**	**Z**	**T**
	X	-0.0104	0.1034	-0.1409	0.0563
	Y	-0.1253	-0.0115	-0.2558	-0.0586
	Z	0.1325	0.2463	0.002	0.1992
	T	-0.0468	0.067	-0.1773	0.0199

3.1.2.2 Solution of the Zero-Sum Game Matrix

Firstly, the smallest of the rows, the largest values of the columns are found to solve the zero-sum game payoff matrix in Table 5 in the zero-sum game. It is seen that the largest value among the smallest values of the rows is 0.002. The smallest value among the largest values of the columns is obtained as 0.002. Thus, the value of the game is 0.002.

Table 5. *Solution of the Zero-Sum Game*

	The Problem Solving Method (Second Player)					
Direct Instruction Method (First player)		**X**	**Y**	**Z**	**T**	**Minimum**
	X	-0.0104	0.1034	-0.1409	0.0563	-0.1409
	Y	-0.1253	-0.0115	-0.2558	-0.0586	-0.2558
	Z	0.1325	0.2463	**0.002**	0.1992	**0.002**
	T	-0.0468	0.067	-0.1773	0.0199	-0.1773
	Maximum	0.1325	0.2463	**0.002**	0.1992	

According to this result, Z strategy of first player (direct instruction method) is more profitable than each strategy of other player. According to the information obtained from the target group, it can be said that the direct instruction method is better in terms of its usage than the problem solving method, as Z strategy is determined as the usage properties of the teaching method.

According to the payoff matrix, good strategies for direct instruction method are X, Z and T strategies. The best strategy among these is the Z strategy because this strategy will always win the direct instruction method and earn the most with 0.2463. Since Y strategy will always lose the player direct instruction method, the direct instruction method does not use this strategy at all.

The problem solving method player can use the whole of X, Y, Z and T strategies. When the values of these strategies are examined, X strategy will lose at most 0.1325, Y strategy at most 0.2463, Z strategy at most 0.002 and Z strategy at most 0.1992. Z strategy will be the least-lost among these strategies.

In case of applying Z strategy for the direct instruction method against the problem solving method, the gain of the direct instruction method will be 0.002. Since this value is the maximum gain that the direct instruction method can attain and the least amount that the problem solving method lose, the game reaches equilibrium point or saddle point. (It is achieved through the application of strategies (Z, Z)). The value determined by the saddle point is 0.002 and this value is the value of the game.

3.1.2.3 Establishment of Non-Zero-Sum Game Matrix

The second strategic game problem that is established in the study is related to the criteria teachers' choice about teaching method. In the questionnaire, the criteria that the teachers took into consideration when choosing the teaching method are investigated with the eighth question of the questionnaire and it is researched whether the players meet these criteria or not. The scores are arranged according to the answers given and the results are given in Table 6.

Table 6. *Scores obtained from the criteria that teachers take into consideration when choosing teaching method*

Strategies	Scores	Percentage Scores
X	498	0.2514
Y	283	0.1429
Z	771	0.3892
T	429	0.2165
Total	1981	1.0000

The priorities of the method preference of teachers using problem solving method and direct instruction method are compared according to the determined strategies. The high scores given by the teachers on the priorities of their method preferences indicate that the players (teaching methods) can respond to the expectations of the teachers. The following table is created for this comparison.

Table 7. *Comparison of Teacher Priorities*

Strategies	Problem Solving Method		Direct Instruction Method		Priorities	
	Scores	Percentage Scores	Scores	Percentage Scores	Scores	Percentage Scores
X	180	0.2521	173	0.2625	498	0.2514
Y	98	0.1372	98	0.1487	283	0.1429
Z	282	0.3950	259	0.3930	771	0.3892
T	154	0.2157	129	0.1958	429	0.2165
Total	714	1.0000	659	1.0000	1981	1.0000

A non-zero-sum game matrix is constructed to investigate the proximity of two players to the predictions measured by Question 8 of the questionnaire. In this game problem, the first player is also determined as the direct instruction method. In order to construct a non-zero-sum game matrix, the differences of the scores of the teachers using the problem solving method and the direct instruction method according to the priorities of the teachers are examined. According to the determined strategies, the distance of the direct instruction method player to the priorities of the determined method is determined and these values are given in Table 8. Teachers who use direct instruction method have higher points in Z strategy in terms of all four strategies with respect to priorities determined for teaching method.

On the other hand, the distances of problem solving method to the priorities of the determined method are specified and these values are presented in Table 9. According to this table, scores given to Strategy Y for the problem solving method are also lower in terms of all four strategies in respect of the priorities for the teaching method.

Table 8. *Matrix showing the distance of the direct instruction method player to the specified priorities*

	X	Y	Z	T
X	0.0111	0.1196	-0.1267	0.0460
Y	-0.1027	0.0058	-0.2405	-0.0678
Z	0.1416	0.2501	0.0038	0.1765
T	-0.0556	0.0529	-0.1934	-0.0207

Table 9. *Matrix showing the distance of the problem solving method player to the specified priorities*

	X	Y	Z	T
X	0.0007	0.1092	-0.1371	0.0356
Y	-0.1142	-0.0057	-0.2520	-0.0793
Z	0.1436	0.2521	0.0058	0.1785
T	-0.0357	0.0728	-0.1735	0.0292

Table 8 and Table 9 show how close each player is to the priorities of the methods determined by the scores of each strategy. Small differences in these matrices indicate that the players are close to the priorities of the desired method, while large differences indicate that they are far away. Negative differences indicate that the relevant strategy is below the state of the desired method properties. For example, teachers using direct instruction method have 0.3930 points for Z strategy, while explaining expectation about method they points importance of Z strategy to 0.3892 (see Table 7). The positive difference here indicates that the direct instruction method is above expectations in terms of the relevant strategy. The values in Table 8 and Table 9 are multiplied by 100 and values greater than zero can be thought of as the relative gains of the players and negative values as the relative loss of the player. According to the obtained information, the non-zero-sum game matrix is obtained as in Table 10.

Table 10. *Non-Zero-Sum Game Matrix*

Direct Instruction Method (First player)		The Problem Solving Method (Second Player)			
		X	**Y**	**Z**	**T**
	X	(1.11; 0.07)	(11.96; 10.92)	(-12.67; -13.71)	(4.60; 3.56)
	Y	(-10.27; -11.42)	(0.58; -0.57)	(-24.05; -25.20)	(-6.78; -7.93)
	Z	(14.16; 14.36)	(25.01; 25.21)	(0.38; 0.58)	(17.65; 17.85)
	T	(-5.56; -3.57)	(5.29; 7.28)	(-19.34; -17.35)	(-2.07; 2.92)

3.1.2.4 Solution of Non-Zero-Sum Game Matrix

The dominant strategies are sought to determine the equilibrium point of the payoff matrix in Table 10 while solving the non-zero-sum game matrix generated by the teachers' views. For the direct instruction method game player, Z strategy is the best strategy for all strategies of the problem solving method. Y strategy is the dominant strategy for the problem solving method. Thus, the dominant strategy in game is (25.01, 25.21) at (Z, Y). This dominant strategy balance is the Nash equilibrium of the game at the same time. This situation can be seen as in Table 11. This strategy is both acceptable and profitable for both players.

Table 11. *Nash equilibrium*

Direct Instruction Method (First player)		The Problem Solving Method (Second Player)			
		X	**Y**	**Z**	**T**
	X	(1.11; 0.07)	(11.96; 10.92)	(-12.67; -13.71)	(4.60; 3.56)
	Y	(-10.27; -11.42)	(0.58; -0.57)	(-24.05; -25.20)	(-6.78; -7.93)
	Z	(14.16; 14.36)	**(25.01; 25.21)**	(0.38; 0.58)	(17.65; 17.85)
	T	(-5.56; -3.57)	(5.29; 7.28)	(-19.34; -17.35)	(-2.07; 2.92)

4. Discussion and Conclusion

One of the methods used by mutual decision-makers to make optimal decisions in their situations is game theory (Doğan et al., 2015). In this study, the two most used teaching methods of teachers are determined through a questionnaire and considered as two players. In addition, by the views of teachers the prominent features of these teaching methods have been discussed from the point of view of game theory. The prepared questionnaire is sent to the teachers via internet. The obtained data are used to construct the game matrices. Two separate games are established within the scope of the study. The two most preferred teaching methods are considered as two players. For this purpose, the criteria that the teachers can take into consideration in the teaching method preferences are determined and these strategies are grouped according to the related fields based on the information in the literature (e.g., Tan et al., 2002; Küçükahmet, 2004; Tok, 2007; Görücü, 2015).

In the study, two different game problems are formed and solved, one of which is zero-sum and the other is non-zero-sum. While zero-sum game's payoff matrix and its solution are presented, non-zero-sum game matrix is created and dominant strategy is determined. In the direction of the results obtained, which factors are important in the choice of teaching methods have been discussed from the perspective of game theory.

According to the zero-sum game analysis where the features of the direct instruction method are compared with the features of the problem solving method; the best strategy of the first player, the direct instruction method, is the Z strategy, which is specified as features related to usage of methods. Therefore, it can be said that direct instruction method's features in terms of usage is better than problem solving method. In other words, the method of direct instruction is more straightforward than the method of problem solving in terms of ease of use, time, cost, physical facilities, and number of students. This result completely corresponds to the information on the advantages of the direct instruction method in the literature (Savaş, 2007; Sönmez, 2008, Arıcı, 2006) and the disadvantages of the problem solving method (Çoban, 2012).

According to the zero-sum game matrix obtained in this study, the best strategies of the direct instruction method are X, Z and T strategies. When the values of these strategies are examined, it is

seen that Z strategy is the best strategy (because the maximum gain value is 0.2463). According to these results, the direct instruction method is more superior to the problem solving method in terms of the students' characteristics (X strategy) (the readiness of students, the willingness of student, and the developmental characteristics of students). According to the results of this study, although the method of lecture is superior to the problem solving method in terms of student characteristics, Küçükahmet (2004) states that teachers should choose the most appropriate method-technique by taking into account the student characteristics. While some methods are better for students than some students are; for example, lecture (direct instruction) method is reasonably effective for auditory learners (Tan & Erdoğan, 2005), problem solving method is better for collaborative learning environment for students like group activities (Gök, 2006). Similarly, in terms of external factors (school administration, parents, classroom environment), direct instruction method is better than the problem solving method. This result is obtained with the information acquired from the teachers who participated in this study. Teachers state that the method of lecture is superior in terms of external factors. We can interpret this result as follows: The most common teaching method used by the teachers and the people in the teaching environment in general is direct instruction method. The problem solving method can be thought as not very advantageous by external people (school administration, parents) in terms of some features such as time consuming, expensive, requiring different materials (Çoban, 2012).

In this study, direct instruction method is determined as the first player and the game problem is created according to it. Therefore, all positive values in the game matrix are gain for the method of lecture and negative values are lost for the problem solving method. When the solution matrix of the zero-sum game is examined, all values in the Y column are negative for the direct instruction method. In other words, the method of lecture does not use the Y strategy, because this strategy will always lose the player. This result shows that the Y strategy of the teaching method (in terms of teacher) is less profitable than all strategies of problem solving method. That is, the method of direct instruction is weaker compared to the problem solving method in terms of the teacher's skill in the method and the methods used by other teachers.

The problem solving method can use the whole of X, Y, Z and T strategies. When the values of these strategies are examined; X strategy will be at most 0.1325, Y strategy at most 0.2463, Z strategy at most 0.002 and Z strategy at most 0.1992. Among these strategies, there is at least a loss in Z strategy. In any case, this strategy is the most profitable method of direct instruction, the least loss strategy of the problem solving method. The game reaches the saddle at this value and the value of the game is fixed at 0.002. That is, the main result of the game problem created in this study is that the direct instruction method is better than the problem solving method in terms of its usage characteristics (ease of use, physical facilities, time, cost, and number of students). The superior aspects of the method of lecture to the problem-solving method in terms of the Z strategy have been discussed above.

In this study, it is possible to make comments about the weaknesses and strengths of the two teaching methods that are dominant by a different perspective. With the results of the research, the priorities of the teachers have been searched about which features of the preferred methods should be put forward in the instructional process to be planned for teaching that is more efficient. The usage characteristic of the lecture method, which is in line with the information in the literature, is important to be preferred by teachers (Savaş, 2007; Sönmez, 2008, Arıcı, 2006).

According to the non-zero-sum game matrix related to the priorities of these two methods, the game balance is determined as the cell (Z, Y). As a result of this game, it can be said that in parallel with the result of the previous problem, the use of the method of direct instruction meets the priorities of the teachers. On the other hand, the problem solving method has exceeded the expectation of the target group in terms of the teacher features determined as Y strategy. According to the game matrix obtained, it means that it is necessary to develop the Y strategy, that is to say the teachers' characteristics, for the direct instruction method. Similarly, it is important to improve the usage characteristics of the problem solving method in terms of preference, because, children are directed to think creatively in problem solving method (Kılıç & Samancı, 2005). Hiebert and Wearne (2003) state that problem solving approach develops deep and rich understandings of students in mathematics courses. Students are active in the problem solving method; it raises interest in learning (Gök, 2006). Therefore, as the problem solving method becomes widespread, the possibility of gaining the upper

level skills required for education will increase.

Surely, different teaching objectives require different teaching methods (Tok, 2007). For example, when teaching some mathematical concepts or geometric thinking skills, computer-supported teaching method has advantage in transferring some abstract knowledge (Hurme & Järvelä, 2005). It is commonly thought that direct instruction method is of low in efficiency when transferring such kinds of knowledge. But direct instruction method stimulates students' interest in learning when the auditory knowledge such as language learning (Arıcı, 2006). Tan and Erdogan (2015) states that direct instruction method is effective for auditory learners.

There is no one best teaching method (Jia at al., 2017). The present research indicates that relying on direct instruction method or problem solving method does not by itself guarantee enhanced students' academic success or other skills. For example, problem solving method may be questioned because it is time-consuming and not efficient in large groups (Çoban, 2012). These reasons make implementation in the classroom difficult. Perhaps in the future teachers can master in the teaching ideas of direct instruction and problem solving methods to make them more efficient. It should be possible to create an optimal mixture of the direct instruction and problem solving methods for the classroom. Future research should be conducted to improve all the methods/techniques including the direct instruction and problem solving methods and to use them more effectively.

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Appendix 1. Questionnaire

This research has been conducted in order to determine the priorities of the teachers in teaching method selection by Yildiz Technical University. Your sincere answers in this regard are important for our investigation. Thank you in advance for your contributions.

First part

1. What is your gender?
Female ☐ Male ☐
2. What is your branch of teaching?
…….. teacher
3. How many years have you been teaching?
……..year/years
4. What is the department/faculty you graduate from?
……..
5. Do you have pedagogical formation?
……
6. Which teaching method do you prefer most in your courses? (Direct instruction, discussion, problem solving, cooperative learning, demonstration, case study, other)
……

Second part

7. Please evaluate the following criteria for the teaching method you use most in your lessons.

Criteria	Not important	Somewhat important	Important	Very important
Readiness of students				
The willingness of students				
Number of students				
Teacher's skill in method				
The methods used by other teachers				
Ease of use				
The properties of the subject				
Time				
Financial possibility				
Goals to reach				
Physical facilities				
School administration				
Parents				

8. Please evaluate the following criteria according to your preference in your choice of teaching method in general.

Criteria	Not important	Somewhat important	Important	Very important
Readiness of students				
The willingness of students				
Number of students				
Teacher's skill in method				
The methods used by other teachers				
Ease of use				
The properties of the subject				
Time				
Financial possibility				
Goals to reach				
Physical facilities				
School administration				
Parents				

Appendix 2. Calculation of total scores of strategies

Problem solving method				Direct instruction method			
X1	X2	X3	Sum of X	X1	X2	X3	Sum of X
4	4	4	12	3	3	3	9
3	2	2	7	4	4	3	11
3	3	4	10	3	4	4	11
3	3	3	9	4	3	3	10
3	4	4	11	4	4	3	11
3	4	3	10	4	4	4	12
3	3	3	9	4	4	3	11
3	5	4	12	4	3	3	10
4	5	3	12	4	2	4	10
4	3	3	10	4	3	3	10
3	3	4	10	3	4	3	10
4	4	4	12	4	4	4	12
4	3	5	12	4	3	5	12
4	4	4	12	4	4	4	12
4	3	3	10	4	3	3	10
4	3	4	11	3	5	4	12

3	4	4	11				
Total Score			180	Total Score			173

Problem solving method			Direct instruction method		
Y1	Y2	Sum of Y	Y1	Y2	Sum of Y
4	3	7	2	4	6
2	1	3	2	4	6
2	2	4	3	4	7
5	3	8	5	3	8
3	5	8	2	2	4
3	3	6	3	4	7
4	2	6	3	5	8
2	4	6	2	2	4
1	2	3	2	4	6
3	2	5	2	4	6
4	2	6	2	3	5
3	3	6	2	4	6
3	3	6	4	3	7
3	2	5	3	3	6
4	2	6	3	3	6
3	2	5	4	2	6
5	3	8			
Total Score		98	Total Score		98

Problem solving method				Direct instruction method			
T1	T2	T3	Sum of T	T1	T2	T3	Sum of T
3	3	3	9	1	1	1	3
3	3	2	8	2	2	1	5
3	2	3	8	3	2	2	7
4	4	4	12	2	3	3	8
4	3	3	10	2	2	4	8
3	3	3	9	3	3	3	9
3	3	3	9	3	3	3	9
3	3	3	9	2	2	4	8
1	1	1	3	2	2	3	7
4	2	2	8	2	2	3	7
3	3	2	8	2	2	5	9
2	4	4	10	3	3	4	11
3	3	3	12	3	3	4	11
3	3	2	8	4	2	4	10
2	3	3	8	3	3	2	8
3	4	4	11	3	3	3	9
4	4	4	12				
Total Score			154	Total Score			129

Problem solving method						Direct instruction method					
Z1	Z2	Z3	Z4	Z5	Sum of Z	Z1	Z2	Z3	Z4	Z5	Sum of Z
4	4	3	3	3	17	2	2	2	3	3	12
4	3	3	3	3	16	4	3	3	3	3	16
3	3	2	2	3	13	4	3	4	3	3	17
4	4	3	4	4	19	3	3	3	3	3	15
3	2	3	3	4	15	3	3	2	2	4	14
4	4	4	3	3	18	3	5	3	3	3	17
3	3	3	3	3	15	4	4	3	3	3	17
4	4	4	3	3	18	3	2	2	2	4	13
5	4	4	4	1	18	3	3	4	4	3	17
4	4	4	4	4	20	3	3	4	4	4	18

2	2	2	3	3	12	3	4	4	4	3	18
3	4	3	3	2	15	3	4	4	4	3	18
4	5	3	3	3	18	4	4	4	4	3	19
4	5	3	2	3	17	3	3	3	3	3	15
3	5	4	2	2	16	3	3	3	3	4	16
4	4	2	2	4	16	4	4	3	3	3	17
6	3	3	3	4	19						