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Strategies of Nonsolidary Behavior in Teaching Organization

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Abstract—A system of interpersonal relationship and its modeling in the form of finite noncooperative game is studied in this article by means of payoff functions. In such games for the main principle of optimality Nash's Equilibrium Situation is acknowledged. The stages of development of Game Theory are analyzed including the modern situation. Two groups – nonsolidary and solidary of different behaviors characterized for the relationship are defined. The strategies of nonsolidary behavior characterized for the strategic relationships of the players are described and the strategies of solidary behavior are connected with negotiations and agreements. Teaching organization is defined as a management of S system comprising a P teacher (professor) and $K = \{1,2,\ldots,n\}$ collective of pupils (students). Each participant of S system has its own interest and difference from each other. This situation gives us a ground to consider some aspects of Game Theory model for optimal management of S

Index Terms—Teaching organization, Noncooperative game, Nash equilibrium, Nonsolidary behavior.

I. Introduction

In practice, any action of a man always concerns the interest of other man or men that assists or hinders them to achieve the goal.Using it a complex chain of interpersonal relations is created. In such case people while planning the response actions evaluate the possible results of different versions of actions of other individuals.

Under the words "Interpersonal relations" or "Interrelation" psychologists mean the integrity of interactions which is originated between separate people, frequently they are accompanied by emotional feelings and they transmit us in definite form of the state of inner world of a man. Emotional feelings have positive and negative character, i.e., in the process of interpersonal relation appear some sympathy or antipathy towards the partner, also a satisfaction with him or the obtained results by simultaneous activity. The Interrelations in reality are striving to trust which in itself comprises the support expectation and belief that the partner does not betray and use the situation to the detriment.

Business and personal relations are distinguished. Business relation is originated during the fulfillment of official duties. In case of business relation we have: the equality relation and submission relation. In case of equality relation two or several members of group fulfill the similar functions, have the similar rights and obligations (e.g., students in a teaching group). In case of submission relation one person occupies a position to realize the control over the fulfillment of the obligation (let's say a teacher). Personal relations are expressed in friendship, partnership, comradeship, etc.

Realization of progressive technologies of education is connected with comprehension and perception in new way of ideas, tasks, and validities of simultaneous actions in intra-situational relationships of a teacher and students. The goal of intra-situational relationship is providing with students' interests and quickness of its achieving depends on interaction of all parties (sides) of teaching situation.

In psychological diagnostics of interpersonal relations a scheme has been developed that gives a possibility to be registered by the integral plan the diverse actions of interactions (interactions) in the group [1]. In psychological diagnostics of interrelation it is very important to carry out an observation by imitation of a game on the definite living situation. Observation of a human action in situational test of a game allows us to make a good diagnosis by means of which we are able to see in advance its development in a real living situation. It is very important to distinguish individual personal features of the participants of relations which are originated and influence on the process of interrelation.

The real system of interrelations is so complex that it can't have a visual precise mathematical interpretation. Modeling of interrelation is a mean for its representation in simplified form. One of them is Game Theory model its formal-mathematical analysis helps us to make an analysis of interpersonal relations.

Individuals and groups (parties) participating in interrelations are called the players. The concept of the player helps us to create a model of a social role of an individual: a husband, wife, teacher, pupil, seller, buyer, etc. Thus, a game is a simplified mathematical model of interrelations of several players. It is used in living situations, particular, in teaching organization.

We used it in the situations of a teaching organization in the article [2]. At present we will define some problems and consequences according to a system of interpersonal relationship.

The rest of the paper includes these contents: in the second part Game Theory and its meaning for organizing interrelations is described. Noncooperative (strategic) game is defined with Nash equilibrium. In the third part diverse behavior solidary and nonsolidary characteristic for interperconal relations are defined. The fourth part is dedicated to apply noncooperative game model for teaching organization and nonsolidary behaviors characteristic for its optimal functioning. Corresponding problems are given.

II. Model of Noncooperative Game

Game Theory more completely –Mathematical Game Theory is a field of a modern mathematics. It is a theory of mathematical models and methods that studies the problems of receiving the optimal (rational) decisions in conditions of a conflict, diversity of ideas [3,4,5,6]. Exclusiveness (Uniqueness) of these conditions are defined by their practical need in life and development of society, as well, by the complexity that we encounter during making decisions. The designation of Game Theory is to carry out the recommendations for rational action in definite conditions. This field occupies a specific place among other fields of mathematics. Its main task is to look for the ways of choosing the clever actions of people and collectives having the discerning interests to the social phenomena. Moreover, such actions reveal in all forms the content of people's all social being and thus Game Theory has a multilateral usage in all spheres of life.

Game Theory studies from the very beginning the explanation of the Parties' behavior and prognostication (forecasting) in conflicting and economical situations [3]. The area of its usage has been widened and it is possible to use it for a very broad analysis of social-economical, politics, national security, law, psychology, philosophy, ecology and technological processes, in the spheres of management of informational technologies organizational systems [7,8,9,10,11,12].

Thus, Game Theory studies the situations of interrelations where the process of participating people and collectives is guided by noncoincident (sometimes mutually conflicting) motive. All of them are called the players. Conflict in Game Theory means all kinds of disagreement to any phenomenon related to people, their groups and parties, to any phenomenon, situation or a subject, with different opinions. And a conflicting situation means all situations – phenomenon the parties participating where they strive to the definite aim and have a possibility to make several choice. Game Theory undermines that the subject while receiving a decision should envisage the possible solutions of other subjects the result depends on choice of other participants. That is why in Game Theory all players are rational and at the same time are clever in the sense that they can find optimal decisions both for his and other participants.

At present, Game Theory is the main standard instrument of economical and political theories that helps us to analyze the complex economical and political phenomena in all fields of economics and politics. Thus, on one hand, Game Theory is a mathematical field that is used nearly in all spheres of people's activities. On the other hand it is a unity of mathematical instruments needed for constructing models of economical theory and at the same time it is considered as a part of "Mathematical economics".

Among the various methods of solution of conflicts the exclusiveness of the methods of Game Theory is that for ensuring the own aims it is the only one that envisages the analysis and assessments of alternative strategies of behavior of all parties participating in a conflict situation. This significantly improves the adequacy and reliability of the results. Besides, there are analysis and assessments not only alternative strategies of behavior of the parties participating in conflict but as well by using of these strategies analysis and assessments of created situations by using of these strategies are made. This gives as a possibility to form the development of possible versions of scenario of conflicts and crises and define a probabilistic scenario. Thus, Game theory as a scientific field and at the same time a unit of many scientific directions (Game Theory) is a mathematical theory of interrelations – studies interactions between people and parties who are guided by the noncoincident motives (sometimes contradictory) [6].

Let's define a model of a noncooperative (strategic) game of n player. Let's assume that $N=\{1,2,\ldots,n\}$ is the multitude of players. Let's indicate the finite sets of strategies of each $i \in N(i=1,\ldots,n)$ player correspondingly by $X_1,\ldots,X_n$. By choosing the $x_i \in X_i$ strategy by the $i \in N(i=1,\ldots,n)$ player the following situation is received:

$$x=(x_1,\ldots,x_n)\in X=\prod_{i\in N} X_i \ . \qquad (1)$$

In the process of carrying out a decision a man enjoys his privileges i.e. chooses an action that in his opinion, gives him the most privileged (preferential) result. For the determination of the privileged result let's use an utility (the same payoff) function. The utility functions, the problems of their existence, finding and using are studied in Utility theory that is a constituting mathematical discipline of Game theory. The utility function will comply with each alternative (or situation) real number – with this alternative utility it performs a monotonic transformation of sorted multitude into set of real numbers.

Definition 1. The function of real-valued H_i defined sorted on X set situation is called an utility (payoff) function of $i \in N$ player if one of the following condition is fulfilled:

$$\begin{aligned} x \geq_i y \Leftrightarrow H_i(x) \geq H_i(y); \\ x \succ_i y \Leftrightarrow H_i(x) > H_i(y); \\ x \approx_i y \Leftrightarrow H_i(x) = H_i(y). \end{aligned} \quad (2)$$

With allowance of all above mentioned let's define a model

$$\Gamma =< N, \{X_i\}_{i\in N}, \{H_i\}_{i\in N} >, \quad (3)$$

that is called a noncooperative game of n player with a normal form (or with functions of payoff).

In case of two players, i.e. when in Γ game $n = 2$, it is given in the form of matrix. If a game is nonstandard than in all situations playoffs are given by means of pair numbers and it is called a bimatrix game. In case if a game is antagonistic then in each situation the payoff is given by one number – by the payoff of the first player.

By means of Game Theory the main exclusivity of modeling of strategic conflict is finding of J. Nash equilibrium (equilibrium, stable) situation on the basis of analysis of a model of a corresponding game. Consequently, in Γ game the main principle of optimality is Nash equilibrium situation. For its determination let's note

$$x_{-i} = (x_1,..., x_{i-1}, x_{i+1},..., x_n), \; x = (x_i, x_{-i}), \quad (4)$$

where $i \in N$, $x \in X$ and $x_i \in X_i$.

Definition 2. The situation $x^* \in X$ is called Nash equilibrium situation in Γ game if for $\forall i \in N$ and $\forall x_i \in X_i$ is fulfilled $H_i(x^*) \geq H_i(x_i, x^*_{-i})$. where $i \in N$, $x \in X$ and $x_i \in X_i$.

Nash equilibrium situation is the only steady and reliable situation for agreement on collective action. Such situation is characterized by the following feature: In situation given by any party by unilateral change of its strategy this state should not be improved. That means: none of the participant is able to increase its own payoff if other players acting rationally will correctly estimate their strategies. As a consequence of the principle of Nash equilibrium in noncooperative games the various equilibrium situations are available. This principle of optimality and Pareto optimality principle where the first is the strategic principle, and the second – is a compromised one, they are the main principles of optimality in all fields. Thus, Game Theory considers the independent mechanisms which lead us to "a good equilibrium" to solve the tasks of collective interrelations rationally. Realizing the corresponding actions the players receive finally the utilities (payoffs). The aim of the players is to choose the optimal strategies by which they receive an optimal utility.

As a consequence of above indicated we can say that Game Theory is a strict strategic thinking [13]. This is an art by which we are able to guess the next step of an opponent in the process of interrelation. The main part of this theory does not contradict to usual everyday wisdom and reasonable opinion. That is why by its study it is possible to form a new point of view about the world arranging and people's interrelations. It is deemed that knowing of this field will make the business more successful and suitable environment in life.

III. Nonsolidary and Solidary Behaviors

A man is characterized by changeability of its behavior which depends on his inner state, professionalism and life experience, surrounding social environment, etc. In Game theory these features are expressed by changing the player's strategies. With the aim that among the strategies of the player there were always the best objective then he would always use it as changing in this case would not have any sense. But in a specific situation of real life a man usually considers several strategies of behavior. It is impossible to distinguish the best one from them. Only the game model gives us a chance to investigate such uniqueness several strategies of behavior that expresses the different aspects of a man and they do not exclude each other.

We are able to unite the diverse behaviors characteristic for interpersonal relations in two groups – **nonsolidary and solidary.** Each group unites the strategies of diverse types. Nonsolidary behavior strategies are characterized by the individual choice independently the strategies of his behavior, at the same time he either envisages the behavior of other individual at all, or on the basis of the experience envisages the possible version of his behavior. Nonsolidary behavior unites the cautious, optimizing, deviating and innovative strategies. Let's characterize these for the case of two players.

A strategy of cautious behavior gives a guarantee to the player to receive a definite volume of payoff by choosing of other player independently. For instance, a maximini strategy which is calculated choosing of maximum from the several minimal meaning of the payoff. Each player may have several cautious strategies but to all there corresponds the only meaning of the maximin.

Optimizing strategy is the same equilibrium strategy which differs from the maximizing strategy so as the payoff from the possible payoffs corresponding to the equilibrium strategy is not maximal. It corresponds to the local and not to the global maximum. Similarly, in the process of using the equilibrium strategy by one player if the second player uses as well the equilibrium strategy he receives a local maximum of the payoff. In case if one player deviates from the equilibrium situation then by using an equilibrium strategy by the second player he can't have a maximizing effect.

Using an equilibrium strategy by a man in the role of basic norm of behavior in interpersonal relations is performed as a result of generalization of his experience which comprises as well using deviating behavior. The deviating behavior of the player means the decay from the equilibrium strategy if he is sure that the participant will use by all means of the indicated strategy. Comprehension by a man of the negative result of such behavior that is realized by choosing of nonequilibrium alternative is a clincher during choosing the optimizing behavior by him. The experience of deviation behavior gives a man a strong belief that the other participant of the game will use an equilibrium strategy by all means. Such experience serves at the same time to proving of rational behavior of other player and prophecy of the result of future interrelation with him.

Iinnovative strategy is a systematic deviation from one equilibrium situation for finding the other equilibrium that is more useful for a novator player. The aim of the innovative behavior in the game is not in strengthening the achieved equilibrium state but the attempt to pass onto the more privileged state. In the model of game of interpersonal relations the aim of innovative behavior can be achieved if in a matrix of payoff of the game there exists another equilibrium situation where the payoff of an innovator player will be more than in initial equilibrium situation. If such situation is not available in the game then the innovative behavior has no sense and the innovator player will return to the initial equilibrium strategy.

In real life the interactive individuals will frequently negotiate in future on using the definite strategies of behavior, that is an object of studying nonstrategic, cooperative Game Theory [14]. In such case the behavior of the players is called Solidary.

The strategies of solidary behavior are more characteristic for the "Institutional people" (for the person having a behavior established in the society). Individuals connect such strategies to the negotiations and agreements [15]. The corresponding situation can not be corresponding to the equilibrium strategies and cautious strategies. Solidary behavior has two main causes. 1 – More utility for all parties. In case of two players such situation is given in a matrix of payoff when in any situation the payoff of both players is maximal but does comply neither to equilibrium situation, nor to cautious strategies. Such situation is not chosen if there is not a solidary behavior between the players. In case if the players agree to choose it then the violation of the agreement between them will not be favorable for none of parties that is why it should be fulfilled. 2 – Ethical acceptability of solidary behavior. Following agreement in interpersonal relations is defined by the ethic acceptability of solidary behavior that frequently is the inner mechanism. Violation of the agreement can be followed by the moral losses for the individual on the basis of the public judgment and that is why this factor can be preferential than the increase of possible payoff. In the models of games of actual interpersonal relations it is not envisaged the ethical factor. In such models there is not envisaged the coercive keeping of the agreement.

IV. Teaching Organization

In teaching organization the learner model cannot be completely modeled based on one single method through the entire development process, but it needs a combination between several methods that will help for a complete modeling [16]. The purpose of the present research is to designate the effects of Scratch-based game activities on students' attitudes towards learning computer programming, self-efficacy beliefs and levels of academic achievement [17]. Using role situations in the teaching process improves the studying process better and it makes classes dynamic and interesting [18]. Nowadays teaching-learning games and digital interactive activities are very important in order to understand the benefits and difficulties for their use [19].

Under teaching organization we mean the management of organizational S system comprising of P teacher (professor) and of $K = \{1,2,\ldots,n\}$ collective of pupils (students). Each participant of S system has its own and different interest. This circumstance gives us a ground for optimal management of S to consider some aspects of a model of game theory. The individuals (players, parties) participating in this system can choose one or several actions – strategy. Having fulfilled the corresponding actions finally they get utilities (payoffs). The aim of the players is to choose the optimal strategies where they get a maximal utility.

Let us construct a game model of noncooperative game corresponding to the given system has been built for optimal functioning where nonsolidary behavior is characterised in conditions of availability of Nash's equilibrium. For visualization a noncooperative game has been considered and solved between a teacher and a student.

Let the number of P teacher, as a player is 0. Thus S system is functioning by $n+1$ player and let this set is: $N = P \bigcup K = \{0,1,2,\ldots,n\}$. Let's indicate the finite sets of strategies of each $i \in N$ player of N set by $X_0, X_1,\ldots, X_n$. By choosing of strategy $x_i \in X_i$ by each $i \in N$ player we get the following situation

$$x = (x_0, x_1,\ldots, x_n) \in X = \prod_{i \in N} X_i. \qquad (5)$$

On X set of situations each $i \in N$ player has a function of utility (payoff) H_i. Let's define a model

$$\Gamma(H) = < N, \{X_i\}_{i \in N}, \{H_i\}_{i \in N} > \qquad (6)$$

of noncooperative game corresponding to the given game in normal form. As we've already indicated the main principle of optimality in it is Nash equilibrium situation (or Nash equilibrium) x^*, the unilateral decaying is not favorable for none of the players.

What kind can be the possible behavior of the players in $\Gamma(H)$ game? Let's consider the specific tasks and show that for optimal functioning of $\Gamma(H)$ model corresponding to S system it is characteristic the nonsolidary behaviors.

Problem 1 ("Checking knowledge weekly"). Let's consider a situation when a teacher of higher school has to carry out the students' attestation systematically, weekly. Simultaneously, he can check up the student's knowledge but it is possible not to do this and put him (her) an average rate automatically. A student, in his turn can be prepared or not for the attestation.

If a student is prepared and a teacher checks him then the student will receive a maximal utility 10 which is conditioned by higher formal assessment, by moral satisfaction and promotion him by the teacher. In such case a teacher also gets a maximal utility 2 which is conditioned by dully prepared work by the student, by attitude of the student towards the subject and the respect to the teacher. If a student is not prepared, and a teacher checks him than the student gets the minimal utility (-5) (the lowest assessment, the inner dissatisfaction, rebuking from the teacher and the group). The teacher receives similarly the minimal utility (-2) (it expresses the disrespect towards the subject and the teacher).

If a student has been prepared and a teacher has not checked him than the student experiences definite kind of disappointment that we assess by (-2) and the teacher doesn't experience neither the positive, nor the negative emotion so as in this case he has no relation with the students. That is why his utility is 0. Let's say that the student is not prepared and the teacher does not check him but he assess his knowledge by average rate. Then the student feels satisfaction because he was able to receive a positive assessment without any efforts and labor. Let's asses his joy by 5. The utility of the teacher analogous of the previous case will be 0.

Model compiling and its analysis. We have a model of a nonantagonisic game that is given by bimatrix game where the 1st player is a student and the 2nd is a teacher:

$$(H_1, H_2) = \begin{pmatrix} (10,2)^* & (-2,0) \\ (-5,-2) & (5,0)^* \end{pmatrix}. \qquad (7)$$

There is a set of strategies of the 1st player-student {the 1st – is prepared, the 2nd – is not prepared} and there is a set of strategies of the teacher {he has checked the 1st, he has not checked the 2nd}.

Let's consider only nonsolidary strategies of the players so as in this situation it is impossible to have solidary strategies. In the first turn we notice that we have not dominated or the irrational strategies in games; the second – is a cautious i.e. a maximal strategy 1 – to be prepared so as it'll defend him from the stress. For a teacher the cautious strategy is 2 – not to check up that defends him from the negative emotions caused by the unprepared student; The third – in game we have 2 equilibrium situations in pure strategies – (1,1) and (2,2). In the first situation the decay effect for the student is quite important and it equals to $10-(-5)=15$, and for the teacher - $0-(-2)=2$; (2,2) equilibrium describes a situation of imitation of study when a student systematically is not prepared and the teacher does not check up the knowledge of the student. In this case the deviation effect of the student is $5-(-2)=7$, and for the teacher it equals to $0-(-2)=2$; The fourth – the innovative behavior of the student and the teacher has a sense in equilibrium situation (2,2). This indicates to (1,1) the necessity of passing onto the equilibrium situation that is preferential for both of them. In the given case the innovative strategies have nonantagonistic character. That is why the student is switched over the honest behavior as a result of this the teacher is sure that a student is prepared and can start to check up his knowledge. An innovative behavior of a teacher lies in systematic checking up (revision) the student's knowledge that arises the student's a wish of honest behavior. Both players are given a priority to an intense work.

If we solve game (5) by a graphical method as in [2], we have as well one equilibrium situation in mixed strategies $\left(\frac{2}{9}, \frac{7}{17}\right)$ with the utilities of players $\left(\frac{141}{51}, -\frac{71}{153}\right)$.

It is clear that the situation (1,1) is predominant then this situation and consequently an active behavior is acceptable for both players.

Let us discuss from [2] the problem 1 in the case of nonsolidary behaviors' strategies.

Problem 2 ("Student's examination model"). Let's assume that a student (the 1st player) is preparing for the exam with the aim to get the desired assessment. An examination is received by a teacher (the 2nd player). Let's deem that a student has two strategies: 1 – to be prepared dully, 2 – not to be prepared. A teacher has two strategies as well: 1 – to put a positive assessment to the student, 2 – not to give him a positive assessment. What are their optimal decisions?

Model compiling and its analysis. Let's compile a model of the game. We have 4 situations: (1,1), (1,2), (2,1), (2,2). Let's assess them. The situation (1,1) indicates that a student has been prepared dully and the teacher has put him the corresponding mark. In this case let's evaluate the utility of the student and the teacher relatively by 10 and 2 (assessment scores). Thus in situation (1,1) their utility is a pair $(10,2)$. It is clear that the situation (1,2) (a student was prepared, and the teacher did not put him an assessment) is forbidding for the student that expresses by utility (-2) and the utility of the teacher since he has revealed the unjust and it influences negatively on his authority let's evaluate by (-2). We have got that in situation (1,2) the payoffs of the players are given by the pair of numbers $(-2,-2)$. In situation (2,1) (a student has not been prepared, and the teacher either deceived himself or because of some other reason put him a mark) the utility of the student is positive, let's admit that it is 5, and the utility of the teacher, in comparison to previous case, is rather (more) negative for his authority that we assess at (-3). In situation (2,2) – a student is not prepared and the teacher assessed him relatively – neither of them loses nor wins, let his utility is 0. And the teacher by a repeatedly coming to the student should try to work additionally that makes his utility negative and let's assess it by (-1). Thus we have a bimatrix game:

$$(H_1, H_2) = \begin{pmatrix} (10,2)^* & (-2,-2) \\ (5,-3) & (0,-1)^* \end{pmatrix}. \qquad (8)$$

In the given game we have two equilibrium situations in pure strategies (1,1) and (2,2), correspondingly to the utilities $(10,2)$, $(0,-1)$ and the following situations: A student prepares a subject and a teacher puts the desired assessment; A student does not prepare a subject and the teacher denies him to put the desired assessment.

Similarly as in previous task here, too, an innovative behavior of a student and a teacher makes a sense in an equilibrium situation (2,2) that indicates to the fact that for both players it is better to choose the first strategy – a student should be prepared dully and a teacher will assess his knowledge rightly. Only in this case a maximal importance of utility is obtained both by a student and a teacher. Let's note that in indicated model the role of the 1st player we can imagine the whole group as one player.

In the given game similarly to the previous one there is an equilibrium situation in mixed strategies $\left(\frac{1}{3}, \frac{2}{7}\right)$ with utilities of players $\left(\frac{10}{7}, -\frac{58}{21}\right)$.

It is clear that the situation (1,1) is predominant and consequently for both players an active behavior is acceptable.

Note. For teaching organization noncooperative game model for examining the members of $K = \{1,2,\ldots,n\}$ students can be used, in case of two pure strategies with some examining criteria [20]. Unfortunately in this model Nash Equilibrium may not be existed.

V. Conclusion

Teaching organization of a specific subject has been represented by the form of noncooperative (strategic) game that is fulfilled by means of relationship. In this relationship the parties (players) participating in the game use the strategies of nonsolidary behavior independently from each other with desire to receive a maximal utility. The players are oriented on the main principle of optimality of noncooperative games– Nash's equilibrium. The important component of teaching organization has been considered – an organizational problem of checking up the student's knowledge showing that by using of a model of real game both a student and a teacher are interested under the motif to increase the utility for both parties objectively. It arises a desire for honest behavior for students that means studying and a teacher will check up students' knowledge systematically and objectively. Without the main principle of optimality for solving the organizational problem of examining students' knowledge maybe it will be one of the most supporting strategy for decreasing high school authority.

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