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Efficiency of Collaborative Computer Problem Solving by the Students of the Young Adolescence: The Contribution of Social and Emotional Intelligence

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The present study is focused on the measurement of the game efficiency by the younger adolescences in the individual and collaborative game problem solving conditions. The previously elaborated computer game system "PL-modified" was used. Social and emotional intelligence as well as gender factor were additionally controlled. 189 middle-school students from the 5—6th grades participated in this study. The results showed that game efficiency was higher in collaborative problem solving conditions (in comparison with the individual game) no matter which additional factor was controlled. Furthermore, the whole sample was divided in two groups by the criterion of the level of social intelligence of those participants who played in each pair. Thus, the group 1 included players with the equal level of social intelligence whereas the group 2 was presented by the gamers with the different levels of social intelligence. The pairs form the group 1 outperformed those participants from the group 2 in their game efficiency. Another independent result concerns significant impact of social intelligence on the game performance in the pairs of boys. Emotional intelligence demonstrated only one significant positive correlation with the one parameter of game efficiency in the individual conditions. The present results are discussed in terms of the prospects of the usage of 'PL-modified' computer game system in the psychological studies conducted on the sample of young adolescents and taking their cognitive abilities into account.

Keywords: efficiency of game problem solving; computer game system "PL-modified"; social intelligence; emotional intelligence; mental actions of analysis and planning; collaborative problem solving.

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Успешность совместного решения игровых компьютерных задач учащимися младшего подросткового возраста: вклад социального и эмоционального интеллекта

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Исследование направлено на оценку успешности решения игровой компьютерной задачи на примере разработанной компьютерной системы «PL-modified» учащимися младшего подросткового возраста в условиях их индивидуальной и совместной (в паре с партнером) работы. Отдельно оценивались и контролировались такие переменные, как: индивидуальные различия в уровне социального и эмоционального интеллекта, гендерный фактор. Для реализации поставленной задачи было проведено исследование на выборке учеников 5—6-х классов (189 человек). Игровая результативность оказалась выше в условиях совместного решения задач независимо от других контролируемых факторов. Кроме того, выборка учащихся была разделена на две группы с учетом уровня социального интеллекта, который демонстрировали играющие в парах партнеры. Так, группу 1 составили испытуемые с одинаковым уровнем интеллекта, а группу 2 — с разным уровнем социального интеллекта. Результаты сравнительного анализа показали, что игровая результативность в парах выше, когда когнитивные возможности игроков равны. Отдельным результатом можно считать вклад социального интеллекта в показатели игровой результативности в парах у мальчиков. В свою очередь, данные эмоционального интеллекта показали положительную связь с одним по-

казателем игровой результативности только в индивидуальных условиях игры. Представленные результаты обсуждаются с позиции дальнейших перспектив использования компьютерной системы «PL-modified» в психологических исследованиях, а также с точки зрения роли изначальных когнитивных возможностей самих игроков.

Ключевые слова: успешность решения игровых задач; компьютерная игровая система «PL-modified»; социальный интеллект; эмоциональный интеллект; абстрактный интеллект; умственные действия анализа и планирования; рефлексия; совместное решение задач.

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Introduction to the scientific problem

In recent years, the enthusiasm of teenagers and youth to play video games increase. According to Russian Public Opinion Research Center , the number young people 18-24 years old playing video games, increased from 40% in 2019 [3] to 56% in 2022, with 20% of them playing daily. Most often used for games mobile phone and landline available computer [9]. Even more common passion for video games among children and teenagers sprouts. Thus, according to JSC Laboratories Kaspersky", 83% of Russian children are old over 7 years old play video games [4]. Similar data are also provided by foreign studies — 81% of adolescents and young adults young people from 10 to 24 years old play video games, and friendships are formed and maintained have been online since school age [15]. As the researchers note, under conditions global digitalization children's game also inevitably undergoes a digital transformation and becomes specific type of age-related play activity, in which largely occurs socialization of modern children [2; 6; 7]. In this regard, psychologists are interested in possibilities of video games for the development of social skills, especially among teenagers, who often experience difficulties in communication with peers. The first similar studies were conducted on samples children with autism and showed good performance results. In 2006 it was presented at digital board game SIDES, developed by aimed at helping teenagers with the syndrome Aspergers acquire skills to effectively group work. Six-month results activities have demonstrated that co-seating board computer games are motivating and supportive tool to facilitate effective active group work among the target audience [17]. Subsequently it was carried out many similar studies that showed that the use of information but-communication technologies in therapy opens up new prospects for treatment many areas in people with disorders autism spectrum. K. Grossard with colleagues provide data on 31 "serious game", 16 of which are aimed at recognizing formation or production of emotions, and 15 — on social skills [13].

Despite the fact that such games looked promising for developing many different skills, they have some restrictions: most of them designed for high-functioning of people; their clinical validation is rare meets evidentiary standards medicine; game design is usually not descriptive varies; in many cases clinical validation and playability/game design incompatible. According to the authors, about future research plans should be more reliable from a methodological point of view, including including stability assessment social and emotional changes skills [13]. It is also necessary to take into account the possible negative influence of certain elements video games — for example, with the help of a specially developed video game based on Minecraft it was shown that modeled in game situation social competition, increasing cognitive load, has a negative effect — reduces concentration, learning efficiency and situational interest. The authors note that although competition is one of basic elements of video games, you need. It is possible to strike a delicate balance between increasing the mental load on players and motivational benefits in the process of achieving game results [16]. New ones are currently being developed "serious games" aimed at development social competencies, and not only for children with symptoms of ASD, but also for normotypical adolescents. One of these games became LINA, a smartphone-based augmented reality game designed for children from 10 years old and their teachers. This game can be played by the whole class to facilitate and improve class interaction and reduce stress factors. The authors believe that use of augmented reality, sharing an exciting story and shared gameplay in a common classroom space makes it possible to use teenagers' passion for digital technologies to improve social connections in the real world [15].

The effectiveness of communication processes in video games can be assessed in different ways, for this it is used as post-interviews of participants and evaluation team gaming productivity. There is a large number of studies which use psychophysiological diagnostic methods, for example, recording eye movements during social interaction [1]. Social intelligence adolescents playing video games is a significant predictor of positive relationships with parents and peers, and its level is negatively associated with negative emotions, and these effects manifest themselves over time [14].

Thus, the development of "serious games" aimed at developing communication among adolescents and young adults and their cognitive capabilities is a current direction of modern practical psychology. Moreover, as the studies described above show, individual psychological characteristics players, including differences in social skills (social intelligence) and emotional responses (emotional intelligence) can make a significant contribution in the efficiency of solving game problems. The presented research is aimed to study the contribution of individual psychological differences in younger adolescents — namely, the level of their social and emotional intelligence — on indicators of their success in solving computer game problems in different game conditions: individually and in interaction (in pare) with a partner.

General design and research methods

The study used a modified version of the "PL-modified" computer gaming system developed by the authors to implement the tasks in previous studies [5]. A sample computer game is shown in Fig. 1: on a field of size 9x9 cells according to certain rules ("patterns") colored colors appear balloons. The player's task is to line up balls of the same color to score points. Understanding the rules for the appearance of balls should help more effective game, manifested in particular, in more points. Specific parameters

of the game — understanding rules and their use in the game are diagnostic markers of specific mental actions — analysis (understanding rules) and planning (game results).

The procedure for research and evaluation of the parameters of the effectiveness of solving game problems. The study was conducted at school for three academic hours (lessons). At the first lesson, participants were introduced to the "PL-modified" system, for two minutes they played the training version games with random appearance of balls. Next, the participants played individual version of the game consisting of three 10-minute sessions in which the balls appeared according to certain patterns, different in every session. After each of three sessions ended, each participant had to answer questions about what the rules were used in the game. By answers the actors' understanding of the elements of the pattern was assessed. It was also recorded the number collected by each participant points. Thus, to assess the effectiveness of solving game problems, we carried out calculation of the following parameters: 1) general number of correctly named rules (patterns of the appearance of balls), which characterized the formation mental action (hereinafter referred to as UD) analysis, 2) game performance, which characterized the formation of the mental action of planning and was calculated according to the following formula: X1/X2, where X1 is the general number of points scored in each game, X2 is the number of game moves. This calculation was made in order to equalize the capabilities of players

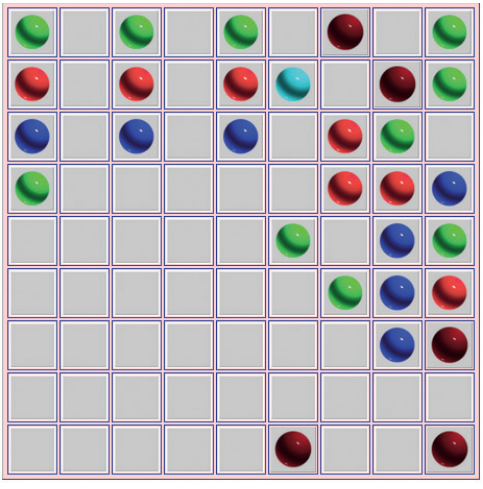

Fig.1. The playing field of the "PL-modified'" system

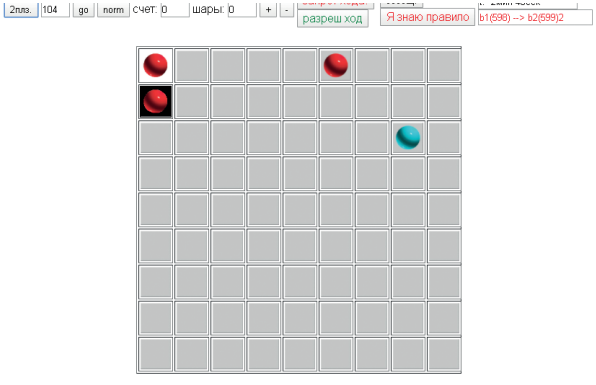

Fig.2. An example of a playing field with options, with examples of the presentation of balls, permission / prohibition of a move

in different game conditions (so how obvious it is that individually a person will obviously score more points, than working in pairs)[1].

In the second lesson, the participants played the game in pairs with a partner, for which they were randomly assigned to pairs. The participants took turns making moves, but each of them had the opportunity to forbid or allow each move of the partner (see Fig. 2). It is assumed that the proposed format of the game in the form of a dialogue initiates the mental activity of students, activating the use of mental actions to successfully complete the task. During the game, the participants had the opportunity to communicate with each other. In this version of the game, the participants also first played the training version with a random presentation of the marbles, then moved on to the main version with the regular presentation of the marbles. In it, as well as in the individual version, there were three sessions of 10 minutes each with different patterns in each session. Participants answered questions about the elements of regularities one by one, and the number of points scored was recorded for the pair.

Thus, in total, for each respondent, 4 indicators of game performance were recorded: 1. the number of named elements of regularities in an individual game (LE of analysis); 2. performance indicator in an individual game (planning UD); 3. the number of named patterns in the game paired with a partner (UD analysis — separately for each player); 4. performance indicator in the game paired with a partner (planning UD for each player).

In the third lesson, participants filled out tests of abstract, social and emotional intelligence in paper format. Assessment of general (abstract) intelligence was carried out using the J. Raven Standard Progressive Matrices test[2]. The level of social and emotional intelligence was assessed using two tests decision-making designed specifically for adolescents 10—15 years old [8].

Data analysis was carried out using the methods of mathematical statistics — correlation analysis and comparison of averages, and was carried out in the IBM SPSS Statistics 23 program.

Sample. The study involved 189 Russian-speaking students of a secondary school in Moscow (46% girls and 54% boys), age range: 10—12 years.

Results

The results of the study provide data on: 1) game performance indicators in two game conditions: in an individual format and in the form of an active dialogue between the participants; 2) game performance indicators in two game conditions, taking into account the individual psychological differences of the actors; 3) game performance indicators in two game conditions, taking into account the gender differences of the actors.

Average indicators for two variables — LGD analysis and planning — are presented in Table. 1.

The Wilcoxon non-parametric statistical t-test was used to compare the average values of the indicators in the two game conditions. The results of both tables indicate the following. First, there are obvious significant differences in the severity of game indicators between the two game conditions. This applies to both the plan-

[1] Indicators of success in solving a game problem (game performance) were calculated in accordance with criteria developed and described in previous studies by the authors [5]. This article focuses attention is focused on another subject of research, therefore the indicators of UD analysis and planning will not be disclosed in detail, they appear as the main parameters for solving game problems.

[2] The study used a shortened version of the test consisting of 12 tasks, which was previously tested in several studies, including on students of the Faculty of Software Engineering at Moscow State University of Psychology and Education [12].

Table 1

Average values of game performance indicators (standard deviations are given in parentheses)

Name of indicator	Game type			
	UD Analysis		UD Planning	
	Ind. a game	Pairs game	Ind. a game	Pairs game
1st game	0,91	0,75*	1,31	1,48*
2nd game	0,87	0,9	1,64	2,08**
3rd game	0,9	0,61**	1,14	2,72**
General game indicator	3,33 (2)	2,56 (1,61)**	4,1 (1,31)	6,31 (3,38)**

** differences are significant at the level p ≤ 0.006; ** differences are significant at the level p ≤ 0.000.*

ning indicator and the analysis indicator. Secondly, despite the higher indicators of analysis in individual conditions, it is the game performance (planning indicator) in the conditions of joint solution of game problems that gradually increases with each new game set and, in general, turns out to be higher in the conditions of two players working in pairs.

Next, a correlation analysis of intelligence indicators (abstract, social and emotional) was carried out with the main indicators of game performance. The Spearman coefficient was applied to calculate the values. No significant differences were found, except for a positive relationship between the level of social intelligence and the indicator of planning in a game in pairs, however, the resulting indicator slightly exceeds the required significance level threshold (r = 0.2; p = 0.07). These data allow us to conclude that general intelligence does not affect the gaming performance of the test takers. However, individual differences in social intelligence can be significant. To confirm this assumption, the conditions of the game in a pair with a partner were analyzed from a different angle, namely: the entire sample of subjects was divided into two groups: group 1 (54 people) consisted of actors playing in a pair with the same level of social intelligence, group 2 (48 people)consisted of actors who worked in pairs and whose level of social intelligence differed (by one or more standard deviations). In table. 2 shows the average values of the studied variables[3].

The data in the table also show significant differences in game performance

Table 2

Mean values for the tested variables (standard deviations are given in parentheses)

Name of indicator		Group 1	Group 2
Analysis	Ind. a game	3,52 (2)	3,45 (2)
	Pairs game	2,67 (1,71)	2,66 (1,4)
Planning	Ind. a game	4,03 (1)	4,4 (1,73)
	Pairs game	6,27 (3,6)**	5,2 (2,18)*

** differences are significant at the level p ≤ 0.06; ** differences are significant at the level p ≤ 0.001.*

[3] The results of each actor were marked as follows: as higher than 66.7% of the sample (high level), in the range from 33.3 to 66.7% of the sample (medium level), or lower than 33.3% of the sample (low level).

between the conditions of work individually and in pairs with a partner — these patterns are observed regardless of the division into group type and, despite the fact that the understanding of the rules for constructing patterns is slightly (but still insignificant) higher in individual game conditions. In addition, the results of the table show that if in an individual game the indicators of gaming performance are almost equal in both groups of actors, then in the case of playing in pairs with a partner, this indicator is higher in group 1,when the players have equal opportunities in the manifestation of the level of social intelligence. Thus, despite the absence of significant correlations of game results with cognitive abilities, nevertheless, the contribution of cognitive variables, in particular, in this case, social intelligence matters when it comes to the interaction of two players.

Next, a correlation analysis was carried out between cognitive abilities and game performance indicators, taking into account the division of the sample by gender. Given that differences in the manifestation of levels of social and emotional intelligence in boys and girls have been studied for a long time [11], we assume the possibility of obtaining different effects. Table below. 3, which contains the main results of the correlation analysis between the studied variables on the sample of boys.

The results of the table show that the level of social intelligence of boys is associated with such variables as LE of analysis (i.e., understanding the rules in an individual game), as well as LE of planning (game performance in a game paired with a partner). With an understanding of the rules in an individual game, it reveals significant positive correlations and the level of emotional intelligence. No such associations were found in girls. Emotional intelligence also turned out to be the only one of the studied indicators, the level of which differed in boys and girls — in girls it was significantly higher when analyzed by Student's t-test (9.31 and 6.68, respectively, $p \leq .01$). The indicators of analysis and planning themselves do not differ between boys and girls, but they turn out to be higher when paired with a partner, regardless of the gender of the actors.

Study Findings

The study was devoted to assessing the degree of formation of mental actions of analysis and planning of schoolchildren of younger adolescence through game indicators, namely: using a specially designed computer game system "PL-modified" in two game conditions,individually and with a partner. In addition, game performance indicators were compared taking into account the cognitive capabilities (level of social intelligence) of the players in a pair, as well as taking into account the gender factor. The results obtained allow us to formulate several fundamental conclusions.

TaTable 3

The results of the correlation analysis of the level of abstract intelligence, social and emotional intelligence and gaming performance in individual and group play among boys (paired correlations)

	Abstract intelligence	Social intelligence	Emotional intellect
Analysis *(ind. a game)*	0,19	**0,28***	**0,33***
Analysis *(pair game)*	-0,03	0,14	0,02
Planning *(ind. a game)*	0,16	–0,12	0,16
Planning *(pair game)*	0,04	**0,34***	0,25

** differences are significant at the level $p \leq 0,05$.*

First, game performance indicators as diagnostic markers of mental actions of analysis and planning, as well as patterns of relationships between them, are mediated by several factors: game conditions (individually / in pairs) and intellectual resources (equal / unequal abilities). The empirical facts obtained indicate that the game conditions in pairs are more productive, which is manifested, first of all, in higher indicators of game performance (SP planning) both for the entire game and for each new stage. These effects allow us to conclude that there are favorable opportunities for using individual computer games as a modern tool for diagnosing mental actions with the possibility of organizing joint problem solving, where a productive dialogue is needed to get the most out of the game task being solved. This conclusion is confirmed by both the recurring general effects of previous studies [5] and the same data on the greater productivity of the playing conditions in a pair with a partner at each game stage, taking into account additional psychological factors.

A separate issue is related to the mental action of analysis, the indicators of which are higher in individual conditions of the game, which contradicts the previously obtained data of previous studies by the authors. Such effects may be partly due to the limitations of the process of interpreting the results, when knowledge of the rules of the game (by which the LEV of analysis was understood) in the conditions of working in pairs was also assessed individually for each player (for certain technical reasons). It seems that a deeper procedure for evaluating game indicators will also make it possible to obtain more differentiated results in relation to game indicators, and, consequently, the mental actions of players. In any case, it should be taken into account that a joint game is a complex structural phenomenon, “sensitive” both to external dimensions (organization of diagnostics) and to internal differences associated with the individual psychological characteristics of the players themselves.

Secondly, the (indirect) contribution of social intelligence to game outcomes is found. Although significant correlations were not obtained on the general sample of players, nevertheless, the analysis of the gaming performance of couples, taking into account their level of social intelligence, revealed a significant superiority in favor of partners with equal opportunities. In addition, an important result is the contribution of the boys’ social intelligence to the indicators of LE of analysis (when playing individually) and LE of planning (in pairs with a partner). This phenomenon can be commented on taking into account the specifics of the sample itself — it was made up of students of younger adolescence. Communication is the leading activity of younger adolescents [10], in this regard, the individual psychological characteristics of players in this age category are the prism through which the results of any activity are refracted. Previous research has also shown the importance of abstract intelligence for adolescent couples at play. Thus, the cognitive capabilities of the players are an important factor to be taken into account when developing diagnostic computer games. As for gender differences, it is obvious that it is boys who need the same (in terms of level) partner to a greater extent in order to demonstrate effective play. Taking into account the fact that mental actions of planning are behind the indicators of game performance, the contribution of social intelligence to the formation of specific mental actions in the game is indicative in boys. The game interaction of girls in this regard depends to a lesser extent on their cognitive level.

The results obtained, of course, are an intermediate stage on a long journey of studying computer games as a diagnostic tool and the influence of their conditions on the manifestation of the mental capabilities of the players. At the same time, it is already

important to understand how important it is precisely an integrated approach to the studied psychological variables, which is realized with the subtle, competent use of computer games to assess the potential of students.

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