Original Research

The Effectiveness of Chess on Problem-Solving, Working Memory, and Concentration of Male High School Students

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Abstract: The purpose of this study was to investigate the effectiveness of chess on the ability to problem-solving, working memory, and concentration of high school students. The statistical population consisted of all 10th-grade male students of Ahvaz city. A total of 40 subjects (20 experimental and 20 control subjects) were enrolled in this study by a multi-stage random method. The research design was experimental and pretest-posttest with a control group, along with data collection tools, including the Cassidy and Lang's problem-solving style questionnaire (PSSG), Cornoldi's working memory test (CWMT), and Weinstein and Palmer's learning and study strategies inventory (LASSI). The experimental group received 15 sessions of training and practiced chess for four months, and the control group did not receive any intervention at this time. The results showed that chess significantly improved working memory and concentration of students in the experimental group compared with the control group but could not significantly improve the ability of problem-solving in these students. The results of this study encourage us to use this game more to improve memory or treat concentration problems.

Keywords: Chess, Problem-Solving, Working memory, Concentration

Introduction

For all children, play is certainly an integral part of their lives. Play is the only pivotal activity that children take part in all places and times. Play is defined as a self-motivated, enjoyable, self-directed, and needless goal that children do not need to learn (Landroth, 2002; translated by Davarpanah, 2011, p. 30). Religious teachings, educators, philosophers, and psychologists all agree that play has a unique role in nurturing a child's physical and mental abilities (Ghazi , 1989). Play is one of the most effective and mainstream ways of learning for children, and the importance of play in child development is that some learning theorists regard learning disorder as a result of poor play, especially in sensory-motor games in childhood, and suggest the game as the best way to treat this type of disorder (Kephart, 1971, cited by Cortilla & Horwitz, 2014). Nowadays, the use of play therapy in the field of child psychotherapy is very popular. The child develops physically, emotionally, intellectually, and socially during play, and in addition to enjoying the process, he or she is equipped with skills that are central to his or her life (Salter, 2013).

Psychologists have categorized games into two categories, i.e., physical and intellectual games (Mahjour,

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2004). An examination of the history of all kinds of games shows that human beings have moved from physical games to intellectual games (Whitebread & Jameson, 2010). In this regard, chess is one of the prominent intellectual games, which have attracted the attention of people for centuries. Chess, as a two-player board game, provides enjoyable conditions, which players with high focus and concentration, constantly producing and solving problems, as well as planning and anticipating, to win the game by eliminating opponent's pieces (Karimianpour, 2010).

Although playing chess has been the most popular form of entertainment for centuries, in the past two decades, researchers in the field of education have sought to explore its academic and educational benefits. They have aimed to use it as a tool to enhance the cognitive and educational abilities of children and adolescents. There have been numerous studies to date exploring the potential benefits of chess on various cognitive abilities, such as attention (Schultz et al., 2008), development of spatial concepts (Sigirtmac, 2012), general intelligence (Hong & Bart, 2007), and metacognition (Kazemi, Yekaytar, & Mohammadi Bolban, 2012; Christiaen & Verhofstadt-Denève, 1981).

Some researches confirmed the positive relationship between playing chess and some psychological traits, including reasoning, creativity, hardiness, and self-confidence (Litterap, 1998; Aciego, Garcia, & Betancourt, 2012; Bilalic, McLeod, & Gobet, 2007). Sigirtmac (2012) reported a positive and significant relationship between chess and academic performance, spatial visualization, and logical thinking. Based on the results of these and similar researches, the use of chess in the curriculum of some countries, including Canada, Sweden, Cuba, Turkey, and America, became formal and sometimes unofficial. Moreover, many research projects were underway to investigate the effects of this game or have been taken place (Sala, Gobet, Trinchero, & Ventura, 2016). For example, in the state of New Brunswick, Canada, there is a textbook called "Challenging Mathematics" in which chess is used to teach mathematics (Isabella, 2006; quoted by Razvani, Fadaie, & Goya, 2014).

To date, many studies have examined the positive effects of chess on children's mathematical ability (Barrett & Fish, 2011; Kazemi et al., 2012; Sala, Gorini, & Pravettoni, 2015; Trinchero, 2013). Barrett and Fish (2011) examined the effectiveness of chess training on the mathematical development of children in special care centers by using the Texas Assessment of Knowledge and Skills (TAKS) program, whose results showed that the chess training group performed better in math than the control group. Have shown themselves, Sala et al. (2015) and Trinchero (2013) focused on studying the effects of chess training on the mathematical problem-solving ability in an elementary school; compared with the control group, the results showed systematic superiority of experimental group performance (which was trained and practiced in playing chess). Furthermore, compared to the control group, Sala et al. (2016) examined the relationship between chess and students' mathematical ability. Their results showed that chess training was more effective than conventional mathematical training. However, their subsequent follow-up showed that these effects are not generally transmitted to out-of-school environments.

Since chess is a mental activity and exciting game, the general expectation of the chess community is that chess can enhance the general abilities and reasoning of players (Bart, 2014). The results of some recent studies have challenged this claim. By reviewing research projects that examined the effects of chess on cognitive and academic ability, Gobet and Campitelli (2006) concluded that most of these projects lacked placebo control. Therefore, coaches' expectations, emotional states, and attentions from starting a new activity in this regard are likely mixed with the real effects of chess results. Schultz et al. (2008) reported disappointing results in teaching chess to children with learning disabilities. In a meta-analysis study that included 24 studies on the effectiveness of chess on cognitive and academic abilities, and especially on mathematical learning, Sala and Gobet (2016) found that the effect of chess on average mathematics was modest but not significant on cognitive ability. In an extensive study of 3,000 British students (9 to 10-year-old), who attended chess training classes, McGovern (2016) found that contrary to the results of previous studies attending chess training classes did not improve students' academic achievement. In his research report, he challenged the claim that chess can improve students' concentration, confidence, and thinking ability.

However, Poston and Vandenkieboom (2019) have reported a moderate to strong effect of chess on students' math and reading ability; in their study; children who participated professionally in chess tournaments were compared to children who were only in clubs They were entertained by the game, learning math and reading better, and the effects were longer lasting.

In addition to examining the effects of chess training on children's problem-solving ability, some research has examined the effect of chess training on the other mental abilities, including concentration and memory. Since a chess player has to constantly focus on all the pieces, especially the key pieces, and closely monitor the movements and alignment of the opponent's pieces, it is expected that the chess exercises will strengthen attention and concentration on its players. In their research, El-Daou and El-Shamieh (2015) concluded that the concentration of students with attention deficit hyperactivity disorder (ADHD) increased with continuous chess training. Jankovic and Novak (2019) also found that chess promotes high levels of thinking, including creativity, evaluation, and problem-solving, especially when one needs to use these cognitive skills in competitive activities. In contrast, Storey (2000) found no significant relationship between chess and mental abilities, such as concentration, problem-solving, and creativity. Success in chess, on the other hand, requires the player to draw a map or maps, then memorize the steps until they reach the goal and keep them redrawn with the opponent's moves, if necessary. Therefore, the use of these measures requires memory, especially strong working memory. In line with this, the results of studies by Bart (2014) and Burgoyne, Sala, Gobet, Macnamara, as well as Campitelli and Hambrick (2016) confirmed the effectiveness of chess on working memory, fluid intelligence, and student concentration. In explaining these results, the researchers suggest that chess probably enhances mental abilities, such as reasoning, memory, thinking, concentration, and problem-solving, and that improvement of these elements also develops students' cognitive and metacognitive processes. Therefore, since the background of the study of chess effects on mental abilities is not uniform, according to McGovern (2016), parents are still wondering whether training classes are effective in enhancing children's academic and cognitive abilities or not. On the other hand, there is little research, especially in Iran, on the effectiveness of chess on these variables (i.e., problem-solving, working memory, and concentration). Therefore, the purpose of the present study was to investigate the effectiveness of chess training on problem-solving ability, working memory, and high school students' concentration.

Material and Method

The research method was experimental and the research design was pretest-posttest with control group. Initially, all subjects were tested on dependent variables "Problem Solving, Working Memory and Concentration" and after intervention on the experimental group for 4 months, received post-test from both experimental and control groups. It should be noted that the control group received no intervention during this 4-month period.

Population, sample, and sampling method: The statistical population of this study consisted of all 10th-grade male students of a high school in Ahvaz city, and the sampling method in this study was multistage cluster random sampling. Thus, one of the four Ahvaz education districts was randomly selected from a municipal district (District 1), and from that education district, a high school was randomly selected. Next, from that high school, which had two 10th-graders, one class was randomly selected as the experimental group, and the other one was considered as the control group. Because there was a need for informed consent from the experiment group's students for a 16-session chess course, out of the 31-student in class, only 20 student agreed to participate in chess training classes. Twenty subjects from the other class were randomly selected as the control group (out of 25 volunteer students).

Research tools: The tools used in the present study are a problem-solving style questionnaire (PSSQ), Cornoldi's working memory test (CWMT), and learning and Study Strategies Inventory (LASSI), which are presented below.

Problem-solving style questionnaire: PSSQ was developed by Cassidy and Long (1996) to measure problem-solving ability in different life situations. The questionnaire has 24 questions and six components of problem-solving helplessness, problem-solving avoidance style, problem-solving inhibition or control, self-confidence in problem-solving, creative problem-solving style, and approach style to problem-solving. It should be noted that each component has four questions that are scored as "yes = score 1," "no = score zero," and "do not know = score 0.5," and the total score of each participant ranges from 0 to 24. In the present study, the total score of this questionnaire was used to assess problem-solving ability (Shatri, Ashkani, & Modarres Gharavi, 2009). The validity and reliability of this questionnaire have been reported favorably by its creators. Cassidy and Long (1996), in a study, reported Cronbach's alpha, for this questionnaire and different components, between 0.51 to 0.86. In another study, Cassidy (2009) confirmed the validity of this questionnaire using factor analysis. In the present study, after confirming the factor structure of this questionnaire through confirmatory factor analysis, its reliability in all components ranged from 0.54 to 0.84.

Cornoldi's working memory test: CWMT, also known as the working memory or active matrix, was designed by Cornoldi (1998, as quoted in Cornoldi & Vecchi, 2003). The test consists of a 3-by-3 matrix with only one moving black square at the bottom left and the black square as the starting point of the test. In this test, the examiner asks the subject to look closely at the matrix and the square of the black square, then listen carefully to instructions that include moving up, down, left, or right of the black square and through mental imagination, show the new place of the black square as directed . It should be noted that this test is run three times, and each contains six commands. The reliability of this test was reported favorably in many studies, including Ladoni Fard, Shojaee, and Hemmati Alamdarloo (2016), as well as Pourmohadreza Tajrishi, Ashouri, Jalil Abknar, and Behpezhoo (2014). Moreover, the formal and content validity of this test was also confirmed by several instructors and specialists in educational psychology.

Learning and study strategies inventory . LASSI was first designed by Weinstein and Palmer (2002) and has undergone many changes so far. The last edition of this list was done by Weinstein and Palmer and Acee (2016), in which the number of articles decreased from 80 to 60 compared to the original version. It contains ten subscales of information processing, choice of core ideas, test strategies, attitudes, anxiety, motivation, mindfulness, self-examination, study aids, and time management that each subscale (in the third edition) has six items. In the present study, the concentration subscale of this questionnaire was used to measure students' concentration, which is measured using a five-point Likert spectrum (strongly disagree, score 1 to strongly agree, score 5). The validity and reliability of this test have been repeatedly verified by its creators and has been used by many American universities to identify students with poor academic performance. The formal validity and content of this list after its translation were reviewed and approved by several professors and experts in educational psychology, and Cronbach's alpha was 0.86 for the focus subscale.

Method of Conducting Research: After the pre-test of the dependent variables (i.e., problem-solving, working memory, and concentration) on the experimental and control groups, the intervention consisted of chess training for the experimental group, and the control group did not receive any intervention. After 15 sessions of chess training, the post-test of the experimental and control groups was performed.

Intervention description: The intervention consisted of chess training and was conducted by a chess training instructor according to the chapters and resources introduced by the Chess Education Federation (Khalil Hosseini Chess Leaflet). The chess training sessions were as follows:

- First session: Pre-test on two groups and introducing chess game to the experimental group;
- Second session: Introducing chess pieces;
- Third session: Learning the basics of chess;
- Fourth session: Playing with several experimental groups and provide corrective feedback;
- Fifth to eighth Sessions: Pairing with students and giving necessary advice;
- Ninth to thirteenth sessions: Computer-assisted chess training and after each session the students must notify the coach of the outcome of his or her game;
- Fourteenth and Fifteenth Sessions: Holding a group match; and
- Sixteenth session: Post-test of two groups.

Results

As can be seen in Table 1, the mean of the dependent variables (problem solving, working memory, and concentration) is generally higher in the post-test than in the pre-test phase. Multivariate analysis of covariance (MANCOVA) was used to investigate this difference. In this method, by comparing pre-test scores (controlling for primary differences), post-test scores are compared between the experimental and control groups. It should be noted that before analyzing the data, its assumptions (homogeneity of variances, homogeneity of variance-covariance, data normality, linearity, and regression slope homogeneity) were analyzed and confirmed. Data were analyzed by SPSS-22 software and significance level $\alpha = 0.05$.

Table 1. Mean and standard deviation of problem solving, working memory, and concentration in the experimental and control groups, pre-test and post-test.

Variable	Group	Phase	Mean	SD
problem solving	experimental	Pre-test	20.65	4.10
		Post-test	22.9	3.98
	control	Pre-test	20.85	3.44
		Post-test	22.75	3.97
working memory	experimental	Pre-test	7.60	2.85
		Post-test	9.55	2.64
	control	Pre-test	6.80	2.85
		Post-test	7.60	2.53
concentration	experimental	Pre-test	21.35	5.44
		Post-test	23.70	5.49
	control	Pre-test	21.40	5.36
		Post-test	22.67	5.40

Table 2. Results of Multivariate Covariance Analysis for Comparison of Problem Solving, Working Memory and Concentration in Experimental and Control Groups

Effect		Value	F	DF hypotrophies	DF error	P	Partial Eta Squared
group	Pillai's Trace	0.365	6.32	3	33	0.002	0.365
	Wilks' Lambda	0.365	6.32	3	33	0.002	0.365
	Hotelling's Trace	0.365	6.32	3	33	0.002	0.365
	Roy's Largest Root	0.365	6.32	3	33	0.002	0.365

Results of multivariate analysis of covariance showed that there was a significant difference between the two experimental and control groups in at least one of the dependent variables (problem solving, working memory and concentration) ($F = 6.32$, $p <0.002$). The MANCOVA results are analyzed to determine which variables or variables have significant differences between the two groups (Table 3).

Table 3. Results of univariate covariance analysis to examine differences between each of the dependent variables (problem solving, working memory, and concentration) in the experimental and control groups

Source	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
problem solving	19.50	1	19.50	2.53	0.07	0.09
working memory	21.40	1	21.40	5.88	0.02	0.14
concentration	44.25	1	44.25	10.55	0.003	0.23

The results of univariate covariance analysis showed:

- There was no significant difference between the two groups in the ability to problem solving by adjusting the pre-test scores ($F = 2.53$, $p <0.07$). In other words, the game of chess failed to significantly increase the ability of the experimental group to problem solving (compared to the control group). Therefore, the hypothesis of the effectiveness of chess playing on the ability to problem-solving in students was not confirmed.

- Also, by adjusting pre-test scores, the experimental and control groups had significant differences in working memory post-test ($F = 5.88$, $p <0.02$). In other words, the game of chess was able to significantly increase the working memory of the experiment group compared to the control group (who did not play this game). Therefore, the hypothesis of the effectiveness of chess playing on working memory in students was confirmed. In addition, by adjusting pre-test scores, the experimental and control groups had a significant difference in post-test concentration ($F = 10.55$, $p <0.003$). In other words, the game of chess could significantly increase the concentration of the experiment group compared to the control group (which did not play the game). Therefore, the hypothesis of the effectiveness of chess play on the concentration in students was confirmed.

Discussion

The results showed that by adjusting the pre-test scores, the chess game did not significantly improve the problem solving ability of the students in the experimental group compared to the control group, but the exercises of this game significantly increased working memory and concentration group students in the experimental group compared to the control group. The following will explain these findings.

Chess and problem-solving. As the results show, playing chess exercises did not significantly increase students' problem-solving ability. In other words, by adjusting pre-test scores, there was no significant difference in post-test scores of problem-solving of experimental and control groups. This finding is consistent with researches of Goblet and Campitelli (2006), as well as McGovern (2016), and are inconsistent with Literp (1998), Bilalic et al. (2007), Root (2008), Trinchero (2013), and Sala et al. (2015). Comparison of the mean pre-test and post-test of the experimental and control groups showed that the post-test mean of the experimental group increased compared to their pre-test, but this increase was not statistically significant.

In explaining this insignificance, one might argue that one of the reasons is the different types of problem-solving approaches. In other words, most studies have shown that chess exercises increase problem-solving ability, and in most of them problem-solving is limited to the school situation and academic problems.

Thus, since the present study is about problem-solving in real-life environments, so the generalization of school-based problem-solving strategies to real-life problems has not been done well. In this regard, Sala et al. (2016) found that the effects of chess were related to learning environments, and it is mostly not transferred to out-of-school environments. According to the theory of similar elements of Thorndike and Voodworth (As quoted in Hergnahan & Olsson, 2004; as translated by Saif, 2006), since elements are similar between two situations (namely chess-solving and real-life problems) , there is little resemblance (this transfer is not well done). In other words, since problem solving is at the top of the learning hierarchy (Fardanesh, 1986), achieving this type of learning requires more time, effort, and practice on the part of the learner. Thus, perhaps the lack of intervention time did not provide sufficient learning opportunities to enhance problem solving in students .

Chess and working memory. The results indicate that playing chess exercises was able to significantly increase students' working memory. In other words, by adjusting pre-test scores, there was a significant difference in the post-test scores of working memory in experimental and control groups. This finding is consistent with the findings of Bart (2014), and Sala et al. (2016) and is inconsistent with studies of Goblet and Campitelli (2006), Melby-Lervag, Redick, and Hulme (2016). In explaining the effectiveness of chess on students' working memory, it can be said that the nature of chess is that the player must think well before making any move, check the position of his or her opponent, and keep in mind all possible aspects of the map. Design a long- or short-term map and keep this map in mind for the duration of the run. Thus, chess will challenge the player's memory and thereby reinforce it.

In a study, Schoenfeld (1985, quoted by Razvani et al., 2014) examined the differences between expert and beginner chess players and concluded that one of their main differences is that expert chess players compared to beginner chess players, designs, and movements. Much more can be remembered, and this is one of the most important secrets of their success. Another explanation is that according to some research, chess can enhance students' metacognitive processes (Kazemi et al., 2012), and reinforcing these processes, and according to research results, chess can result in enhanced learning, memorization, and ultimate recall (Saif, 2013).

Chess and concentration. The results indicate that playing chess exercises significantly increased students' concentration power. In other words, by adjusting pre-test scores, there was a significant difference in post-test scores of concentration of experimental and control groups. This finding is consistent with the research by Schultz et al. (2008), Borgion et al. (2016), and Sala et al. (2017) and is inconsistent with the Goblet and Campitelli (2006) and McGovern (2016) studies. In explaining the effectiveness of chess on student's concentration, it can be said that for success in chess the player should focus all his or her mind on the opponent and carefully observe the movements of the opponent. In other words, although accuracy in academic assignments may be difficult for students, in a game or competition, because of the excitement and motivation to succeed or avoid failure, the student commits himself to Keep your attention on all the moves and moves on the chessboard. Deep focus on chess is so important that even a few seconds of distraction during the match can have a profound effect on the outcome of the game (Gobet, 2014). Former world chess champion Bobby Fisher says: "Chess requires total focus, during the game, I try to use my whole mind to concentrate, but most players use only part of their minds during the game, and the rest of their minds are rotating elsewhere." Increased precision and concentration are due to the flexibility of the brain, and therefore many child therapists find high-precision games (including chess) useful to increase the child's attention and concentration. In this regard, El-Daou and El-Shamieh (2015) have reported that playing chess continuously is beneficial for ADHD children .

It should be noted that this study was conducted on high school male students in Ahvaz, therefore, caution should be exercised in generalizing its results to girls, other age groups and geographical areas. Likewise, the lack of conditions for long-term follow-up is one of the limitations of this study, which suggests that future researches should consider the follow-up stage if possible in order to evaluate the long-term effectiveness of chess. In addition, considering the effectiveness of chess on students' working memory and concentration ability, parents, education managers, school principals, and especially physical education teachers are suggested to provide the necessary conditions for chess interest and learning, especially at an early age. Child and adolescent psychotherapists are also advised to use the game more frequently to treat educational, academic, and behavioral problems in children and adolescents.

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