JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452

The Effect of Chess Instruction on Mathematics Motivational Strategies for Learning and Error Model of Students' Problem Solving Based on Newman Model

Farhad Kazemi
Departement of Mathematics, Ghorveh Branch, **Islamic Azad University**, Ghorveh, Iran
Baten_2921@yahoo.com

Received: 2022 March 15; **Revised:** 2022 April 20; **Accepted:** 2022 May 10.

Abstract
The purpose of this study was to investigate the effect of chess instruction on mathematics motivational strategies forlearning (MMSL) and error model of students' problem solving at different level of education based on Newman model. In this study 180 boy students at fifth, eighth and ninth grades were randomly selected and divided to the experimental and control groups. Students at the experimental group were under chess instruction for six months. The results of MMSL questionnaire showed that,at subscales of Expectancy and Metacognitive strategies, the score of students in the experimental group was significantly higher than the control group; but in subscales of value, cognitive strategies and non-informational resource there was no significant difference. In addition, at the subscale of Affect which is related to test anxiety, the score of students in the control group was significantly higher than the experimental group. The interviews analyze showed that firstly, students of experimental group at the three grades, were more successful than students of control group in problem solving and in general, achieved 16.9% more progress than control group. Secondly, errors mean of experimental group, in three grades, was less than control group. Thirdly, interviews analyze showed that various problems create different models of errors.
Keywords: chess; problem solving; Newman model; motivational strategies

Introduction

In addition to being a subject matter, mathematics is a way of thinking which is formed on the basis of being able to understand and display problem position, describing the underlying concepts of the problem, organizing and classifying the required information and clarifying the way a problem may be solved. Not only in mathematics education but in other sciences, the final goal of training is to help the learners solve the problems in the relevant field of study (Salih et.al, 2019). Ganieh (1985) Finds the problem solving the best possible form of learning and defines it as: the process in which the learner discovers a Combination of past learned formulas and can use them in such a way that lead him to solve a new problem. Furthermore, he believes that problem solving is not just using or applying formula, techniques, skills, and learned concepts of the person's prior knowledge and experience in a new situation, but it is a process that brings about new learning(cited in Allamolhodae, 2009).

Much effort has been made by researchers and instructorsin order to increase the students' mathematics problem solving ability by some methods or ways. Chess as an interesting play and full of creative and original ideas, has attracted the attention of researchers as a powerful tool to increase the ability of mathematics problem solving, abstract thinking, critical and creative thinking, visualization or imagination, and reasoning skills. In his book called: chess moral, Benjamin Franklin, sees chess beyond entertainment and attribute some valuable features to it such as insight, forethought, precaution and endurance to achieve desirable results. These are very important in human life. He added that chess cause to get and improve these skills and makes the skill as an integral part and habit and applicable in all situations or opportunity, since life is a kind of chess play (Franklin, 1776). So, we may claim that Franklin was among the first pioneers who proposed the hypothesis that chess enhances the worthy qualities of the mind and he raised the question whether chess make humans cleverer or not(cited in celone, 2001).

Many researchers have argued for effectiveness and suitability of chess for educational purposes (Sala&Gobet, 2016, Jerim et al. 2016, Bart, 2014, Kazemi et al, 2012). Chess gives an optimal tradeoff between complexity and simplicity, and also between tactics and strategies which is very ideal. Chess combines number, space and time aspects and brings about more concentration, problem solving and metacognitive capabilities(Sala &Gobet, 2016). Regarding the reasons for chess effectiveness, Bart (2014) argues that chess playing brings about developing cognitive skills like attention, concentration, intelligence and reasoning and these cognitive abilities are transferred to other domains and provide the learners with wide range of skills.

On the reasons for developing problem solving skills, on the part of the chess players, Sala et al. (2016) assert that a) math and chess are isomorphic domains. by playing chess, pure and abstract aspects of math concepts are decreased and math concepts are increasingly managed. b) a chess player should have high-level skills such as planning, precise computations, supervision, and abstract thinking. These skills are necessary for math problem solving. c) The rate of failure and success of a chess-player is the result of his mental calculations and attempt during the game time and this, in turn, brings about enhancing self-confidence and ability of the given person.

With regard to the effect of chess on cognitive ability, by doing a meta analysis, Burgoyne et al. (2016) come to the conclusion that there is a positive correlation between chess skills and cognitive abilities like fluid intelligence, processing speed, working memory, and knowledge perception. In another meta-analysis study which was done by Sala &Gobeth (2016) it was demonstrated that cognitive ability of students' chess players was more than non player chess students as much as half of an standard deviation, in abilities like reasoning, planning, and numerical skills. Trinchiro (2013) holds that attention and concentration of the students can be increased by chess playing. This can justify math problem solving ability on the part of the chess players. In fact, the chess player can improve reading capability and proper interpretation of math problems. So the students can apply math knowledge and reflection on his strategies and activities. Kazemi et.al (2012) suggested that with teaching chess to students, below objective will be achievable:

(a) Students will be able to think about the problem in a principled and correct way and will be able to analyze the problem correctly. In fact, they learn the basic method and framework of thinking on problem solving; (b) Practicing and analyzing different chess positions increase students' ability to understand, be creative and reason; (c) Students in higher education can easily relate the complexity and beauty of chess with pure mathematics; in fact the complexity of pure mathematics will be tangible; (d) Chess gives students the ability not to give up too quickly when faced with a difficult problem and to try as hard as they can to solve the problem. In fact, chess makes students tireless and hopeful. In the other hand, chess will create a **strong belief system in the learners.**

Kennedy (1998) states that chess develops students' metacognitive abilities so that students can better manage and execute their thoughts. In addition, it builds life skills and critical thinking(cited in Kazemi et.al, 2012). Horgan(1988) also states that chess is a good tool for problem solving, a good way to play, study problem solving and make decisions; because chess is a system that defined by rules. When faced with a problem, the first step is to examine and evaluate the problem as a whole without paying too much attention to detail. In fact, the search for patterns or similarities with previous experiences, similarities of judgments may include the necessary levels of abstract thought. Just as mathematics may be defined as the study of structures, it is also important to know the patterns in chess in order to solve problems. After identifying similarities and patterns, an overall strategy can be developed to solve the problems and generalized if possible. This involves creating alternatives that are a creative process. A good chess player, like a good problem solver, can achieve a wide range of outlines together. Therefore, all available problem-solving methods should be reviewed before implementation so that the most appropriate solution to the problem can be selected and implemented. Good players, like the problem solvers, go back after the strategy is implemented and evaluate the outcome of the strategy in order to increase the level of skill and expertise and, if possible, to find newer ways.

Motivational strategies for learning mathematics

It has been commonly seen that students who very similar in learning ability and aptitude are quite different at academic progress; this difference is not only seen in learning school subjects but it is also seen in other non-academic activities. This aspect of human behavior is related to motivational area. Recognizing the concept of motivation and being aware of different motivation and their effect on students' learning process may help the teacher to use better methods in designing and carrying out her/his own educational programs. The term of motivation can be

defined as a invigorating and director factor and keeping behaviorSaief (2005).
Seifert (2005) pointed out that motivation is a tendency to act in a particular way. Middleton &spanias (1999) assert that motivation is the same personal explanations to act or do some tasks in the forthcoming situations. According to this theory, success or achievement in mathematics is greatly dependent on motivation to do activities. Saief (2005) pointed out that if students have a high level of motivation for the learning subject, then they pay meticulous attention to the teacher, do their homework seriously, searching for more knowledge about their subject matter, and will make much progress. P. (349). Furthermore O'Neil &Driling (1994) asserted that many factors may affect the academic success of the learners, among which motivation and learning strategies have more important roles. Armio (1998) holds that one of the main reasons why teacher select the traditional way of teaching is that students have little or no motivation for learning the subject.he states that when students do not show interest in a subject,This can affect on their performance and attention to the teacher.When a large number of students believe that they can not pass the test,this factor will also affect the teacher. In addition to students' apathy,The teacher is involved in other problems as well (e.g., low income,Low social status, large teacher-pupils ratio, …). These factors make the teacher simply go for the simplest teaching method which is the same as "chalk and talk" and use less educational tools and teaching methods.
Hannula (2006) showed that motivation can be used for behavior orientation and to control feelings. He also asserts that motivation can manifested in three areas: cognition, behavior and feelings. Pantezyar&Philipo (2015) also commented on these three aspects and argued that cognition occurs when the person believes in the nature of assignment, behaviors is manifested when a person owns an effective and consistent strategy to solve problems. Feelings are shown when people feel disappointed at not considering the problems.
Aeschlimann et al. (2016) hold that enhancing motivation conditions, at math and science classes, is a hopeful intervening strategy which ensures that more people are involved in the jobs relating to math, technology and science. Among effective factors on math learning, motivation is one of the effective factors (Lim& Chapman (2015). Various studies have analyzed correlation between motivation and math performance. Herges et al. (2017) come to the conclusion that intrinsic motivation has positive correlation with math performance of students at 6, 7 and 8 grades. The study of Teran&Negoyan (2021) showed that amotivation has negative correlation with math performance. Also, intrinsic motivation, introjected regulation and identified regulation have positive correlation with math performance.

Errors in problem solving

Errors which arise in the process of math learning, can show different ways of student thinking and they should not be considered as wrong way of thinking because these errors are necessary stages for concept development students. Therefore, analyzing students' errors and

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452

their reasons are of utmost importance. Recognizing the errors that students make, can help a teacher to adopt more appropriate approaches to correct his or her way of teaching (Yaftian, 2021).

Although some students have the ability to solve math problems, some others may face difficulty in problem-solving process which leads to some errors. Teachers have constantly tried to understand the nature of student errors, their classification, reasons for their arising so that they may improve their student learning.Batel (2005) asserts that two main types of errors which concern the students are as follows: calculation errors and systematic errors. Calculation errors are the ones that occur due to inattention. When the teacher asks the student to assess his or her answers, or reconsider his own calculations, he realizes his own errors provided that he understands the concept taught. But systematic errors arise due to concept misconception on the part of the leaners and they usually can't recognize and correct them.

Yaftian(2021) assert that, In general, errors are the result of inattention, misinterpretation of symbols or text, poor knowledge of the subject, lack of knowledge or inability in analyzing answers to problems, and misunderstanding.Accordingly, Khalo&Bayaga (2014) hold that recognizing student errors, during problem solving can help improve math teaching. Moreover, Durkaya et al. (2011)assert that knowledge of student errors encourages the teachers to draw back the negative effects of them on their learner math perception. It may also result in recognizing the basis of poor conceptual understanding in the students. Zakarya&Yussof (2009) argue that student errors are not the result of their weakness but they are due to lack of strategies that are used for problem-solving. They come to the conclusion that learners face challenge on perceiving problems and therefore, they can't apply proper strategies for a solution. Furthermore, they attribute student failure to their involvement with problem format and attempt to find a formula to get the answer fast and in a few short stages. They also concluded that the reason of making errors is that learners apply the principles without understanding basic concepts. In this regard, Kilpatrick et al. (2001) assert that math teachers make little efforts to nurture students' ability to develop their effective strategies for solving linguistic problems. In addition, math teachers have not provided good and effective activities for developing problem-solving components like students' coding and interpretation.

There are various methods for analyzing students' errors. One of them is Newman error analysis procedure which includes a systematic way for analyzing the errors that students make in answering written math questions. This is a hierarchal procedure and it is based on the theory that during problem solving, students follow regular mental models that can be divided into distinct stages. Newman was a foreign language teacher who believed that most of the students' mathematics problem solving errors were due to lack of oral skills and improper understanding of the problem, therefore to systematize students' errors in mathematics problem solving, Newman's problem solving procedure was introduced in the mid 1970s which includes five phases and interviews should be used to diagnose students' errors (cited in klemoutus and Elerton, 1995). When Newman (1977) carried out his first research, he found that almost 50% of students' errors in math problem-solving occur before applying processing skills, (that is, in the stage of reading, Comprehension and Transformation). Klements (1996) study is also consistent with that of Newman. He also found that levels of errors in reading, conceiving and converting are greater in lower grades than that of higher grades.In contrast, the level of converting errors and processing skills are greater among higher grades. According to some studies, the greatest errors occur at conceiving and converting stages and the least ones occur at reading and coding stages. In fact, making errors at reading and Comprehension levels relates to poor linguistic knowledge and in Transformation, processing skill and encoding is due to lack of mathematical knowledge. White (2005)holds that by applying Newman error analysis procedure, teachers can recognize and analyze the students' errors and what occurs in their minds and in this way , they can rectify their way thinking. He also believes that teachers have an important role in providing good educational opportunities to prevent making errors or encountering them. If student errors can be considered as one of their learning resources, it may result in enhancing students' learning and efficiency.

Method of Research

The purpose of this study, which is a part of wider study, is to investigate the effect of chess training on motivational strategies for learning of mathematics, students' problem-solving ability, and errors model of mathematics problem solving at various levels of education.

The statistical sample of this study was 180 boy students at fifth, eighth and ninth grades in Sanandaj schools in vest of Iran. At primary school two classes and at junior high school four classes were randomly selected among the schools. Having described the research objectives for the students, 86 students were randomly assigned to experimental group, among whom 28 students were at fifth grade, 27 students at eighth grade and 31 students were at ninth grade. The remaining 94 students were assigned to control group, among whom 29 students at fifth grade, 32 students at eighth grade and 33 students were at ninth grade.

In this study students in experimental group besides doing routine activities of school, were taught chess for six months and two sessions in a week. Totally, the teaching hours were 96. The results of T-test on students' last year mathematics scores in both experimental and control group indicate homogeneity at both groups and significant change was not observed at $P<0.05$; therefore, the condition was good to carry out the study. At the end of training period, MMSLQ questionnaire (Liu & Lin, 2010) was performed on students. This questionnaire includes two sub-scales of motivation and learning strategies. Motivation scale consists of 29 items and investigates students' motivation for learning. The sub-scale includes three components, that are, Value, Expectancy and Affect, and in which value comprises 14 items and is related to tendency to intrinsic and extrinsic goal orientation, and

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452
value of homework. Expectancy includes 9 items and is aboutcontrol beliefs for learning and self-efficiency. Affect also consists of 6 items and is about mathematics anxiety. The reliability of these three components was 0.884, 0.872 and 0.759 respectively. Learning strategy scale includes 37 items and four components of cognitive strategies including (Rehearsal, Elaboration, Organization), metacognitive strategies including (critical thinking and self-regulation), Informational resources management including (Exploratory behavior on internet, Communication behavior on internet) and Non-informational resources Management including (Effort regulation, Time and study environment, Peer-learning, Help-seeking).

The reliability of those four components was 0.921, 0.890, 0.932 and 0.874 respectively. MMSLQ was designed or developed based on Likert five scale items including Strongly disagree, disagree, neutral, agree and strongly agree. Which one assigned the points of 1, 2, 3, 4 and 5 respectively. In this scale, the score mean of each factor is 3. If a subject's score is more than 3 in that factor, it means that the subject's ability is positive and less than 3 means the subject's ability is low in that factor. Given this study was done on Iranian students and these students have limited access to the internet and/or the schools themselves were not equipped with the internet, the component of data resource management was deleted in a questionnaire carried on the students.

To investigate the pattern of students' problem solving errors, in both groups, Newman's procedure of problem solving was used; that is, according to Newman's way of interviewing; each student is given a problem to solve it and the researcher investigates students' errors at different phases of Newman's problem solving procedure. Before starting the interviews, each student was supplied with a flash card included different phases of Newman's procedure and at the time of interviewing with a person the sign X is put on the flash card, by the interviewer, whenever an error takes place. The way of interviewing was such that if on interviewee made any error in any phase of the procedure, no preventive, reforming or reactive response was made on part of interviewer to make him aware of his own error and the interview went on until the subject came up with true or false answer. The Subjects could correct their solutions if they detected errors, but there was no change in the frequency of their previously recorded errors on flash cards.

Following is an example of Newman's procedure which was done by the researcher with one of the fifth grade students. In this interview 'R' for the researcher and 'S' for the student.

Problem: Four builders can build a wall in nine days. If the wall is to be built in six days, how many builders should work together?

Interview process

R: can you read the problem? (Reading level)

S: Yes, and start reading the problem.

R: Tell me what the problem wants you to do? (**Comprehension** level)

S: After a few moments he says: the number of builders and again;

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452
R: Can you tell me which solution or operation you should use to solve the problem? (Transformation level)
S: Proportional way
R: what kind of Proportional?
S: well Proportional!!!
R: Ok. Write down the solution.
S: All right (and starts writing the solution)

4 persons	9 days
x	6 days

It is clear that the error has taken place at Transformation level.
R: Do the Calculations (level of processing skills)

S: x = 6× 4 = 2.6

9

R: Is the answer right or reasonable?
S: Yes!!!
And other interviews were done in the same way.
For fifth grade students the above-mentioned problem was set and put in interview and for ninth and eighth students two problems were selected that are included in the appendix.

Data analysis
In the following tables the students' performance in both groups and in various phases of MMSLQ is summarized.

Table(1): the students' performance in subscales of mathematics motivation

groups	Value						Expectancy				Affect	
	Intrinsic goal orientation		Extrinsic goal orientation		Task value		Control beliefs for learning		Self-efficacy		Test anxiety	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Chess player	2.71	.63	2.84	.85	2.66	.59	3.92	.61	3.38	.63	2.48	.54
Non-Chess player	2.69	.77	2.76	.91	2.70	.48	2.73	.94	2.54	.79	2.95	.81

It is clear from the data in table(1), the mean score of chess player students(experimental group) and those who do not play chess(control group) is almost equal, at three factors, including intrinsic goal orientation, extrinsic goal orientation and task valve, and T-test result did not show significance difference at P<0.05 level. In intrinsic goal orientation (t=0.37, p=0.14) in extrinsic goal orientation (t=0.44, p=0.11) and in Task value (t=0.39, p=0.13). In addition, the data in table(1) show that mean score of the chess player students was more than non-chess players students at factors such as control beliefs for learning and self-efficacy; it also had significant difference at P<0.01 level. At the factor of control beliefs for learning (t=2.93, p=0.001) and in the self–efficacy factor (t=2.75, p=0.005), but in test anxiety factor, the mean score of the non-chess player students was more than chess player students and there is a significant difference at $P<0.05$ (t=-2.41, p=0.02).

Table(2): the students' performance in subscales of mathematics learning strategies

groups	Cognitive strategies						Non-informational resources management								Meta-cognitive strategies			
	Rehearsal		Elaboration		Organization		Effort regulation		Time and study environment		Peer learning		Help seeking		Critical thinking		Self regulation	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Chess player	2.65	.74	2.44	.52	2.79	.78	3.14	.56	3.01	.91	2.55	.42	2.35	.49	3.47	.88	3.94	.87
Non Chess player	2.62	.83	2.50	.67	2.68	.65	2.63	.84	2.75	.83	2.71	.59	2.69	.65	2.59	.95	2.51	.98

It is clear from the data in table(2), the mean score of chess player students is little more than mean score of non-chess player students in rehearsal and organization factors, but T-test result did not show significance difference at $P<0.05$ level. In rehearsal factor (t=0.38, p=0.13)and in organization factor(t=0.47, p=0.11). although the mean score of non-chess player students is little more than mean score of chess player students in elaboration factor, T-test result did not show significance difference at $P<0.05$ level (t=-0.41, p=0.13). In addition, in the factors of effort regulation, time and study environment,critical thinking, and self regulation, the mean score of the chess player students was more than non-chess players and this difference was significant. At the factor effort regulation (t=2.28, p=0.037) in factor time and study environment(t=1.97, p=0.04)in factor critical thinking(t=2.78, p=0.003) and in the factor self regulation(t=3.05, p=0.000). As it is clear from the data in the table(2), among all strategies, chess teaching has the highest effect on increasing or developing meta cognitive strategies. The results show that mean score of the students who had not played chess at factors such as peer learning and help seeking was more than students who were chess players. Although there is no significant difference at Peer learning factor (t=-1.23, p=0.07), in Help seeking

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452
factor the difference is significant at p<0.05(t=-2.11, p=0.04).

Table(3): total score of students in both o scales of MMSLQ

groups	Mathematics Motivation Scale						Mathematics Learning Strategies Scale					
	Value		Expectancy		Affect		Cognitive strategies		Meta-cognitive strategies		Non-informational resources management	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Chess player	2.73	.68	3.65	.79	2.48	.56	2.62	.57	3.70	.71	2.76	.64
Non-Chess player	2.71	.75	2.63	.84	2.95	.73	2.60	.54	2.55	.92	2.69	.70

It is clear from the data in table(3), the mean score of both groups in subscales of value, cognitive strategies and Non-informational resources management is almost equal and T-test result did not show significance difference. In value (t=0.36, p=0.15), in cognitive strategies (t=0.41, p=0.13) and in non-informational resources management(t=0.49, p=0.1). In addition, the data show that mean score of the chess player students was more than non-chess players students at factors of expectancy and meta-cognitive strategies; it also had significant difference at P<0.01 level. At the factor of expectancy (t=2.83, p=0.002) and in the meta-cognitive strategies factor (t=2.88, p=0.001). also in affect factor that is about test anxiety, the mean score of the non-chess player students was more than chess player students and there is a significant difference at P<0.05 (t=-2.41, p=0.02).

In this study to compare the total score of students' MMSLQ, T-test was used. The results show that there is a significant difference between total score of both groupsand performance of chess player students was more than non-chess players (t(178)=2.37, p=0.02). the results are summarized in table(4).

Table(4): the results of T-test to compare the total score of both groups in MMSLQ

groups	**number**	**mean**	**Std. deviation**	**t**	**df**	**Sig(2-tailed)**
Chess player	86	283	13.42	2.37	178	P=0.02
Non-Chess player	94	275	15.07			

In the next part, we will address the analysis of Newman's interviews. The result of interviews analysis showed that 54 students of experimental group and 43 students of control groups were successful at problem solving. The results are given for each group separately inTable(5).

Table(5): The resultof students' performance in problem solving based on Newman's interviews

	EG	KG	SEG		SKG		Successful difference in each grade
			n	%	n	%	
Fifth grade	28	29	18	64.2	13	44.8	19.4
Eighth grade	27	32	16	59.2	15	46.8	12.4
Ninth grade	31	33	20	64.5	15	45.4	19.1
total	86	94	54	62.6	43	45.7	**16.9**

Note: In this table EG is the number of experimental group students(chess player), KG is the number of Control group students(non-chess player), SEG is the number Successful students at experimental group and SKG is the number of successful students in control group.

As it is clear from data in table (5), Experimental group students at each three levels of education, achieved more success in problem solving than students in control group. The amount of progress for fifth grade students was 19.4%, for eighth grade 12.4% and ninth grade students, it was 19.1%.The results showed that, totally, 62.6% of the students at experimental group(chess player students) were successful at problem solving, while this was only 45.7% for control group; therefore, the success of experimental group students at problem solving was 16.9% more than the control group.

The frequency of students' errors in both group and in different phases of Newman Model are shown in tables (6&7).

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 2, 2022, p. 2698-2716
https://publishoa.com
ISSN: 1309-3452

Table(6):The frequency of students' errors in experimental group at different phases of Newman model

	experimental group	reading		Comprehension		transformation		process		encoding		Error mean
		n	%	n	%	n	%	n	%	n	%	
Fifth grade	28	1	3.6	3	10.7	21	75	6	21.4	11	39.2	1.5
Eighth grade	27	0	0.0	4	14.8	13	48.1	14	51.8	10	37	1.52
Ninth grade	31	0	0.0	15	48.3	13	41.9	7	22.6	7	22.6	1.35
Total	86	1	1.2	22	25.6	47	54.6	27	31.4	28	32.5	1.46

Data of table(6) shows that 21 students (75%) at fifth grade commit errors at transformation stage and chose wrong solutions for the problem at first. In fact, high frequency of selecting wrong strategy, is related to the nature of the problem. To solve this problem, the students must use inverse proportion but only 7 students could recognize it quite well. At the end, 11 other students realized their own errors during problem-solving process and changed their own strategy. Moreover, 39.2% of the students made errors at encoding stage and 21.4 % at processing stages committed errors. 10.7% of the students and 3.6% of them committed errors at Comprehension and reading stages respectively.

For eighth grade students, a computational algebraic problem was designed. 13 students (48.1%) made errors at transformation stage. Furthermore, 51.8% of the students committed errors at processing stage and 37% of them at encoding stage did so. High frequency of processing errors relates to the nature of problem computational. Additionally, large numbers of the students made errors at encoding and validation of the answer stage. Also, 14.8% of the students face challenges at Comprehension stage.

A geometrical problem was designed for the ninth grade in which the students were asked to calculate the area of a sphere. In this problem, the greatest errors were on Comprehension stage (48.3%). Also, 41.9% of the students committed errors at transformation stage. In fact, their main challenge was their inability to remember the formula of the sphere area. Besides, 22.6% of the students made errors similarly at processing and enccoding stages.

The data in table(6) shows that error mean of the experimental group students at fifth, eighth and ninth grades was 1.5, 1.52 and 1.35 error for each student respectively, which shows a large number. The reason for large mean of students' errors was that if the students made an error during the interview, the interview was not stoped and committing errors was also possible at other stages of problem-solving. In general, the level of errors of experimental group students at reading, Comprehension, transformation, processing and encoding was 1.2%, 25.6%, 54.6%, 31.4% and 32.5% respectively. It was demonstrated in this study that various problems present different models of errors which are consistent with the results of other research.

Table(7):The frequency of students' errors in control group at different phases of Newman model

	Control group	reading		Comprehension		transformation		process		encoding		Error mean
		n	%	n	%	n	%	n	%	n	%	
Fifth grade	29	1	3.4	4	13.8	23	79.3	11	37.9	15	51.7	1.86
Eighth grade	32	0	0.0	6	18.7	17	53.1	20	62.5	15	46.9	1.81
Ninth grade	33	0	0.0	18	54.5	19	57.5	10	30.3	12	36.3	1.78
Total	94	1	1.1	28	29.8	59	62.8	41	43.5	42	44.8	1.82

Data of table(7) shows that the level of errors of control group students in fifth drade at reading, Comprehension, transformation, processing and encoding was 3.4%, 13.8%, 79.3%, 37.9% and 51.7% respectively. Similar to the students in the experimental group, the control group had the most errors in the transformation and then encoding phase. In addition, for eighth grade students, the level of errors at reading, Comprehension, transformation, processing and encoding was 0.0%, 18.7%, 53.1%, 62.5% and 46.9% respectively.In the eighth grade, the error pattern of students in both experimental and control groups is similar in terms of error percentage in different stages.Also for ninth grade students, the level of errors at reading, Comprehension, transformation, processing and encoding was 0.0%, 54.5%, 57.5%, 30.3% and 36.3% respectively.In the ninth grade, the error pattern of the control and experimental students was not exactly repeated. In fact, in the control group, the highest error statistics are related to the transformation stage (57.5%), and then Comprehension stage (54.5%). Meanwhile,in the experimental group, there is a transformation stage (41.9%) and a Comprehension stage (48.3%).

In general, the level of errors of control group students at reading, Comprehension, transformation, processing and encoding was 1.1%, 29.8%, 62.8%, 43.5% and 44.8% respectively. The data in table(7) shows that error mean of the control group students at fifth, eighth and ninth grades was 1.86, 1.81 and 1.78 error for each student respectively, which shows a large number.The comparison of data in two tables(6&7) shows that mean of the errors of control group students was more than that of experimental group at Comprehension, transformation, processing, and encoding stages and the differences was 4.2%, 8.2%, 12.1% and 12.3% respectively. There was few errors at reading stage and there was little or no difference.

Conclusion

The purpose of this study was to investigate the effect of chess instruction on mathematics motivational strategies for learning (MMSL) and error model of students' problem solving at different level of education based on Newman model. The data analysis showed thatperformance of experimental group studentsin factors of control beliefs for learning, self-efficacy(Expectancy), effort regulation, time and study environment (Non-informational resources Management), critical thinking, and self regulation(Meta-cognitive strategies), is more than control group students and their difference was significant.

The analysis of MMSLQ showed that chess training can increase and develop motivational beliefs and high level thinking skills. Lim &Chapman(2015) assert thatamong effective factors on mathematics learning, motivation is one of the effective factors. Furthermore O'Neil &Driling (1994) asserted that many factors may affect the academic success of the learners, among which motivation and learning strategies have more important roles. .Stipek (2002) asserted When student are compared in terms of motivational beliefs, it should be said that students with high level of motivational beliefs appraise themselves as competent, self-efficient and independent. People, who do not trust in their own ability, may feel incompetent on facing and doing such assignments. In addition, students who confide in their own capability, can solve the problems by focusing on right strategies.Ostovar and Abedi(2016) assert that, College students who use more learning strategies, try to make the information meaningful, to create rational connection with background information, to control the process of learning, and to set right learning environment and by applying these strategies learn the material better and improve their academic performance. In other words, by using metacognitive strategies, the students are aware of their own learning. They often use cognitive strategies and in most cases, they consider homework assignments as a challenge and utilize it as learning opportunity.

In this study results showed that in Help seeking(Non-informational resources Management) and Test anxiety factors(Affect), performance of control group students was more than experimental group and their difference was significant. The possible reason for this difference in factor of Help seeking is that, given the individual nature of chess playing, the students who play chess have learned to rely on themselves and compete up to their utmost efforts, In fact, chess playing enhances self confidence.Also about test anxiety factor,this result shows that chess playing has a role in decreasing anxiety of chess player students. The possible explanation for decreasing stress is that the students' chess players are probably exposed to competition conditions and tolerated various stress and anxiety, so they have learned how to take action and manage themselves or decrease stress.

The result of Newman's interviews showed that students of experimental group at the three grades, were more successful than students of control group in problem solving and in general, achieved 16.9% more progress than control group.Many researchers have shown that chess increases learners' ability to solve math problems((Ferreira and Palhares,2008;Kazemi et al, 2012; Sala et al 2016; Erhanetal,2009; Sigirtmac, 2012; Celone, 2001; Liptrap,1997).

On the reasons for developing problem solving skills, on the part of the chess players, Sala et al (2016) assert that: a) math and chess are isomorphic domains. By playing chess, pure and abstract aspects of math concepts are decreased and math concepts are increasingly managed; b) a chess player should have high level skills such as planning, precise computations, supervision, and abstract thinking. These skills are necessary for math problem solving; c) The ratio of failure and success of a chess player is the result of his mental computations and attempt during the game time and this, in turn, brings about enhancing self confidence and ability of the given person.Trinchiro (2013) holds that attention and concentration of the students can be increased by chess playing. This can justify math problem solving ability on the part of the chess players. In fact, the chess can improve reading capability and proper interpretation of math problems. So the students can apply math knowledge and reflection on his strategies and activities.

The result of Newman's interviews showed that the error mean of problem solving of experimental group at comprehension, transformation, processing, and encoding stages, in three grades, was less than that of control group and the differences was 4.2%, 8.2%, 12.1% and 12.3% respectively. There were few errors at reading stage and there was little or no difference; also interviews analyze showed that various problems create different models of errors.

Yaftian(2021) assert that In general, errors are the result of inattention, misinterpretation of symbols or text, poor knowledge of the subject, lack of knowledge or inability in analyzing answers to problems, and misunderstanding.Kelements(1996) found that making errors at reading and conceiving levels relates to poor linguistic knowledge and in converting, processing skill and coding is due to lack of mathematical knowledge.Zakarya& Yousef (2009) argue that student errors are not the result of their weakness but they are due to lack of strategies that are used for problem-solving. They come to the conclusion that learners face challenge on perceiving problems and therefore, they can't apply proper strategies for a solution. Furthermore, they attribute student failure to their involvement with problem format and attempt to find a formula to get the answer fast and in a few short stages. They also concluded that the reason of making errors is that learners apply the principles without understanding basic concepts.

Discussion

The result of this study showed that chess playing increase and develop motivational beliefs, problem solving ability, high level thinking skills, and decrease of anxiety. The big question is that why does chess playing have growing potential of such valuable qualities? To answer this question we should consider the trend of thinking of a chess player to choose a proper and right movement.

Chess is one of the individual games that is held with no spectator. In comparison with team sports like soccer, volleyball etc... in which the performance and motivation of an individual are influenced by spectators , in chess it is the person himself or herself who should win by trying and will power and nobody has an effect on his or her performance. A chess game includes stress, excitement, anxiety, strong cognitive activity, complex planning, fear of defeat, and in a nutshell , we may call it "**a deafening silence**". In such a position the chess player knows that success (victory) depends on only his or her exact mental calculations and efforts; therefore, they should do their best and work decidedly to achieve victory or success. A chess player should make the best possible choice by full understanding of the position, Identifying all possible movements, and analyzing related variation to each movement. He or she should take all opponents' reaction into account by making any movement and make sure of every movement that he/she may precede. He should ask himself why should I have such a movement? Does this movement lead to any success? If the opponent acts in this or that way would my condition be better or worse? Only when by doing the analysis of all of these cases that would he/she be able to have a movement. It should be note that all of these mental thinking and activity must be in a limited time, since in chess playing each player has a certain time and he/she should come up with a result, otherwise, he/she will be a loser even by having better position. By considering the thinking course of a chess player, It is clear that his/her mental activity include all strategies and top levels of thinking ability such as critical thinking, metacognitive strategies, self-motivation, self-regulation, self-confidence, self-reliance, time management and so on. Naturally, playing with a prominent opponent, Limited time of a game, involving in challenging and complex positions are the factors which bring about sever stress and anxiety in players. As the time goes on, chess players gradually learn how to control their nervous system and stress in various stressful situation like game condition and school tests; they may do so by gaining experience from their previous games.

Reference

1. Aeschlimann, B., Herzog, W., & Makarova, E. (2016). How to foster students' motivation in mathematics and science classes and promote students' STEM career choice. A study in Swiss high schools. International Journal of Educational Research, 79, 31-41. https://doi.org/https://doi.org/10.1016/j.ijer.2016.06.004
2. Allamolhodae, H.(2009) principle of education mathematics. Publisher of future world
3. Aremu, Ayotola, (1998). Motivating Learners for more

effective achievement in mathematics. Nigerian *Journal of Applied Psychology*, 4(1), 27-34.

4. Bart, W. M. (2014). On the effect of chess training on scholastic achievement. Frontiers in Psychology, 5(762). doi:10.3389/fpsyg.2014. 00762.
5. Bottle, G. (2005). Teaching mathematics in the primary school: The essential guide.
6. C Black. (Translated by ShahrnazBakhshalizadeh, 2012). (In Persian)
7. Burgoyne, A. P., Sala, G., Gobet, F., Macnamara, B. N., Campitelli, G., & Hambrick, D. Z. (2016). The relationship between cognitive ability and chess skill: A comprehensive meta-analysis. Intelligence, 59, 72–83. doi:10.1016/j.intell.2016.08.002
8. Celone, James (2001). The Effects of a Chess Program on Abstract Reasoning and Problem-Solving in Elementary. School Children Ann Arbor, MI. Bell & Howell Information and Learning Co.
9. Clements, M. A., &Ellerton, N. F. (1996). Mathematics Education Research: Past, Present and Future. Bangkok, Thailand: UNESCO.
10. Durkaya, M., Aksu, Z., Öçal, M. F., Şenel, E. Ö., Konyalıoğlu, A. C., Hızarcı, S., & Kaplan, A. (2011).
11. Secondary school mathematics teachers' approaches to students' possible mistakes. Procedia-Social and Behavioral Sciences, 15, 2569-2573.
12. Hannula, M. S. (2006). Motivation in mathematics: Goals reflected in emotions. Educational Studies in
13. Mathematics, 63(2), 165-178. https://doi.org/10.1007/s10649-005-9019-8 .
14. Herges, R. M., Duffied, S., Martin, W., &Wageman, J. (2017). Motivation and achievement of middle school mathematics students. The Mathematics Educator, 26(1), 83-106. https://ojs01.galib.uga.edu/tme/article/download/2027/1932
15. Horgan, D., (1988). Where experts come from. Paper presented at the Annual Meeting of the Decision Sciences Institute, Lincoln, NE.
16. Jerrim, J., Macmillan, L., Micklewright, J., Sawtell, M., & Wiggins, M. (2016). Chess in schools:. Evaluation report and executive summary. Education Endowment Foundation. Retrieved from https:// educationendowmentfoundation.org.uk/public/files/Projects/ Evaluation_Reports/EEF_Project_ Report_Chess_in_Schools.pdf.
17. Kazemi, F., Yektayar, M., & Abad, A. M. B. (2012). Investigation the impact of chess play on developing meta-cognitive ability and math problemsolving power of students at different levels of education. Procedia Social and Behavioral Sciences, 32, 372–379. doi:10.1016/j.sbspro. 2012.01.056
18. Kilpatrick, J., Swafford, J., &Findell, B. (2001). Adding it up: Helping Children Learn

Mathematics. Washington DC: National Academy Press.

19. Khalo, X. &Bayaga A. (2014).Underlying factors related to errors in financial mathematics due to incorrect or rigidity of thinking, The Journal for Transdisciplinary Research in Southern Africa, 10(3), 340-354.
20. Lim, S. Y., & Chapman, E. (2015b). Identifying affective domains that correlate and predict mathematics performance in high-performing students in Singapore. Educational Psychology, 35(6), 747-764. https://doi.org/10.1080/01443410.2013.860221
21. Liu, E.Z.F; Lin, C.H.(2010) the survey study of mathematics motivated strategies or learning questionnaire for grade 10-12 Taiwanese students. The Turkish Online Journal of Educational Technology – April 2010, 9 (2).
22. Middleton, J. A. &Spanias, P. A. 1999. "Motivation for achievement in mathematics: Findings, generalization and criticism of the research", *Journal for Research in Mathematics Education*, 30(1), 65–88.
23. O'Neil, J. R., & Drillings, M. (1994). *Motivation: theory and research*. Hillsdale, New Jersey Hove.
24. Pantziara, M., &Philippou, G. N. (2015). Students' motivation in the mathematics classroom. Revealing causes and consequences. International Journal of Science and Mathematics Education, 13(2), 385-411. https://doi.org/https://doi.org/10.1007/s10763-013-9502-0
25. Sala, G., &Gobet, F. (2016). Does chess instruction improve mathematical problem-solving ability? Two experimental studies with an active control group.A three-group design to control for placebo effects. Proceedings of the 38th Annual Meeting of the Cognitive Science Society.
26. Sala, G., &Gobet, F. (2016). Do the benefits of chess instruction transfer to academic and cognitive skills? A meta-analysis. Educational Research Review, 18, 46–57. doi:10.1016/j.edurev.2016.02.002
27. Sala, G., &Gobet, F. (2017c). Working memory training in typically developing children: A meta-analysis of the available evidence. Developmental Psychology.doi:10.1037/dev0000265.
28. Salih Hasan, Soltanian, W; Ghaderi, H. (2019) The Effect of Metacognitive Teaching Method on Student's Conceptual and Procedural Problem Solving Ability in Engineering Mathematics. Indian Journal of Science and Technology, Vol 12(20).
29. Seifert, K. (2005). Learning about peers: A missed opportunity for educational psychology. The Clearing House, 78(5), 239-243.
30. Trinchero, R. (2013). Can chess training improve Pisa scores in mathematics? An experiment in

Italian primary schools. Kasparov Chess Foundation Europe. Retrieved from www. kcfe.eu/sites/default/files/Trinchero_KCFE.pdf Metacognition in Learning and Instruction, pp. 33-67, Dordrecht , --Netherlands : Kluwer.

31. Tran, L.T; Nguyen, T.S.(2021) MOTIVATION AND MATHEMATICS ACHIEVEMENT A VIETNAMESE CASE STUDY. Journal on Mathematics Education Volume 12, No. 3, September 2021, pp. 449-468
32. White, A. L. (2005). Active mathematics In classrooms: Finding out why children ake mistakes-and then doing something to help them. Square one,15(4), 15-19.
33. Yaftian, N,(2021) Evaluating the errors of fourth grade students based on Newman analysis model in solving mathematical problems. Journal of Research in Teaching. Vol 8, No 4, Winter 2021
34. Zakaria E, Yusoff N, 2009. Attitudes and Problem-Solving Skills in Algebra among Malaysian Matriculation College Students. European Journal of Social Sciences, 8(2), 232-236.