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Research Article

Investigation of the effect of Go (Baduk) education on problem solving processes and thinking styles*

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Abstract

According to the report published by the World Economic Forum in 2020, the top five skills that will be needed most in 2025 are analytical thinking and innovation, active learning and learning strategies, complex problem solving, critical thinking and analysis, creativity, originality, and initiative. Problem-solving has always been among the essential skill areas an individual needs to develop. On the other hand, mathematics is important in developing this skill by providing logical thinking and reasoning ability. For this reason, the research's primary purpose is to examine the effect of the Go game instructional design, which was prepared by taking into account the problem-solving steps of Polya, on the students' problem-solving processes and thinking styles. A quantitative research method, a single group pre-test-post-test design, was used to achieve this aim. When the literature is examined, it has been seen that the Go (Baduk) education program and curricula, which are widely played in Asian countries, are included in their curricula. Still, although various tools are used in teaching mathematics with games in Turkey, the Go strategy game was used for the first time in this study. 18 volunteer elementary mathematics teacher candidates participated in the research in the summer term of 2021. The study used Cable Reel and Airplane Boarding Activities, Thinking Styles Scale, and opinion form as data collection tools. The data obtained as a result of the study were analyzed statistically. When the findings that emerged as a result of the analysis are interpreted, it can be stated that the GO education process has a positive effect on the problem-solving skills of teacher candidates

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Introduction

The game of Go, considered one of the oldest intelligence games, dates back to 4 thousand years ago. According to one rumor, King Yao's purpose was to teach his son Tan Chu discipline and concentration (Barsbey, 2012), while another rumor was to teach astronomy. Recent studies have shown a significant difference between the brain waves of students who play and do not play Go (Ahn, 2010), that it can be used in the treatment of diseases such as Alzheimer's and depression (Lin, 2015). Teaching Go improves students' cognitive functions with attention deficit and hyperactivity disorder (Kim, 2014). However, the fact that it contains more moves than chess and is a game with simple rules but a complex structure could not affect the regions far from the starting point for a long time.

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Although there is information that chess was played in the 2000s BC., it is considered to have emerged in the 6th century AD, and the origin of the first computer to play chess dates back to 1951. However, even though the game of Go was released 4000 years ago, Alphago, artificial intelligence with the algorithm of the game of Go, came out in 2015 and beat the Go player at the Pro level for the first time. This can be explained by the fact that the game has a unique philosophy. The game of Go caught the attention of world chess champion Emmanuel Lasker who said, "If there are aliens, they are probably playing GO." he said. In our country, the game of Go started with the publication of two translations in TUBITAK science journals in 1970 and 1971, and then the METU Go Community was established in 1989 (TGOD, 2016). It has gradually spread to the present day with such a small community. There are 159 active players registered with the Turkish Go Players Association (Rating list of players from TR,2021).

Go, an important strategy and intelligence game are included in the elective courses in secondary schools within the scope of the Intelligence Games Course. The aims of intelligence games lesson are “to enable students to recognize and develop their intellectual potential, to be able to find original and new solutions to the problems they encounter, to make fast and correct decisions, to develop their study skills by creating a competitive environment within games, to create different perspectives, to gain self-confidence, to reason and think logically and to develop a positive attitude towards problem-solving” (TTKB, 2013).

The concepts of "problem-solving" and "reasoning" expressed in the program appear as skills students are expected to have in many different disciplines. Polya (1957) stated problem-solving as reaching the goal most shortly and beneficially, and on top of that, he put forward his studies expressing the steps of problem-solving. In addition, studies have revealed the relationship between problem-solving and reasoning (Chang, 2002, Chang, 2010). Studies showing that students learn to solve problems informally have also taken their place in the literature (Yazgan & Bintaş, 2005). Although there are different ways in the curriculum to help students gain problem-solving and reasoning skills, using the game in this sense makes the job enjoyable for both teachers and students (Anlıak, Dinçer, 2005). People discover playing games before learning to think and make cultural transfers through games before actions such as reading, writing, and speaking (Huizinga, 1938 as cited in Yılmaz 2017). Today's studies show that intelligence games positively affect problem-solving, critical thinking, and creativity (Bottino, Ott, & Benigno, 2009; Demirel, 2015).

Conceptual Framework

When the literature is examined, there are various studies in which intelligence games are used for teaching mathematics (Aydoğdu & Ayaz, 2007; Büyükaşık, 2017; McFeetors & Palfy, 2017; Kwoen, 2016; Şahin, 2019; Ün, 2010). These studies are presented in Baduk (Go) education, especially in the South Korean education system (Kwoen, 2016). In some studies conducted in our country, it has been observed that the effect of chess (Büyükaşık, 2017; Ün, 2010) on problem-solving has been examined. In this study, activities were prepared based on the game of Go, a strategy and intelligence game with much more possibilities than chess. Go, an ancient Chinese game that inspired artificial intelligence algorithms, is a cult game, especially in the Far East. This game inspired the AlphaGo artificial intelligence algorithm development and has been seen as a standard for comparing machine and human intelligence. In this sense, in this study, the effect of Go, a strategy and intelligence game, on problem-solving processes and thinking skills is emphasized. In this sense, it is thought that this study will contribute to the literature in light of the teaching design and the findings on the Go game's problem solving and reasoning skills.

Method

Research Design

In this study, one group pre-test-post-test design, one of the quantitative research designs, was used to examine the effect of Go training on problem-solving processes and thinking styles. Experimental designs are intended to test the cause-effect relationship between variables (Cohen, Manion & Morrison, 2007; Fraenkel & Wallen, 1996). In experimental studies, researchers observe the effects of at least one independent variable on one or more dependent variables. Although there are different experimental designs, a single-group pretest-posttest experimental design was used in this study. Here, an independent variable was applied to a single group, and measurements were made before and after the experiment. The difference between the pre-test and post-test means shows the effect of the independent variable on the dependent variable (Cohen, Manion & Morrison, 2007; Gay & Airasian, 2000). Although the single-group pretest-posttest experimental design is one of the weakest designs among the experimental designs, as Creswell (2012) stated, it

is the nature of the research to prefer the single-group experimental design in studies where a new training module is developed and applied.

Study Group

The research study group was chosen as the appropriate case study group from the purposeful study groups by the purpose of the study and the quantitative methodology taken as the basis. The research focuses on the strategic intelligence game (Go) - problem-solving relationship. Thus, it aims to determine the people and groups that are suitable for the research and easily researched (Creswell, 2012; Sönmez & Alacapınar, 2016). For this reason, the research study group was composed of pre-service mathematics teachers, who will be the most important human factor in delivering mathematics to society. The study group consists of 18 teacher candidates studying in the primary school mathematics teaching language program of 5 different education faculties in Turkey. All of the pre-service teachers in question participated in the research voluntarily.

Practice Process of the Study

Due to the Covid-19 pandemic, the implementation process of the study was carried out using distance education tools. The path followed in this process is shown in Figure 1.

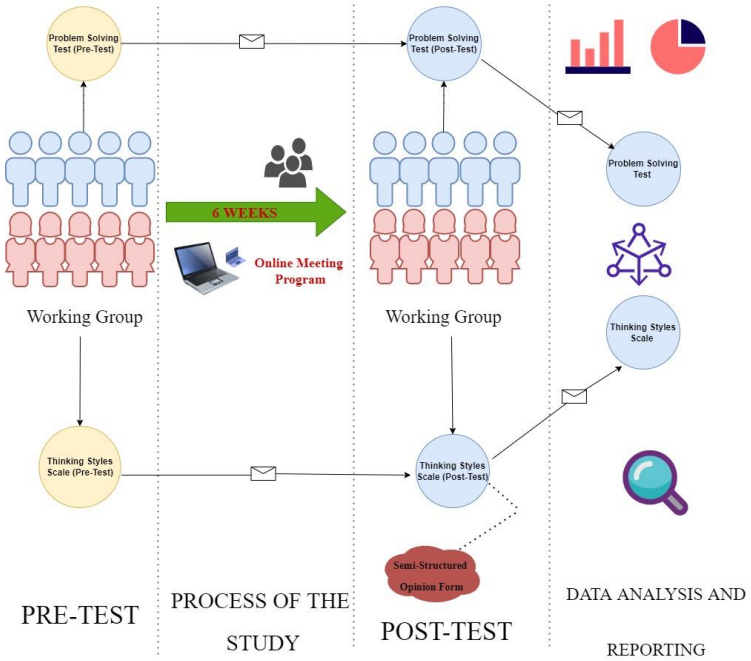

Figure 1. The Path Followed in the Study

The implementation process was carried out in July and August 2021, depending on the process shown in Figure 1. The researchers prepared all activities in the implementation phase. In this regard, the researchers gained experience in the "Teaching Mathematics with Games" course and developed content related to Go (scan the QR code to watch Video 1).

GO Wise Game

Video 1. GO Wise Game

The activities used in this project are the Go strategy game (Baduk) activities prepared by the researchers within the framework of Polya's problem-solving steps. Accordingly, before the implementation phase, the data were collected with pre-tests. The main application continued for six weeks, and in the end, the study was terminated by the post-test application.

In the implementation phase of the study, a remote online meeting program was used. The content was adapted to the digital environment with various web 2.0 tools during the lectures.

Data Collection Tools

Two different data collection tools were used to answer the questions in the research. The first is problem-solving activities, and the other is the thinking styles scale. Information on both data collection tools is given below.

Problem Solving Activities: At this stage, the researchers used the Cable Reel Activity (Föerster & Kaiser, 2010) and the Plane Boarding Activity (Pan, 2007) as data collection tools. These activities have been translated into Turkish by Taşkaya Alim (2018) (Appendix 1 and Appendix 2). An analytical rubric developed by Hollabaugh (1995) and adapted into Turkish by Ünsal and Ergin (2011) was used to score both problem-solving activities. In the rubric in which the four-stage process that Polya brought to the literature was taken into account, the inter-rater reliability coefficient was determined by the Kendall W coefficient. The analytical rubric used is given in Table 1.

Table 1. Rubric Used for Scoring Mathematics Activities

Answer Stages	Criteria to be Used in Evaluation	Score
1. The Process of Understanding the Problem	There is no evidence of an understanding of the problem.	0
	The problem is not understood correctly; the physical description is irrelevant or insufficient.	1
	Some deficiencies in understanding the problem (vector representation, relation, free body diagrams, etc. are missing).	2
	The problem was understood correctly with minor deficiencies (only axes were not named or data was not defined), and a solution plan was started.	3
	The problem was understood correctly (he/she re-expressed the problem in his/her own words with his/her figures and graphics), and the solution plan was started.	4
2. Solution Plan Preparation Process	The solution plan (physical+mathematical) is absent or irrelevant.	0
	The plan is unclear (Which relation to use is not specified or the wrong relation is used)	1
	Planning is ok but contains an error.	2
	Planning is complete. Physical definitions are presented by transforming them into appropriate mathematical forms (Granted and desired ones are determined; these are made available to develop solutions, and the relationships, formulas, and algorithms to be applied are determined)	3
3. Implementation Process of the Plan	There is no evidence that a solution plan or a solution has not been reached.	0
	There is an answer, but the wrong strategy was applied.	1
	The correct relationship has been established, the formula or algorithm has been tried, the necessary tables have been created, graphs have been drawn, and a solution has been tried.	2
4. Evaluation Process	The path and result are both wrong.	0
	The path is wrong, but the result is correct.	1
	The path to go is correct, but the result is wrong.	2
	The path to go is correct (even when an obstacle is encountered, mathematical bounds and other relations lead to the solution), but it contains an error (such as a unit error).	3
	Perfect complete answer.	4
Total	The highest score possible:13	

Thinking Styles Scale: Thinking Styles Scale, Epstein et al. (1996; cited in Invention, 2003) to measure the individual differences that people show in the intuitive-experiential and analytical-rational ways of thinking they use in information processing. The scale consists of 31 items and two sub-dimensions (Appendix 3). The scale was adapted into Turkish by Invention (2003). As a result of the applications performed to determine the test-retest reliability of the scale with language equivalence (n=115), the internal consistency reliability of the scale was found to be .75 for Cognitive Need and .80 for Intuitive Belief. As a result of item-test correlations, two items that disrupted the additive feature of the scale were removed from the scale. As a result of factor analysis, it was seen that all items in the scale were collected in their

respective subscales. As a result of these analyzes, the scale was made ready for use with 29 items. Thus, the number of items in the Need for Cognition subscale decreased to 18, and the score range to 17-85 (Buluş, 2003).

Opinion Form: It is aimed to support the quantitative data with the semi-structured opinion form prepared by the researchers. The opinion form was distributed to the participants along with the post-tests. It aimed to determine their thoughts about the process and support the study's quantitative data with qualitative data to analyze the findings in-depth.

Analysis of Data

Wilcoxon Sequential Signs test, one of the non-parametric analysis methods, was used to analyze the data in the first two problems of the study. This is because the number of students participating in the study was less than 30. In addition, before the analysis phase of the second problem, the Kendall W reliability coefficient between raters was calculated (TabachnickandFidell, 2014; Mertler & Vannatta, 2005; Thode, 2002).

Findings

In this section, the results of the analysis of the sub-problems are prepared to answer the research problem and comment on these results.

Problem: What is the effect of the learning process of the Go game on the thinking styles, problem-solving styles, and problem-solving skills of primary school pre-service mathematics teachers?

In order to seek an answer to this problem situation, the following sub-problems have been answered.

First Sub-Problem: How did the primary school mathematics teacher candidates' problem-solving styles scores change during the learning process of the Go game?

In order to find an answer to the first sub-problem, Wilcoxon signed-rank test was applied to the data collected from 18 pre-service teachers before and after the study. The data obtained are given in Table 2.

Table 2. Wilcoxon Signed-Rank Test of pre-and post-training problem-solving styles scores

Problem Solving Styles Scores	n	Rank Average	Rank Sum	z	p
Negative Rank	6	10.33	62	-0.310	0.756
Positive Rank	10	7.40	74		
Equal	2				

When Table 2 is examined, it is seen that the mean rank of negative (10.33) is higher than the mean positive rank (7.40). Analysis results show that this difference before and after the training is not statistically significant ($z=-0.310$, $p > 0.05$).

Second Sub-Problem: How did the primary school mathematics teacher candidates' thinking style scores change during the learning process of the Go game?

In order to find an answer to the second sub-problem, Wilcoxon signed-rank test was applied to the data collected from 18 pre-service teachers before and after the study. The data obtained are given in Table 3.

Table 3. Wilcoxon Signed-Rank Test Results of pre-and post-education thinking styles scores

Thinking Styles Scores	n	Rank Average	Rank Sum	z	p	d
NegativeRank	5	6	30	-2.421	0.015	1.39
Positive Rank	13	10.85	141			
Equal	0					

When Table 3 is examined, it is seen that the mean rank of positive (10.85) is higher than the mean negative rank (6). This finding indicates an increase in favor of post-experimental thinking style scores. Analysis results show that this difference before and after the training is statistically significant ($z=-2.421$, $p < 0.05$). In other words, after the pre-experimental measurement, the experimental procedure was meaningful, and the students' thinking styles increased their scores. The calculated effect size value indicates that the training process has a high effect ($d = 1.39$).

Third Sub-Problem: How did the primary school mathematics teacher candidates' scores on problem-solving skills change during the learning process of the Go game?

Here, two problems (cable reel and airplane riding) were used, and three experts evaluated the problems with a rubric. For this purpose, the findings related to the rater reliability of the problems used as pre-test and post-test, and then Wilcoxon sequential sign test results are given.

Findings Related to Airplane Riding Activity: Kendall's W coefficient, which shows the agreement between the pre-test and post-test scores given to 18 students by three raters separately for each criterion in the airplane riding activity, is given in Table 4.

Table 4. Pre-Post-Test Kendall's W agreement Coefficient for the Criteria

	Pre-Test			
	The Process of Understanding the Problem	Solution Plan Preparation Process	Implementation Process of the Plan	Assessment Process
Kendall's W Coefficient of Fit	0.942*	0.868*	0.807*	0.960*
	Post-Test			
	The Process of Understanding the Problem	Solution Plan Preparation Process	Implementation Process of the Plan	Assessment Process
	0.981*	0.908*	0.913*	0.965*

*p<0.01

When Table 4 was examined, it was found that the coefficients of agreement between the scorers' scores for each criterion were between 0.807 and 0.981 for the pre-test and post-tests, and all values were statistically significant. When the values are interpreted in general, it can be said that there is a high level of agreement between the raters according to the criteria of VonEye and Mun (2005).

The rater agreement between the pre-test and post-test total scores is given in Table 5.

Table 5. Inter-rater Kendall's W Coefficient Calculated for Total Scores

Total Scores	**Kendall's W Coefficient of Fit**
Pre-Test Total Score	0.919*
Post-Test Total Score	0.974*

*p<0.01

When Table 5 is examined, the coefficient of agreement between the three raters according to the total scores obtained from the pre-test and post-test was calculated as 0.919 for the pre-test and 0.974 for the post-test. This value was found to be significant. This value shows that the agreement between raters is high. Kendall's fit statistics was highly significant for three raters in both tables, a technique in which agreement is calculated by considering rank differences. This finding can be interpreted as the raters showing a high similarity in ranking the individuals.

The result of comparing the mean scores of the three raters for the airplane boarding activity in terms of pre-test and post-test scores with the Wilcoxon Sequential Sign test is presented in Table 6.

Table 6. Wilcoxon Signed Ranks Test Results of Pre-And Post-Training Flight Efficiency Scores

Airplane Riding Event Points	**n**	**Rank Average**	**Rank Sum**	**z**	**p**	**d**
Negative Rank	1	1.50	1.50	-3.565	0.000	3.1
Positive Rank	16	9.47	151.50			
Equal	1					

When Table 6 is examined, it is seen that the mean rank positive (9.47) is higher than the mean negative rank (1.50). This finding is an indication that there is an increase in favor of airplane riding activity scores after the experiment. Analysis results show that this difference before and after the training is statistically significant ($z=-3.565$, $p < 0.05$). In other words, the experimental procedure performed after the pre-training measurement effectively increased the students' airplane riding activity scores. The calculated effect size indicates that education has a high effect ($d = 3.1$).

When Table 6 is examined, it is seen that the mean rank positive (9.47) is higher than the mean negative rank (1.50). This finding is an indication that there is an increase in favor of airplane riding activity scores after the experiment. Analysis results show that this difference before and after the training is statistically significant (z=-3.565, p < 0.05). In other words, the experimental procedure performed after the pre-training measurement effectively increased the students' airplane riding activity scores. The calculated effect size indicates that education has a high effect (d = 3.1).

Findings on Cable Roller Activity: Kendall's W coefficient, which shows the agreement between the pre-test and post-test scores given to 18 students by three raters separately for each criterion in the scoring of the cable reel efficiency, is given in Table 7.

Table 7. Pre-Post-Test Kendall's W Agreement Coefficient for the Criteria

	Pre-Test			
Kendall's W Coefficient of Fit	The Process of Understanding the Problem	Solution Plan Preparation Process	Implementation Process of the Plan	Assessment Process
	0,792*	0,851*	0,883*	0,809*
	Post-Test			
	The Process of Understanding the Problem	Solution Plan Preparation Process	Implementation Process of the Plan	Assessment Process
	0,849*	0,903*	0,964*	0,890*

*p<0.01

When Table 7 was examined, it was found that the coefficients of agreement between the scorers' scores for each criterion were between 0.792 and 0.964 for the pre-test and post-tests, and all values were statistically significant. When the values are interpreted in general, it can be said that there is a high level of agreement between the raters according to the criteria of VonEye and Mun (2005).

The rater agreement between the pre-test and post-test total scores is given in Table 8.

Table 8. Kendall's W coefficient between Raters Calculated for Total Scores

Total Scores	**Kendall's W Coefficient of Fit**
Pre-Test Total Score	0,879*
Post-Test Total Score	0,917*

*p<0.01

When Table 8 is examined, the coefficient of agreement between the three raters according to the total scores obtained from the pre-test and post-test is 0.879 for the pre-test; for the post-test, it was calculated as 0.917, and this value was significant. This value shows that the agreement between raters is high.

Kendall's fit statistics, a technique in which agreement is calculated by considering rank differences, was highly significant for three raters in both tables. This finding can be interpreted as the raters showing a high similarity in ranking the individuals.

The result of comparing the mean scores given by the three raters for the cable reel efficiency in terms of pre-test and post-test scores with the Wilcoxon Sequential Sign test is presented in Table 9.

Table 9. Wilcoxon Signed Ranks Test Results of Pre-and Post-training Cable Reel Efficiency Scores

Cable Roller Activity Point	**n**	**Rank Average**	**Rank Sum**	**z**	**p**	**d**
NegativeRank	2	3	6	-3.219	0.001	2.33
PositiveRank	14	9.29	130			
Equal	2					

When Table 9 is examined, it is seen that the mean rank of positive (9.29) is higher than the mean negative rank (3). This finding indicates an increase in favor of the cable reel efficiency scores after the experiment. Analysis results show that this difference before and after the training is statistically significant (z=-3.219, p<0.05). In other words, the experimental procedure after the pre-training measurement was effective and increased the students' cable reel activity scores. The calculated effect size indicates that education has a high effect (d = 2.33).

Fourth Sub-Problem: What are the opinions of primary school mathematics teacher candidates regarding the Go game learning process?

The opinions of the prospective teachers about the Go training given were as follows:

S1 (Student 1): It was an excellent opportunity to learn the game of Go. Playing with different people helped you gain experience.

S2: It was an instructive process, as we had the opportunity to play online, and the event was designed in stages. I also liked that the philosophy of GO was mentioned during the games.

S3: It was nice that it was fun, wanted competition, and made people think.

S4: If we had solved more GO problems suitable for understanding the game, we could have planned our moves more predictably during the game.

S5: Everyone entered the online meeting program simultaneously, getting very confusing. Longer-term planning could have been done. Instead, separate meeting rooms could be built by dividing them into two groups.

S6: It would be good if we put it into practice by just playing a little more.

When examined in general, there are positive effects of learning Go and evaluations that the process is beneficial. Pre-service teachers negatively stated that the education process is complicated due to the distance, which is short. It has been determined that an educational process that will be carried out by emphasizing the teaching and philosophy of the game will be beneficial for strategic development.

Discussion and Conclusion

Go, the intelligence game focused on strategy development; It is a game for improving decision-making, problem-solving, and empathy skills (TGOD,2002). Go is not different from solving a persistent problem methodologically (Aksüt,2018). This research sought the question, "What is the effect of learning the Go game on the thinking styles, problem-solving styles, and problem-solving skills of primary school mathematics teacher candidates?". For this purpose, within the scope of the research, at the end of a 6-week Go training process with primary school mathematics teacher candidates, how the problem-solving skills of the game and the thinking styles of the individual towards the problem change were examined the pre-test-post-test method. As a result of the analysis made for the first sub-problem, "How did the problem-solving styles scores of primary school mathematics teacher candidates change during the learning process of the Go game?", it shows the difference between pre-and post-training is not statistically significant.

The analysis results for the second sub-problem, "How did the thinking styles scores of primary school mathematics teacher candidates change during the learning process of the Go game?" show that this difference emerged before and after the education was statistically significant. The experimental procedure after the pre-experimental measurement was meaningful, and the students' thinking styles increased their scores. The calculated effect size value shows that the training process has a high effect.

The analysis results for the third sub-problem, "How did the primary school mathematics teacher candidates' scores on problem-solving skills change during the learning process of the Go game?" show that this difference emerged before and after the education was statistically significant. The experimental procedure after the pre-training measurement was effective and increased the students' cable reel activity scores. The calculated effect size value shows that education has a high effect.

In the fourth sub-problem, in the question "What are the opinions of primary school mathematics teacher candidates about the learning process of the Go game?", the first of the negative aspects is the short duration of the education. The candidates stated that the Go intelligence game is different and more complicated than other games. This difficulty and process transformation into a problem-solving activity shows that different results can be obtained based on these results.

As a result, Go training, combined with problem-solving using Polya's strategic steps, positively affected the candidates' problem-solving skills and thinking styles. However, it took as little as six weeks. However, it could not be effective in the concept of the problem-solving method called problem-solving style. The main reason for this is the short six weeks of training. Another reason is that it can be interpreted as a result of each candidate trying to use the steps of Polya given for the problem-solving style (the style in foreign literature and method in some Turkish literature). However, it is known that Go game players of different levels solve Go problems in different styles and make different decisions for each move. (Aksut, 2018). This is undoubted because there are endless options for a move in Go (Silver, Schrittwieser & Simonyan, 2017).

Recommendations

Considering that Go is seen as a critical artificial intelligence problem and is used as a method by which the human mind can be analyzed, creating the infrastructure in which this basic information can be used will benefit the development of intelligence games training and problem-solving activities. New results can be obtained by conducting more extensive research on this subject.

- With the support of the Ministry of National Education, Go courses, such as the courses opened for the game of chess, can be opened, and the students can observe their interest in the game by teaching Go to the willing students.
- Since there is no Go game-focused study in Turkey, studies can be conducted with students whose participants are at the secondary-high school level. Studies can be continued in problem-solving, innovative thinking, and strategic thinking skills. In this direction, it will be ensured that individuals gain competence in 2025 skills mentioned in the world economic forum.
- New results can be obtained by examining the philosophy and approaches of the game of Go in the fields of software and education by examining the studies of Far East countries on AlphaGo and artificial intelligence, inspired by the old game of the world, Go.
- There are no Pro level Go players in our country, but more extensive work can be done with professional Go players.

Ethics Committee Approval

Ethical permission was obtained from the Süleyman Demirel University Social and Human Sciences Ethics Committee for this research (Date of Decision: 28.06.2021; Number of Decisions: E-87432956-050.99-73704). All the rules in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were followed in this research. None of the actions in "Ethics Actions Against Scientific Research and Publication " were carried out.

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