RedFame
Journal of Education and Training Studies
Vol. 8, No. 3; March 2020
ISSN 2324-805X E-ISSN 2324-8068
Published by Redfame Publishing
URL: http://jets.redfame.com

Comparison of Sudoku Solving Skills of Preschool Children Enrolled in the Montessori Approach and the National Education Programs

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Received: November 22, 2019 Accepted: January 13, 2020 Online Published: January 16, 2020

doi:10.11114/jets.v8i3.4620 URL: https://doi.org/10.11114/jets.v8i3.4620

Abstract

According to Johnson-Laird (2010), sudoku, a mind game, is based on a pure deduction and reasoning processes. This study analyzed sudoku solving skills of preschool children and to ascertain whether there was a difference between children who were educated according to the Ministry of Education preschool education program and the Montessori approach. Sudoku skills of children were analyzed by gender, age, duration of preschool attendance, mother's and father's education level and previous experience of playing sudoku using a 12-question Sudoku Skills Measurement Tool developed for this research study.

The study sample of the study consisted of 118 children (57 girls, 61 boys) aged between 54-77 months. The findings showed that there was no significant difference in sudoku skills by gender. However, sudoku skills varied with age (54-65 months and 66-77 months) in favor of older groups. Children's sudoku skills were more developed with an increase in education level of either parent. Children who had been in preschool for longer had higher sudoku scores. A previous experience of playing sudoku did not impact sudoku scores. Sudoku skills of children who were educated according to the Montessori program were more developed compared to those of children educated according to Ministry of National Education program.

Keywords: preschool, children, sudoku, Montessori

1. Introduction

By nature, human beings tend to discover, recognize and explore their surroundings. For the human mind to make and maintain this discovery effectively, individuals have foster themselves and their minds regularly (Feez, 2010). A child portrays the things that he/she cannot immediately perceive in his/her mind by creative thinking and imagination. This imagination, coupled with the organization of images and information in the mind, begins to form the basis of reasoning skills and logical reasoning (thinking) skills (Feez, 2010). Reasoning is the process of proving the truth based on evidence, beliefs and ideas at hand (Leighton, 2004).

Inductive reasoning, is central to a child's developmental stages as it has a central position in judgemental thinking processes, problem solving and decision-making. It also affects a child's ability to learn in kindergarten and school (Josman & Jarus, 2001). Inductive thinking is also considered a prerequisite for understanding mathematics and science and also plays a role in cognitive processes (deChantal & Markovits, 2017). Schunk (2009) stated that inductive reasoning in children is first seen at the age of eight.

Deductive reasoning, in the most general sense, means reaching a conclusion based on facts. It is also defined as the process of switching from a universal proposition to a particular proposition, from laws to events, and from factor to effect (Guncel Turkçe Sozluk). Deductive thinking is one of the main components of cognitive development in learning processes (deChantal & Markovits, 2017). The use of deductive reasoning processes has been observed in young children. A review of the deductive inferences of children indicated that a correct logical process took place and the final inference was quite logical and correct (deChantal & Markovits, 2016; Ergul, 2014; Niklas, Cohrssen & Tayler, 2018).

Piaget (2007) describes the intuitive period (4-7 years), in which reasoning skills are acquired, as the transition period to logical thinking. According to Piaget, even at the age of seven or eight years, a child cannot reason properly. This can be done only when he/she attains the age of 11-12 years. In contrast to Piaget's view, researchers believe that even before the age of 3 years, children understand temporal and causal connections related to reasoning (Amsterlaw & Wellman, 2006;

Bauer &Thal, 1990; O'Connell & Gerard, 1985; Woodward, 2009; Zampini, Suttora, D'Odorico, & Zanchi, 2013). In the process of development, reasoning accelerates, and the child is able to treason on more complex issues.

1.1 Mind (Intelligence) Games

Mind (intelligence) games are activities that enable people to realize their own potential, make quick and correct decisions, produce original solutions in the face of problems, and most importantly, constantly renew themselves (Devecioglu ve Karadag, 2014). Mind games require intensive use of reasoning skills (Bottino, Ott, &Tavella, 2013). The desire or need to have fun, and to think while having fun, has paved the way for the emergence and development of mind games since ancient times (Guven, 2004). Backgammon, Hanoi Tower, Chess Game, Scrabble, Anagram, Rubik's Cube, Sudoku, Tangram, Kendoku, Puzzle, Checkers, Word Search are the games that can be considered in this category. Mind games, which became popular with the development of technology in this century, have gained a sectoral dimension and diversity.

Researchers have also observed positive effects (e.g. motivation, attention, cooperative learning) of mind games (especially computer games), in education (Altun, Hazar & Hazar, 2016; Bottino & Ott, 2006; Bottino, Ott, & Tavella, 2013; Gobet, de Voogt, & Retschitzki, 2004; Heiman, 2014). Research studies have shown that elementary school students who played mind games improved their reasoning and problem-solving skills (Demirel&Yilmaz, 2018; Kurbal, 2015) and their long-term academic skills (Bottino, Ott, & Tavella, 2008; Bottino, Ott, Tavella & Benigno, 2006). Experts have spoken about the important effects of mind games on the learning (Kirriemuir & McFarlane 2004; Mitchell &Savill -Smith 2004) and cognitive development (Ghoneim, & Essam, 2012; Sigirtmac, 2016; Turkoglu & Uslu, 2016) of preschool and primary school children. Reiter, Thornton and Vennebush (2014) reported that children could meaningfully reason with numbers and operations thanks to the kenken, a sudoku variant. (Soduko is a well-known game of the mind games family).

Studies conducted with elementary school children have shown enhanced logical thinking skills (Baek, Kim,Yun, & Cheong, 2008) and intelligence test scores (Mackey, Hill, Stone & Bunge, 2011) among children playing mind games. Turkoglu and Uslu (2016) also illustrated that a cognitive development program with intelligence games played by preschool children had a permanent effect on cognitive development of children.

Ministry of Education (MoNE) 'Mind and intelligence games' course was implemented in Turkey as an elective course since 2013-2014. This course aims to develop students' skills such as concentration, reasoning, comprehension, analytical thinking, problem solving and interpretation. The instruction of intelligence games takes place in three levels: beginner, intermediate and advanced. Mind and intelligence games are divided into various categories based on different theories and practices. These games were divided the into 6 parts and the following units were developed: Mind games, operation games, strategy games, mixed intelligence games, word-logic games and mechanical games (MoNE, 2013).

Mind Games: These types of games are games that can be played individually, with paper and pen. They play a special role in intelligence games and also form the basis of competitions. They are logical puzzles that can be solved based on clues, and not by trial and error. At the beginning of the game, all the information necessary to solve the puzzle is given. It may be difficult to decide in which order to use provided clues. Accurate choices made at this point may reduce the time to solve the puzzle; whereas, inaccurate choices can increase the time it takes to solve the puzzle or limit the possibility of solving the puzzle. In mind games, the person who solves the puzzle is not considered to have any particular knowledge or equipment. Each problem has a unique solution. Many games in the forms of table/diagram to be completed with the use of paper and pen or computer are considered mind games. Sudoku and its' derivatives, mathdoku, Camouflage Booster, Castle of Dreams, Intelligence Castle, ColoursLuo La Happy Adventure, Qoridor, The Road Game, Small Engineer, Subway Connecting Stations, Minesweeper, Magic Pyramid,such as games are the examples of this group of games.

1.2 Sudoku

Sudoku is a popular reasoning game that has been around the world in recent years (Aaronson, 2006; Crook, 2007; Lynce & Ouaknine, 2006). From a scientific point of view, some experts treat sudoku as a part of the Constraint Satisfaction Problems category (Musliu & Winter, 2017; Simonis, 2005). Such problems are those that restrict individuals in terms of the values that are not given, but necessitate having a response within the given data.

Sudoku is the abbreviation of "Sunjiwadokushinnikagiru", which means "the numbers must be single" in Japanese (Wilson, 2006; Wu, Zhou, Again, & Noonan, 2016; Wu, 2012). In Japanese, "Su" means number; "Doku" refers to each unit to be filled with the number on the jigsaw board (Baek, Kim, Yun & Cheong, 2008; Das, Bhatia, Puri & Deep, 2012; Garcia & Palomino, 2007). A proper sudoku requires sequential logical reasoning without trials and chances to make mistakes (Eppstein, 2005; Lynce & Ouaknine, 2006). The Sudoku puzzle is based on the idea of Latin Squares by the famous Swedish mathematician Euler, who lived in the 17th century (Haynes, 2008; Levis, 2007; Lee, Goodwin, & Johnson-Laird, 2008). The first sudoku was published in May 1979 by Dell Pencil Puzzles and Word Games under the name "number position". Subsequently, an interest was established in the game and the jigsaw company Nikoli published it in 1984 in its own journals, giving the name "Sudoku". The traditional and widely used sudoku is a number-based puzzle game and it looks like a grid. The most commonly used model consists of 9 main units, where each main unit consists of 3x3 small cells (the total number of sudoku cells is 81) (Fig.1). The objective of the game is to place the numbers 1 to 9 in a non-repetitive manner on each horizontal and vertical unit in the grid (Aaronson, 2006; Crook, 2007; Donavan, Haaland & Nott, 2018; Haynes, 2008; McGuire, Tugemann, & Civario, 2014; Musliu & Winter, 2017; Wilson, 2006). There are several variations of sudoku based on their degree of difficulty (Chiu, Nasiri & Rashid, 2012; Jones, Perkins, & Roach, 2007; Jones, Roach, & Perkins, 2007). For example, there are simple sudoku patterns of 3x3, 4x4, 5x5 without small unit squares for children or beginners. In addition, there are sudoku designs including 6 cells (2x3 or 3x2), 12 cells (3x4 or 6x2) (Jones, Perkins, Roach, 2007) or 16 pcs 4x4 (Chiu, Nasiri & Rashid, 2012). There are also different designs, such as the Samurai sudoku (called Gattai in Japan) (Fig 2).

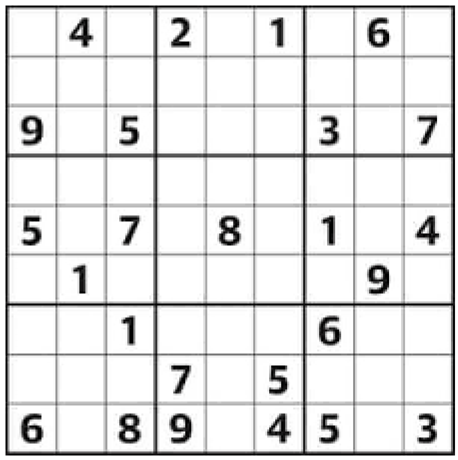

Figure 1. Classical sudoku

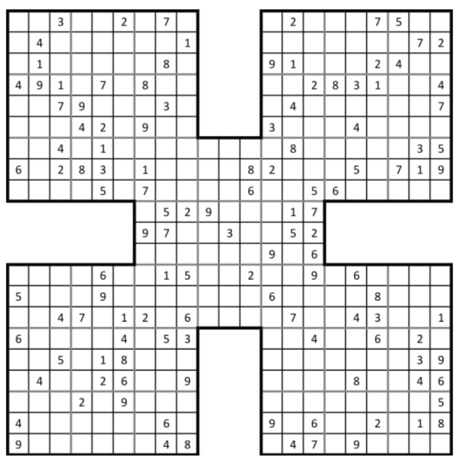

Figure 2. Samurai sudoku (Gattai)

The degree of difficulty of sudoku is determined by the number of cells in total, the number of given cells and their distribution (Jiang, Xue, Li & Yan, 2009). Based on these variables sudokus can be rated as easy, medium, difficult, and very difficult (Das, Bhatia, Puri & Deep, 2012). A sudoku is considered true only when all empty cells are properly filled (Eppstein, 2012) with only one correct completion (McGuire, Tugemann & Civario, 2014).

Sudoku contains skills such as strengthening and exercising memory, attention, planning, reasoning (Altun, Hazar & Hazar, 2016; Grabbe, 2011). According to Johnson-Laird (2010), a cognitive scientist known for his studies of reasoning, sudoku is based on pure deduction and contains reasoning processes. Aaronson (2006) reported that sudoku guided some researchers in the process of developing algorithms through concretization and also contributed to mathematics. Baek, Kim, Yun and Cheong (2008) found that number and symbol-based puzzles had a significant impact on the improvement of cognitive development dimensions and mathematical thinking.

Grossi (2006), in the British Journal of Teachers, stated that the sudoku game, an entertaining learning process, ought to be included in the teaching process (Grossi, 2006; cited in Liao & Shih, 2013).

Recently, researchers and teachers have shown an interest in games used in the classroom and resolved to analyze the functions of different games in child development (Gobet, deVoogt, & Retschitzki, 2004). Additionally, “Sudoku” puzzles, which require reasoning skills, have also drawn the interest of researchers. Scientists have departed from studies on individual thinking to conduct a number of studies investigating creating and solving sudoku at different difficulty levels, (Calimeri, Ianni, Perri & Zangari, 2013; Crook, 2007; Das, Bhatia, Puri & Deep, 2012; Heiman, 2014; Pillay, 2012; Sevgen, Arslan & Samli, 2017; Simonis, 2005; Yato & Seta, 2003). On the other hand, studies that address this subject as a thinking skill are limited. The insufficient number of research studies in preschool education was a key driver to conduct this study was to describe the sudoku skills of preschool children.

1.3 Montessori Approach

Different educational approaches are implemented in preschool education institutions to create favorable conditions that will contribute to the holistic development of children. All these approaches aim to achieve maximum benefit for the child's development and education (Koksal Aksoy & Oguz, 2006; Lillard, Heise, Richey, Tong, Hart, & Bray, 2017). Children's education is supported by different approaches that are widespread around the world. One of these approaches was developed by Maria Montessori who was born in Italy in 1870 and was the the first female doctor in her country. Montessori, who switched her research field from the human body to the human mind, devoted her life to the education of children. During this period, when she was engaged in educational research, she developed her own ideas and created her own educational approach (Durakoglu, 2010; Lillard, 2011).

Montessori argued that each child underwent a unique developmental process and could learn in the context of his/her own orientation and capacity. The child learnt the knowledge not by memorizing but by using his/her own mental skills. For this reason, Montessori concretized the educational environment so that children of all ages could perceive and she also develop a range of materials and methods to convey the educational approach in a harmonious integrity. In a Montessori environment, teachers require students to develop self-regulatory skills to help make suitable choices in their learning environments (Lillard,2011). In this context, children receiving Montessori education are not focused on the concept of success, but are involved in the educational process by analyzing, exploring, making their own choices and steering their mind. In the Montessori model, active learning by the child is essential (Lillard, 2011; Lillard, 2013; Yigit, 2008) to constantly use reasoning, perception, mathematical thinking and problem-solving skills in everyday life and while enrolled in educational institusions.

According to Montessori, the child created his/her own mind by using objects in the environment. She called this type of mind “menteassorbente”. Once the child gained this ability, he/she deliberately and directly explored the environment, established mental relationships, and started to organize knowledge systematically (Durakoglu, 2010; Köksal Akyol & Oguz, 2006). Montessori believed that the child would develop an internal discipline to guide his/her own learning. Within these boundaries, children developed mental discipline by making choices freely and developed the necessary behavioral discipline and emotional self-regulation through self-managed learning. Montessori materials are designed so that a child can see a mistake he/she made. For example, if the child failed to place cubes of the pink tower in the correct order, he/she would not be able to build a tower. This leds him/her to reasoning. In this context, children receiving Montessori education are not focused on the concept of success but they are involved in the educational process by analyzing the process, exploring, making their own choices and directing their mind (Yigit, 2008). Sensory materials are given to the child to explore the world and with the support of these materials, each child begins to classify and organize the observations that his/her mind has previously perceived in accordance with his/her own skills and rhythm (Durakoglu, 2010).

Montessori also believed that the most valid motivation for learning was self-motivation. Children would direct themselves towards learning and they were motivated by the work they did. In this way, they taught themselves (Aydin, 2002; Koksal Akyol &Oguz, 2006). This approach brings to mind a concept named the polarization of attention (concentration). When children did something, they focused on the activity for the sake of their work, not because they had to do it or in compensation for something else; this brought children enjoyment following a task that required deep concentration (Lillard, 2011; Rathunde, 2001).

1.4 The Ministry of National Education (MoNE) Preschool Education Program

The Ministry of National Education (MoNE) Preschool Education Program, an eclectic model implemented in Turkey, was created based on different approaches. Its’ eclectic nature necessitates mastery of different approaches in preschool education programs. In the preschool period, the child's learning is supported by different educational approaches to realize learning. In this period, it is possible to ensure long-term learning, to develop thinking skills and to provide correct guidance in a rich and stimulating environment (Ministry of National Education, 2013).

A review of the research studies has shown that there are studies that have compared the national program to the Montessori approach with varying results (Byun, Blair, & Pate, 2013; Cox & Rowlands, 2000; Durkaya, 2019; Faryadi, 2017; Flynn, 1991; Karnes, Schwedel, & Williams, 1983; Karnes, Teska, & Hodgins, 1970; Lopata, Wallace, & Finn, 2005; Laski &et al., 2016; Pate, & et al., 2014; Toran, 2011; Ongoren, 2008; Yigit, 2008). However, there was no research study analyzing sudoku skills of preschool children and comparing sudoku skills of children educated using to the approach employed by the national program to that of children educated using the Montessori approach. Therefore, the main purpose of this study was to analyze the sudoku solving skills of preschool children and to assess whether there was a difference in sudoku skills between children who were educated according to the MoNE program and Montessori approach. In this context, sudoku skills of children were analyzed in terms of variables such as gender, age, duration of preschool attendance, mother's and father's educational level and previous experience of playing sudoku.

2. Research Methodology

2.1 Study Participants

The study sample consisted of 118 children (57 girls, 61 boys) aged between 54-77 months. At the time of the study, fifty-nine of the children were attending kindergartens in public schools and 59 of them were attending preschool educational institutions that provided education according to the Montessori approach. The average age of children studying in public schools and Montesorri schools was 65.78 months and 67.91 months respectively. The socio-demographic distribution of the study sample is presented below.

The majority of mothers (69.5%) and fathers (79.7%) had a bachelor's degree. As regards preschool children, 36 (30.5%) had been educated for 1 year, 52 (44.1%) for 2 years and 30 (25.4%) for 3 years. The majority of the children (78%) reported not having played sudoku before.

2.2 Materials Used

In this study, the data used to assess sudoku solving skills of children of 5-6-year-old were collected using a sudoku puzzle prepared by the researchers.

2.2.1 Sudoku Skills Measurement Tool

Based on a review of the literature review, pictorially-modified sudoku puzzles of 3x3 and 4x4 grids with only main units (and no subunits) would be suitable for preschool children. In addition, pictorial presentations were used in place of number symbols. While preparing the drafts, sudoku samples of different preschool and primary school programs were reviewed, and the number of pictures to be assigned to the cells and the cells in which the pictures would be placed were determined (Figures 3 and 4). The pictures consisted of a tree, a soccer ball, a clock, a bus and a pencil. In the first stage, a total of 18 sudoku puzzles were prepared, 9 were 3x3 (9 cells) and 9 were 4x4 (16 cells). The 3x3 puzzles had 3 levels of difficulty: 3 blank, 4 blank and 5 blank cells. Similarly, 3 levels of difficulty were also created for 4x4 puzzles: 4 blank, 5 blank and 6 blank cells. A total of 3 puzzles were then prepared for each difficulty level. Then, expert opinions were collected from 4 people (2 preschool teachers and 2 academicians). After all experts gave an "it can be used as it is" approval to the samples, a pilot study was conducted with 8 children. Sudoku puzzles were administered individually in a quiet environment as planned.

During the pilot study, each puzzle took each child at least 20 minutes to complete implying that children were distracted during this period. Upon the consensus of the researchers, to the total number of puzzles was reduced to 12 by decreasing one puzzle from each difficulty level. At this stage, a sample puzzle was added for each child to complete with the researcher. The final version of the puzzle set consisted of one sample sudoku puzzle that the researcher solved with the child, and a set of 12 puzzles consisting of 6 puzzles of 3x3 (9 cells) and 6 puzzles of 4x4 (16 cells) in large puzzle cards of 12x12 and 16x16 cm in size. The small pictorial cards to be placed in the blank cells were 4x4 cm in size to be able to fill the blank cells appropriately. Large sudoku puzzle cards and small cards were printed on cardboard to prevent wear and tear. The cartons were 20x20 cm in size.

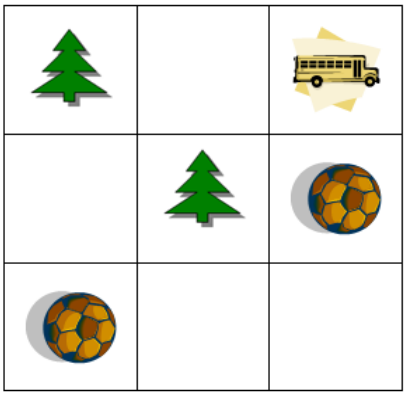

Figure 3**.** 3x3 Sudoku with 4 blanks

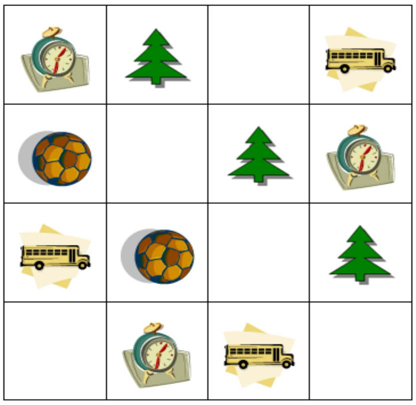

Figure 4.4x4 Sudoku with 5 blanks

Note: A separate form was developed to record the child's demographic information and responses.

2.2.1.1 Validity and Reliability Analysis of Sudoku Skills Measurement Tool

Internal consistency, item total analysis and item discrimination analysis were conducted on the data collected during puzzle administration. After the validity and reliability analysis, difference tests were used to determine the differentiation of the data between the groups.

Cronbach Alpha values were used to check for internal consistency within the scope of the reliability of the scale.

Table 1. Reliability Analysis of Sudoku Skills Measurement Tool

	N	Cronbach's Alpha
3x3 grid	6	.611
4x4 grid	6	.768
Overall	12	.801

In the reliability analysis, the Cronbach Alpha value of the 6-pieces of 3x3 cells, was found to be 0.611, whereas the Cronbach Alpha value of the 6 pieces 4x4 cells consisting was 0.768, and the overall Cronbach Alpha value of the 12 sudoku puzzless was found to be 0.801. The Cronbach Alpha values of the Sudoku skills assessment tool were found to indicate sufficient internal consistency. For the construct validity of the scale, item total and item discrimination analyzes were performed.

Table 2. Item Total Analysis of Sudoku Skills Measurement Tool

		I. Total			I. Total
s1	*R*	.246**	s7	*r*	.668**
	p	.007		*p*	.000
s2	*R*	.619**	s8	*r*	.585**
	p	.000		*p*	.000
s3	*R*	.557**	s9	*r*	.619**
	p	.000		*p*	.000
s4	*R*	.505**	s10	*r*	.605**
	p	.000		*p*	.000
s5	*R*	.635**	s11	*r*	.678**
	p	.000		*p*	.000
s6	*R*	.322**	s12	*r*	.570**
	p	.000		*p*	.000

As can be seen in table2 , as a result of the Item Total Pearson Correlation analysis performed for the construct validity of the sudoku skills assessment tool, the relationship between all items and the item total was found to be significant at p <0.01 level.

Table 3. Item Discrimination of Sudoku Skills Measurement Tool

Item	*group*	*N*	$\overline{X}$	*SD*	*t*	*df*	*P*
s1	bottom27%	32	0.88	0.34	-2.10	31.00	.044
	top27%	32	1.00	0.00			
s2	bottom27%	32	0.28	0.46	-8.90	31.00	.000
	top27%	32	1.00	0.00			
s3	bottom27%	32	0.34	0.48	-6.88	39.17	.000
	top27%	32	0.97	0.18			
s4	bottom27%	32	0.31	0.47	-5.50	56.07	.000
	top27%	32	0.88	0.34			
s5	bottom27%	32	0.09	0.30	-9.87	62.00	.000
	top27%	32	0.88	0.34			
s6	bottom27%	32	0.56	0.50	-2.92	54.01	.005
	top27%	32	0.88	0.34			
s7	bottom27%	32	0.13	0.34	-11.04	62.00	.000
	top27%	32	0.94	0.25			
s8	bottom27%	32	0.22	0.42	-9.31	41.65	.000
	top27%	32	0.97	0.18			
s9	bottom27%	32	0.09	0.30	-8.97	62.00	.000
	top27%	32	0.84	0.37			
s10	bottom27%	32	0.06	0.25	-8.35	50.02	.000
	top27%	32	0.78	0.42			
s11	bottom27%	32	0.06	0.25	-12.40	62.00	.000
	top27%	32	0.91	0.30			
s12	bottom27%	32	0.13	0.34	-9.87	62.00	.000
	top27%	32	0.91	0.30			

In order to test the item discrimination of the Sudoku assessment tool, independent groups t-test was performed to analyze the differences between the 27% group with the highest scores and the 27% with the lowest scores for each of the 12 puzzles among the children participating in the study (Table 3).

As a result of the independent groups t test, a significant difference was observed between the top 27% and the bottom27% groups at p <0.05 level. This finding shows that all questions in the designed sudoku skills assessment tool have the ability to distinguish children according to their skills (Table 3).

2.3 Procedure

Before research implementation, permission was granted from the Ministry of National Education. Research was implemented in schools that approved the research. Initially, researchers were introduced to children by classroom teachers. During the acquaintance phase, researchers showed the children a sample sudoku card and said that the researchers like would play a game called sudoku with the children. The researchers would then continue to work with children who were willing to participate in individual practice sessions.

The administration took place in the following order:

1. The researcher showed the children large sudoku cards and small pictorial cards briefly and reminded the children that the children would play the sudoku game.

2. The researcher then showed the sample sudoku puzzle (3x3) to the child to introduced the rules of the sudoku game and explain to the child what was expected from him/her to do (for example, only 1 of each picture should be placed in a row or column) and the sample sudoku puzzle was solved by guiding the child through the process.

3. When the researcher started practicing with the child, he/she would ask, "How many empty boxes do you see here?"

4. The researcher would then put the pictures required to fill each blank space and one selected different (incorrect) picture in front of the child and ask the child to continue filling the blanks cells with the appropriate small pictorial cards provided.

5. The child would be warned once at each stage, 'You should take care not to put the same pictures side by side and one after the other'.

6. The child was also told "You can continue to solve until you say, "Okay, it's done"; but don't forget to check before you say "done".

7. The child was allowed to complete each sudoku in 60 seconds. However, the child was unaware that this time was being tracked (this period was set by identifying the longest time that children spent solving sudoku puzzles during the pilot study).

8. The child would then continue to solve the sudoku puzzle until he/she would say "Okay, it's done".

9. If the process had exceeded 60 seconds and had not been completed, it was automatically considered incorrect.

10. If the child finished within sixty seconds, the answer was noted as true (1) or false (0). No feedback was given (e.g. well done, bravo, it's wrong, check it out). The child would then start another puzzle.

11. After completing all sudoku puzzles, the child would be asked if he/she had played such a game before.

12. When the trials were completed, researcher informed the child that the game was over, thank the child for participating and escort the child back to his/her classroom.

The application lasted approximately 15 minutes for each child.

3. Results

The distribution of the data was assessed to determine the analyses method to be used. The distribution of the data collected from the sample was evaluated using skewness and kurtosis indicators. Skewness of the data was found as -0.34 (se = 0.22) and kurtosis was -0.82 (se = 0.44). Since the skewness and kurtosis values were between -1 and +1 (Demir, Saatcioglu, & Imrol, 2016) (kurtosis of the 4x4was -1.30), the distribution of the data was considered and parametric tests were used. (Table 4).

Table 4. Normality and Descriptive Findings of the Data

	3x3	4x4	Overall
Min.	0.00	0.00	0.00
Max.	6.00	6.00	12.00
X	4.10	3.19	7.29
SS	1.55	2.03	3.16
Median	4.00	3.00	8.00
Range	6.00	6.00	12.00
Skewness	-0.57	-0.13	***-0.34***
Se	0.22	0.22	0.22
Kurtosis	-0.42	-1.30	***-0.82***
Se	0.44	0.44	0.44

The mean score obtained from 3x3 sudoku puzzles was 4.10 (SD = 1.55) and from the 4x4s puzzles was 3.19 (SD = 2.18). This reflected the difficulty level between 3x3 and 4x4 sudoku puzzles as initially intended. The overall mean score in the study was 7.29 (SD = 3.16).

Table 5. Differentiation of Sudoku Skills by Gender

	Gender	N	$\overline{X}$	Std. Dev.	T	p
3x3 grid	Girl	57	4.30	1.51	1.33	.185
	Boy	61	3.92	1.58		
4x4 grid	Girl	57	3.42	1.98	1.22	.225
	Boy	61	2.97	2.06		
Sudoku overall	Girl	57	7.72	3.08	1.44	.153
	Boy	61	6.89	3.21		

There was no significant difference was observed based on the child's gender (t (116) = 1.33 for 3x3 (p>0,05), t (116) = 1.22 for 4x4 (p>0,05) and t (116) = 1.44 for overall (p>0,05). (Table 5)

Table 6. Differentiation of Sudoku Skills by the child's Age group (Months)

	Agegroup (Month)	N	$\overline{X}$	Std. Dev.	T	p
3x3 grid	54-65	49	3.73	1.73	-2.154	.033
	66-77	69	4.35	1.36		
4x4 grid	54-65	49	2.55	1.94	-2.966	.004
	66-77	69	3.64	1.98		
Sudoku overall	54-65	49	6.29	3.35	-2.975	.004
	66-77	69	7.99	2.83		

Sudoku skills were more developed in older children (t (116) = 2.154 for 3x3 p <0.05, t (116) = 2.966 for 4x4p <0,05 and t (116) = 2.975 for overall p <0.05 (Table 6).

Table 7. Differentiation of Sudoku Skills by mother's level of education

	N	$\overline{X}$	SD	Sof V	Ss	Df	Mean Square	F	p
Primary school graduate	5	4.20	3.03	Between groups	61.41	2	30.71	3.18	.045
High school graduate	31	6.90	3.24	Within Group	1108.79	115	9.64		
Bachelor's degree	82	7.62	3.06	Overall	1170.20	117			
Overall	118	7.29	3.16						

ANOVA test showed an increase in sudoku score with the mother's education level; this was statistically significant at p <0.05 level. Post hoc LSD test was performed to determine if there was a difference between the groups. A significant difference was observed between children of primary school graduate mothers ($\overline{X}$ = 4.20) and children of mothers with bachelor's degrees ($\overline{X}$ = 7.62), in favor of children of mothers with bachelor's degrees (p <0.05) (Table 7).

Table 8. Differentiation of Sudoku Skills According to father's level of education

	N	$\overline{X}$	SD	S of V	Ss	df	Mean Square	F	p
Primary school graduate	7	5.29	3.55	Between groups	84.47	2	42.24	4.47	.013
High school graduate	17	5.76	3.40	Within Group	1085.73	115	9.44		
Bachelor's degree	94	7.71	2.98	Overall	1170.20	117			
Overall	118	7.29	3.16						

ANOVA test was performed to assess for differences in sudoku skills according to the level of education of the child's father. Scores increased with the father's education level; this was statistically significant at $p < 0.05$ level. The Post hoc LSD Test showed significant differences between children primary school graduate fathers ($\overline{X}$ = 5.29) and children of fathers with bachelor's degree ($\overline{X}$ = 7.71) in favor of children with fathers with a bachelor's degree, and between children of high school graduate fathers ($\overline{X}$ = 5.76) and children of fathers with bachelor's degree ($\overline{X}$ = 7.71) in favor of children of fathers with bachelor's degree at $p < 0.05$ level. (Table 8)

Table 9. Differentiation of Sudoku Skills by Duration of Preschool Attendance

	N	$\overline{X}$	SD	S of V	Ss	df	Mean Square	F	P
1 year	34	5.76	3.26	Between groups	148.64	2	74.32	8.39	.000
2 years	54	7.41	2.92	Within Group	1019.13	115	8.86		
3 years	26	8.62	2.86	Overall	1167.77	117			
Overall	118	7.29	3.16						

Higher sudoku scores were observed with increasing duration of preschool attendance; this was statistically significant at $p < 0.01$ level. Scheffe test was performed to assess the difference between individual groups. Significant differences were observed between one-year attendees and two-year attendees at $p < 0.05$ level, and three-year attendees at $p < 0.01$ level, in favor of those who attended preschool for a longer period. (Table 9)

Table 10. Differentiation of Sudoku Skills According to Child's Sudoku Experience

Sudoku experience		*N*	$\overline{X}$	*SS*	*t*	*df*	*P*
3x3 grid	Yes	25	4.08	1.61	-0.08	116.00	.938
	No	93	4.11	1.55			
4x4 grid	Yes	25	3.20	1.85	0.04	116.00	.970
	No	93	3.18	2.08			
Overall	Yes	25	7.28	3.18	-0.01	116.00	.989
	No	93	7.29	3.17			

Based on t-test analysis for independent groups, no significant difference was observed between children who had sudoku experience and children who did not (p>0,05). (Table 10)

Table 11. Differentiation of Sudoku Skills According to the child' education program

GROUP		*N*	$\overline{X}$	*SS*	*t*	*df*	*P*
3x3 grid	MoNE	59	3.71	1.64	-2.80	116.00	*.006*
	MONTESSORI	59	4.49	1.37			
4x4 grid	MoNE	59	2.83	1.93	-1.93	116.00	.056
	MONTESSORI	59	3.54	2.07			
Overall	MoNE	59	6.54	3.09	-2.63	116.00	*.010*
	MONTESSORI	59	8.03	3.08			

Based on t -test for independent groups, there was a significant difference observed between the scores of children attending MoNE program and Montessori program for 3x3 sudoku puzzle scores at $p<0.01$ level, in favor of children attending Montessori program. However, no difference was observed for 4x4 sudoku puzzle scores ($p>0.05$). When comparing the overall mean scores, a significant difference was observed between scores of children educated according to the MoNE preschool education program in comparison to children educated according to the Montessori approach in favor of children educated according to the Montessori approach ($p <0.05$). (Table 11)

4. Discussion and Conclusion

The main purpose of this study was to analyze sudoku solving skills of 5-6-year-old children and assess for differences in sudoku skills between children educated according to the Ministry of Education (MoNE) program and Montessori approach. Sudoku skills of children were analyzed by gender, age, duration of preschool attendance, mother's and father's education level and previous experience of playing sudoku. Although this research focused on sudoku skills, the findings discussed herein mainly focus on cognitive skills and reasoning skills due to the limited information obtained from researches on sudoku skills in this age group.

This study showed that children's sudoku skills did not vary with gender. Similar to previous studies examining children's reasoning skills by gender (Artan & Ergul, 2015; Inan, Aydin & Bilgin, 2017; Ergul, 2014; Pay, 2018).

The performance of children in solving sudoku puzzles differed by age group. The performance of 66-77-month-old children was superior those of 54-65-month-old. This is an expected result and also validites the measuring tool. A similar study showed that the month range made a significant difference in children's reasoning skills (Artan & Ergul, 2015; Ergul, 2014; Pay, 2018).

The educational status of children's parents had a significant effect on children's sudoku solving skills. An increase in children's sudoku solving skills were observed with an increase in parents' educational level. Research studies have shown that the reasoning skills of preschool children vary with the education level of their parents (Artan & Ergul 2015; Ergul, 2014; Pay, 2018).

The duration of preschool education made a difference in children's sudoku solving skills. A longer education duration had a positive effect on children's sudoku skills. In the literature, preschool education had a positive effect on children's educational achievement (Siva, 2008) and mathematics skills (Kilic, 2008) and many cognitive skills (Pay, 2018). Nevertheless, other studies have shown that the duration of preschool education does not make have an impact on reasoning skills (Artan & Ergul, 2015; Ergul, 2014).

In the study, children who had previously encountered, heard and experienced a sudoku puzzle before understood the puzzle faster and completed it with fewer errors. For example; Brophy and Hann (2014) conducted an experimental study with large groups of students to address the question, "Does the Sudoku experience and sudoku type affect puzzle-solving time and the ability solve the puzzle correctly?" Their results showed that students with sudoku experience were more successful in solving puzzles correctly than students with no sudoku experience. However, in our study, this experience did not make any difference in children's sudoku scores. This maybe due to the fact that the children may have not understood the questions correctly and may have also confused the sudoku game with other games. We only documented only the child' experience with sudoku and not how frequently he/she may have played the game. Future studies should consult teachers and families of children to ascertain a child's history of playing sudoku.

A difference was observed between the two educational approaches in favor of the Montessori education. In the literature, studies comparing Montessori approach to and other educational approaches, showed cognitive skills related to reasoning skills were more developed among children in a Montessori program (Ahmadpour & Mujembari, 2015; Durkaya, 2019; Lillard, 2012; Ongoren, 2008; Ongoren & Yazlik, 2019). Drenckhahn (1961) also illustrated that the mathematics materials used in Montessori education supported children's logical thinking.

5. Recommendations

Researchers has shown that computer games or other games played at home affect children's reasoning skills (Bergman, Nutley et al., 2011; Mackey, Hill, Stone & Bunge, 2011). Therefore, it is important that children play sudoku puzzles suited to their development level under the guidance of the family at home.

Games for educational purposes should be created based on educational theories and development levels of children. However, limited information exists on this issue (Kiili, 2007). This issue should also be considered when creating computer sudoku games.

Liao and Shih (2013) reported that sudoku solving practices using labyrinth paths performed by elementary school children with make it easier for these children to learn sudoku rules and increase their motivation to learn sudoku. Therefore, we recommend teaching sudoku rules to preschool children using different techniques to ease the learning process.

Because reasoning is a feature that could be improved in children, parents and educators ought to influence and enrich children’s reasoning skills through mind games such as sudoku.

References

Aaronson, L. (2006). Sudoku science. *IEEE Spectrum*, *43*(2), 16-17. https://doi.org/10.1109/MSPEC.2006.1584356

Ahmadpour, N., & Mujembari, A. K. (2015). The impact of Montessori teaching method on IQ levels of 5-year old children. *Procedia-Social and Behavioral Sciences, 205*, 122-127. https://doi.org/10.1016/j.sbspro.2015.09.037

Altun, M., Hazar, M., & Hazar, Z. (2016). Investigation of the effects of brain teasers on attention spans of pre-school children. *International Journal of Environmental and Science Education, 11*(15), 8112-8119.

Amsterlaw, J., & Wellman, H. M. (2006). Theories of Mind in transition: A microgenetic study of the development of false belief under-standing. *Journal of Cognition and Development, 7*(2), 139-172. https://doi.org/10.1207/s15327647jcd0702_1

Aydin, I. P. (2002). Alternatif okullar. Ankara: Pegem A Yayincilik.

Baek, Y., Kim, B., Yun, S., & Cheong, D. (2008). Effects of two types of sudoku puzzles on students logical thinking. *Second European Conference on Games Based Learning*, *Reading,* UK: Academic Publishing Limited, 19-24.

Bauer, P. J., & Thal, D. J. (1990). Scripts or scraps: Reconsidering the development of sequential understanding. *Journal of Experimental Child Psychology, 50*(2), 287-304. https://doi.org/10.1016/0022-0965(90)90043-8

Bergman Nutley, S., Söderqvist, S., Bryde, S., Thorell, L. B., Humphreys, K., & Klingberg, T. (2011). Gains in fluid intelligence after training non-verbal reasoning in 4-year-old children: A controlled, randomized study. *Developmental Science, 14(*3), 591-601. https://doi.org/10.1111/j.1467-7687.2010.01022.x

Bottino, R. M., & Ott, M. (2006). Mind games, reasoning skills, and the primary school curriculum. *Learning, Media and Technology, 31*(4), 359-375. https://doi.org/10.1080/17439880601022981

Bottino, R. M., Ott, M., & Tavella M. (2008). The impact of mind game playing on children’s reasoning abilities: Reflections from an experience, In. Conolly T. And Stansfield M (Eds), *Proceedings on the 2nd Europian Conference on Games Based Learning,* Barcelona, Spain: *Academic Publishing*, 51-57.

Bottino, R. M., Ott, M., & Tavella, M. (2013). Children’s performance with digital mind games and evidence for learning behaviour. *Communications in Computer and Information Science*, 235-243. https://doi.org/10.1007/978-3-642-35879-1_28

Bottino, R. M., Ott, M., & Tavella, M. (2013). Investigating the relationship between school performance and the abilities to play mind games. *In Proceedings of the European Conference on Games Based Learning*, 62-71.

Bottino, R. M., Ott, M., Tavella, M., & Benigno, V. (2006). Can digital mind games be used to investigate children’s reasoning abilities? In: Meyer, B. (ed.) Proceedings of the 4th ECGBL Conference on Games Based Learning Copenhagen. Academic Conferences.

Brophy, C., & Hahn, L. (2014). Engaging students in a large lecture: An experiment using sudoku puzzles, *Journal of Statistics Education*, *22*, 1. https://doi.org/10.1080/10691898.2014.11889690

Byun, W., Blair, S. N., & Pate, R. R. (2013). Objectively measured sedentary behavior in preschool children: comparison between Montessori and traditional preschools. *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 2. https://doi.org/10.1186/1479-5868-10-2

Calimeri, F., Ianni, G., Perri, S., & Zangari, J. (2013). The Eternal Battle Between Determinism and Nondeterminism:

Preliminary Studies in the Sudoku Domain. Proceedings of the 20th RCRA workshop on Experimental Evaluation of Algorithms for Solving Problems with Combinatorial Explosion (RCRA 2013). Rome, Italy.

Chiu, A., Nasiri, E., & Rashid, R. (2012). *Parallelization of Sudoku.* http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.6929

Cinan, S. (2010). Sudokubulmacasinda zihinsel adimlar: Haric tutma ve dahil tutma teknikleri. *Turk Psikoloji Dergisi*, *25*(66), 42-52.

Cox, M. V., & Rowlands, A. (2000). The effect of three different educational approaches on children's drawing ability: Steiner, Montessori and traditional. *British Journal of Educational Psychology, 70*, 485-503. https://doi.org/10.1348/000709900158263

Crook, J. F. (2007). A pencil and paper algorithm for solving sudoku puzzles. *Notices of the AMS, 56*(4), 460-468.

Das, K. N., Bhatia, S., Puri, S., & Deep, K. (2012). A retrievable GA for solving sudoku puzzles. *Technical Report,* http://www.cse.psu.edu/~sub194/papers/ sudokuTechReport.pdf

deChantal, P., & Markovits, H. (2017). The capacity to generate alternative ideas is more important than inhibition for logical reasoning in preschool age children. *Memory and Cognition, 45*(2), 208-220. https://doi.org/10.3758/s13421-016-0653-4

Demir, E., Saatcioglu, O., & Imren, F. (2016). Uluslararasi Dergilerde Yayimlanan Egitim Araştirmalarinin Normallik Varsayimlari Acisindan Incelenmesi. *Current Research in Education, 2*(3), 130-148.

Demirel, T., & Karakus, Y. T. (2018). The effects of mind games in math and grammar courses on the achievements and perceived problem-solving skills of secondary school students. *British Journal of Educational Technology.* https://doi.org/10.1111/bjet.12624

Devecioglu, Y., & Karadag, Z. (2014). Amac, beklenti ve onerilerbaglamindazekaoyunlari dersinin degerlendirilmesi. *Bayburt Universitesi Egitim Fakultesi Dergisi, 9*(1), 41-61.

Donavan, D., Haaland, B., & Nott, D. J. (2015). A simple approach to constructing quasi-sudoku-based sliced space filling designs. *Annals of the Institute of Statistical Mathematics*, 1-15.

Drenckhahn, F. (1961). Die idee von Maria Montessoris materialien im lichte der didaktik der mathematik. *International Review of Education, 7*(2), 174-186. https://doi.org/10.1007/BF01433367

Durakoglu, A. (2010). Maria Montessori'ye göre cocugundogasi ve egitimi.YayımlanmamısDoktora Tezi, Gazi Universitesi, Ankara.

Durakoglu, A. (2010). Montessori metodunda okuma ve yazma egitimi. *Aile ve Toplum, 5*(20), 91-104.

Durkaya, S. (2019). *MEB okul öncesi eğitim programına ve Montessori yaklaşımına göre egitim alan anasinifi cocuklarinin sezgisel matematik yeteneklerinin karsilastirilmesi.* Yuksek Lisans Tezi, Marmara Universitesi, 567612.

Eppstein, D. (2005). *Nonrepetitive paths and cycles in graphs with application to Sudoku.*

Eppstein, D. (2012). Solving Single-Digit Sudoku Subproblems. *International Conference on Fun with Algorithms,* 142-153. https://doi.org/10.1007/978-3-642-30347-0_16

Ergul, A. (2014). *Erken matematiksel akil yurutme becerileri degerlendirmearacigelistirilmesi.* Doktora Tezi, Saglık Bilimleri Enstitusu, Cocuk Gelisimi ve Egitimi Programı, Hacettepe Universitesi.359002.

Ergul, A., & Artan, I. (2015). Erken matematiksel akil yurutme becerilerinin incelenmesi. *Afyon Kocatepe Universitesi Kurumsal Egitimbilim Dergisi, 8*(4), 454-485. https://doi.org/10.5578/keg.8984

Faryadi, Q. (2017). The Application of Montessori Method in Learning Mathematics: An Experimental Research. *Open Access Library Journal,* 4, e4140. https://doi.org/10.4236/oalib.1104140

Feez, S. (2010). *Montessori and early childhood, a guide for students.* London: Sage Publishing. https://doi.org/10.4135/9781446269343

Flynn, T. M. (1991). Development of social, personal and cognitive skills of preschool children in Montessori and traditional preschool programs. *Early Child Development and Care, 72*(1), 117-124. https://doi.org/10.1080/0300443910720111

Garcia, G. S., & Palomino, M. (2007). Solving sudoku puzzles with rewriting rules. *Electronic Notes in Theoretical Computer Science,* (176), 79-93. https://doi.org/10.1016/j.entcs.2007.06.009

Ghoneim, A. S., & Essam, D. L. (2012). A Methodology for revealing and monitoring the strategies played by neural networks in mind games. *The 2012 International Joint Conference on Neural Networks (IJCNN) Neural Networks (IJCNN)*, 1-10. https://doi.org/10.1109/IJCNN.2012.6252376

Gobet, F., deVoogt, A., & Retschitzki, J. (2004). Moves in mind: The psychology of board games. Hove, UK: Psychology Press. https://doi.org/10.4324/9780203503638

Grabbe, J. W. (2011). Sudoku and working memory performance for older adults. *Activities, Adaptation & Aging, 35*(3), 241–254. https://doi.org/10.1080/01924788.2011.596748

Guncel Turkçe Sozluk (Contemporary Turkish Dictionary). *Turk dil kurumu sozlukleri*. http://sozluk.gov.tr/

Guven, Y. (2004). *Erken cocuklukta matematiksel duşunme ve matematigi ogrenme.* Istanbul: Kucuk Adimlar Egitim Yayınları.

Haynes, I. W. (2008). *Analysis of generalized sudoku puzzles: A mixture of discrete techniques.* University of South Carolina.

Heiman, S. M. (2014). *A Study on the perception of brain games and their effection memory and cognitive skills.* University of Central Florida.https://stars.library.ucf.edu/honorstheses1990-2015/1575.

Inan, M., Aydin, O., & Bilgin, H. (2017). 6-9 yaş cocuklarinin hareket gelisimleri ile akil yurutme yetenegi arasındaki iliskinin incelenmesi. *Beden Egitimi ve Spor Arastırmalari Dergisi, 9*(1), 24-34.

Jiang, B., Xue, Y., Li, Y., & Yan, G. (2009). Sudoku puzzles generating: From easy to evil. *Chinese Journal of Mathematics in Practice and Theory, 39*, 1-7.

Johnson-Laird, P. N. (2010). Mental models and human reasoning. *PNAS, 107*(43) 18243-18250. https://doi.org/10.1073/pnas.1012933107

Jones, S. K., Perkins, S., & Roach, P. A. (2007). Properties of Sudoku Puzzles. https://www.researchgate.net/profile/Paul_Roach2/publication/264572738_Properties_of_Sudoku_

Jones, S. K., Roach, P. A., & Perkins, S. (2007). Construction of Heuristics for a Search-Based Approach to Solving Sudoku. International Conference on Innovative Techniques and Applications of Artificial Intelligence.

Josman, N., & Jarus, T. (2001). Construct-relatedvalidity of the toglia category assessment and the deductive reasoning test with children who are typically developing. *American Journal of Occupational Therapy,* 55, 524-530. https://doi.org/10.5014/ajot.55.5.524

Karnes, M., Schwedel, A., & Williams, B. (1983). A comparison of five approaches for educating young children from low-income homes. In The Consortium for Longitudinal Studies (Eds.), As the twig is bent: Lasting effects of preschool (pp. 133-170). Hillsdale, NJ: Lawrence Erlbaum.

Karnes, M., Teska, J., & Hodgins, A. S. (1970). The effects of four programs of classroom intervention on the intellectual and language development of 4-year-old disadvantaged children. *American Journal of Orthopsychiatry, 40,* 58-76. https://doi.org/10.1111/j.1939-0025.1970.tb00679.x

Kiili, K. (2007). Foundation for problem-based gaming. *British Journal of Educational Technology, 38*(3), 394-404. https://doi.org/10.1111/j.1467-8535.2007.00704.x

Kilic, Z. (2008). *Ilkogretim birinci sınıf ogretmenleriningoruslerinegore okul oncesiegitim alan ve almayan ogrencilerin gelişim becerilerinin karsılastirilmasi.* Yayımlanmamış Yuksek Lisans Tezi, Beykent Universitesi, Istanbul

Kirriemuir, J., & McFarlane, A. (2004). Literature review in games and learning. *Uturelab series. Report 8,* https://telearn.archives-ouvertes.fr/hal-00190453/document

Koksal, A. A, & Oguz, V. (2006). Cocuk egitiminde Montessori yaklasimi. *Cukurova Universitesi, Sosyal Bilimler Enstitusu Dergisi, 1*(15), 243-256.

Kurbal, M. S. (2015). *An investigation of sixth grade students' problem solving strategies and underlying reasoning in the context of a course on general puzzles and games.* Master Degree Thesis, Middle East Technical University.

Laski, E. V., Vasilyeva, M., & Schiffman, J. (2016). Longitudinal Comparison of Montessori versus Non-Montessori Students' Place-Value and Arithmetic Knowledge. *Journal of Montessori Research, 2*(1), 1. https://doi.org/10.17161/jomr.v2i1.5677

Lee, N. Y. L., Goodwin, G. P., & Johnson-Laird, P. N. (2008). The psychological puzzle of Sudoku. *Thinking & Reasoning, 14*(4), 342-364. https://doi.org/10.1080/13546780802236308

Leighton, J. P. (2004). Defining and describing reason. In. *The Nature of Reasoning.* (Eds. J. P. Leighton and R.J. Sternberg). UK: Cambridge University Press. https://doi.org/10.1017/CBO9780511818714.001

Levis, R. (2007). Metaheuristics can solve Sudoku puzzles. *Journal of Heuristics, 13*, 387-401. https://doi.org/10.1007/s10732-007-9012-8

Liao, G. Z., & Shih, Y. J. (2013). Between sudoku rules and labyrinthine paths a study on design for creative sudoku learning. *National Hsin-chu University of Education*, 58-78. https://doi.org/10.2478/dfl-2014-0016

Lillard, A. S. (2011). Mindfulness Practices in Education: Montessori's Approach. *Mindfulness, 2*(2), 78-85. https://doi.org/10.1007/s12671-011-0045-6

Lillard, A. S. (2013). Playfullearningandmontessorieducation. *NAMTA Journal, 38*(2), 137-174.

Lillard, A. S., Heise, M. J., Richey, E. M., Tong, X., Hart, A., & Bray, P. M. (2017). Montessori preschool elevates and equalizes child outcomes: A longitudinal study. *Front Psychol, 8*. Retrieved from https://doi.org/10.3389/fpsyg.2017.01783

Lillard, S. A. (2012). Preschool children's development in classic Montessori, supplemented Montessori, and conventional programs. *Journal of School Psychology, 50*(3), 379-401. https://doi.org/10.1016/j.jsp.2012.01.001

Lopata, C., Wallace, N., & Finn, K. (2005). Comparison of academic achievement between Montessori and traditional education programs. *Journal of Research in Childhood Education, 20*, 5-13. https://doi.org/10.1080/02568540509594546

Lynce, I., & Ouaknine. (2006). Sudoku as a SAT problem. *In proceedings of the 9th symposium on Artificial intelligence and mathematics.*https://people.mpi-sws.org/~joel/publications/sudoku05.pdf.

Mackey, A. P., Hill, S. S., Stone, S. I., & Bunge, S. A. (2011). Differential effects of reasoning and speed training in children. *Developmental Science*, *14*(3), 582-590. https://doi.org/10.1111/j.1467-7687.2010.01005.x

McGuire, G., Tugemann, B., & Civario, G. (2014). There is no 16-clue sudoku: solving the sudoku minimum number of clues problem via hitting set enumeration. *Experimental Mathematics, 23*(2), 190-217. https://doi.org/10.1080/10586458.2013.870056

McKillup, S. (2012). *Statistics explained: An introductory guide for life scientists* (Second edition). United States: Cambridge University Press. https://doi.org/10.1017/CBO9781139047500

Milli EgitimBakanligi, Talim ve Terbiye Kurulu Baskanligi. (2013*). Ortaokul ve imam hatip ortaokulu zeka oyunları dersi ogretim programı (5.-8. sınıflar).* Ankara: Milli Egitim Bakanlığı Talim ve Terbiye Kurulu Baskanligi. http://teyd.org.tr/pdf/zekaoyunlari.pdf.

Milli EgitimBakanlıgı, Temel Egitim Genel Mudurlugu (2013). *Okul oncesi programı.*https://tegm.meb.gov.tr/dosya/okuloncesi/ooproram.pdf

Mitchell, A., & Savill-Smith, C. (2004). Theuse of computer and video games for learning: a review of the literature. *Learning and Skills Development Agency*. http://dera.ioe.ac.uk/id/eprint/5270.

Musliu, N., & Winter, F. (2017). A hybrid approach for the sudoku problem: Using constraint programming in iterated local search. *IEEE Intelligent Systems, 32*(2), 52-62. https://doi.org/10.1109/MIS.2017.29

Niklas, F., Cohrssen, C., & Tayler, C. (2018). Making a difference to children's reasoning skills before school-entry: the contribution of the home learning environment. *Contemporary Educational Psychology, 54*, 79-88. https://doi.org/10.1016/j.cedpsych.2018.06.001

O'Connell, B. G., & Gerard, A. B. (1985). Scripts and scraps: The development of se- quential understanding. *Child Development, 56*, 671-681. https://doi.org/10.2307/1129757

Ongoren, S. (2008). *Okul oncesiegitim kurumlarına devam eden 4-5 yaş grubucocuklarina geometrik sekil kavrami kazandirmada Montessori egitimyontemininetkililigi.* Yuksek Lisans Tezi, Selcuk Universitesi, 220097.

Ongoren, S., & Yazlik, D. O. (2019). Investigation of mathematical concept skills of children trained with Montessori approach and MoNE pre-school education program. *European Journal of Educational Research*, *8*(1), 9-19. https://doi.org/10.12973/eu-jer.8.1.9

Pate, R. R., O'Neill, J. R., Byun, W., McIver, K. L., Dowda, M., & Brown, W. H. (2014). Physical Activity in Preschool Children: Comparison Between Montessori and Traditional Preschools. *Journal of School Health, 84*(11), 716-721. https://doi.org/10.1111/josh.12207

Pay, G. (2018). *Okul oncesi donem cocuklarının matematiksel akil yurutme becerilerinin incelenmesi.*Yuksek Lisans Tezi, Eskisehir Anadolu Universitesi, Egitim Bilimleri Enstitusu.

Piaget, J. (2007). *Cocukta karar verme ve akil yurutme.* (Y.T.Gunaydin, Cev.) Ankara: Palme Yayıncılık.

Pillay, N. (2012). Finding solutions to sudoku puzzles using human intuitive heuristics. *SACJ, 49*, 25-34. https://doi.org/10.18489/sacj.v49i0.111

Rathunde, K. (2001). Montessori education and optimal experience: A frame work for new research. *The NAMTA Journal, 26*(1), 11-43.

Reiter, H. B., Thornton, J., & Vennebush, G. P. (2014). Using Ken Kento Build reasoning skills. *MathematicsTeacher, 107*(5), 341-347. https://doi.org/10.5951/mathteacher.107.5.0341

Schunk, D.H. (2009). *Eğitimsel bir bakişla öğrenme teorileri* (M. Sahin, Cev.). (5. baskıdan ceviri). Ankara: Nobel Yayın Dagitim.

Sevgen, S., Arslan, E., & Samlı, R. (2017). Solving sudoku puzzle with numbers recognized by using artificial neural networks. *IU-JEEE, 17*(1), 3205-3211.

Sigirtmaç, A. (2016). An investigation on the effectiveness of chess training on creativity and theory of mind development at early childhood. *Educational Research and Reviews, 11*(11), 1056-1063. https://doi.org/10.5897/ERR2016.2676

Simonis. H. (2005). Sudoku As A Constraint Problem. *In CP Workshop on Modeling and Reformulating Constraint Satisfaction Problems*, 13-27.

Siva, L. (2008). *Okul oncesiegitimin ilkokul basarisina etkisi ve bir uygulama.* Doktora Tezi. Beykent Universitesi, 235343.

Toran, M., & Temel, Z. F. (2014). Montessoriyaklasiminincocuklarin kavram edinimi uzerindeki etkisinin incelenmesi. *Ilkogretim Online Dergisi*, *13*(1).

Turkoglu, B., & Uslu, M. (2016). Oyun temelli bilisselgelisim programının 60-72 aylık çocuklarin bilisselgelisimine etkisi. *Uluslararası Egitim Bilimleri Dergisi, 3*(6), 50-68. https://doi.org/10.16991/INESJOURNAL.202

Wilson, R. (2006). The sudoku epidemik. http://www.ams.jhu.edu/~castello/150/handouts/SudokuEpidemic.pdf

Woodward, A. L. (2009). Infants' grasp of others' intentions. *Current Directions in Psychological Science, 18*(1), 53-57. https://doi.org/10.1111/j.1467-8721.2009.01605.x

Wu, Y., Zhou, Y., Agaian, S., & Noonan, J. P. (2016). 2D Sudoku associated bijections for image scrambling. *Information Sciences, 327,* 91-109. https://doi.org/10.1016/j.ins.2015.08.013

Wu, Yue. (2012), *The sudoku array and its applications in information security,* Tufts University.http://hdl.handle.net/10427/012317.

Yato, T., & T. Seta. (2003). Complexity and completeness of finding another solution and its application to puzzles. *IEICE Trans. Fundamentals,* E86-A, (5), 1052-1060.

Yigit, T. (2008). *Okul oncesiegitimkurumlarindaMontessori ve geleneksel ogretimyontemlerini alan çocuklarin sayi kavramini kazanma davranıslarinınkarsılastırilmasi.*Yuksek Lisans Tezi, SelcukUniversitesi.

Zampini, L., Suttora, C., D'Odorico, L., & Zanchi, P. (2013). Sequential reasoning and listening text comprehension in preschool children. *European Journal of Developmental Psychology, 10*(5), 563-579. https://doi.org/10.1080/17405629.2013.766130