AN INVESTIGATION OF SIXTH GRADE STUDENTS' PROBLEM SOLVING STRATEGIES AND UNDERLYING REASONING IN THE CONTEXT OF A COURSE ON GENERAL PUZZLES AND GAMES

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ABSTRACT

AN INVESTIGATION OF SIXTH GRADE STUDENTS' PROBLEM SOLVING STRATEGIES AND UNDERLYING REASONING IN THE CONTEXT OF A COURSE ON GENERAL PUZZLES AND GAMES

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The aim of the present study was to investigate the effects of Puzzles and Games course on the 6th grade students' problem solving and reasoning skills. For this purpose, this study sought for the students' problem solving strategies and underlying reasoning skills in the beginning and at the end of the course. Another specific interest of the study was to determine the students' views about the effectiveness of Puzzles and Games course.

The study was conducted during the Fall semester of 2014-2015 academic year. The participants were 40 6th grade students who took Puzzles and Games course in a private middle school in Ankara. Data were collected through the Mathematical Problem Solving Test (MPT), Puzzles and Games course evaluation forms and semi-structured interviews. MPT was constructed by the researcher depending on the literature, had eight open-ended, non-routine and real life problems, and was implemented as pretest and posttest. Paired samples t-test was run to compare the result of the pre and posttests. Semi-structured interviews were

conducted with seven students to understand their solutions to the problems better. Additionally, the evaluation forms were filled by all the participants to get information about the effectiveness of Puzzles and Games course.

Findings indicated that there was a statistically significant increase in the scores from pretest to posttest. It showed that students who experienced Puzzles and Games course developed their problem solving strategies and underlying reasoning skills. The main reason of this improvement was that reasoning and operation puzzles strategy games and problems, which students engaged in Puzzles and Games course. Finally, it was revealed that students had positive views about Puzzles and Games course and addressed course activities enjoyable and beneficial.

Keywords: Problem solving, reasoning, puzzles, games, Puzzles and Games course

ÖZ

6. SINIF ZEKÂ OYUNLARI DERSİ ÖĞRENCİLERİNİN PROBLEM ÇÖZME STRATEJİLERİNİN VE AKIL YÜRÜTME BECERİLERİNİN İNCELENMESİ

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Bu çalışmanın amacı Zekâ Oyunları dersinin 6. sınıf öğrencilerinin problem çözme ve akıl yürütme becerilerine olan etkisini incelemektir. Bu amaçla, dersin başında ve sonunda öğrencilerin kullandıkları problem çözme stratejileri ve bu stratejilerin altında yatan akıl yürütme becerileri araştırılmıştır. Çalışmanın bir diğer amacı ise öğrencilerin Zekâ Oyunları dersinin etkililiği hakkındaki görüşlerini ortaya çıkarmaktır.

Bu çalışma 2014-2015 öğretim yılının sonbahar döneminde gerçekleştirilmiştir. Çalışmaya Ankara ilinin Gölbaşı semtinde bulunan özel bir ortaokulda okuyan ve Zekâ Oyunları dersi alan 40 6.sınıf öğrencisi katılmıştır. Veriler, matematiksel problem çözme ve akıl yürütme testi, Zekâ Oyunları dersi değerlendirme formları ve yarı-yapılandırılmış görüşmeler ile toplanmıştır. Sekiz tane açık uçlu, rutin olmayan ve gerçek hayat probleminden oluşan test, araştırmacı tarafından literatüre dayalı olarak hazırlanmış ve ön test ve son test şeklinde uygulanmıştır. Testlerin sonuçlarını karşılaştırmak amacıyla eşleştirilmiş t-test

uygulanmıştır. Katılımcıların çözümleri hakkında daha ayrıntılı bilgi edinmek amacıyla yedi katılımcıyla yarı-yapılandırılmış görüşmeler yapılmıştır. Ek olarak, Zekâ Oyunları dersinin etkililiği hakkında katılımcıların fikirlerini almak amacıyla değerlendirme formlarını doldurmaları sağlanmıştır.

Çalışmanın bulguları, öntest ve sontest puanları arasında istatistiksel olarak sontest lehine anlamlı bir fark ortaya çıkarmıştır. Bu bulgu, Zekâ Oyunları dersi alan öğrencilerin problem çözme stratejilerini ve akıl yürütme becerilerini geliştirdiğini göstermektedir. Bu gelişmenin temel nedenin katılımcıların Zekâ Oyunları dersinde oynadıkları akıl yürütme ve işlem oyunlarına, strateji oyunlarına ve çözdükleri zekâ problemlerine bağlı olduğu görülmüştür. Son olarak, katılımcıların Zekâ Oyunları dersi ile ilgili olumlu düşüncelere sahip oldukları ve dersteki aktiviteleri eğlenceli ve yararlı buldukları görülmüştür.

Anahtar Kelimeler: Problem çözme, akıl yürütme, zekâ oyunları, Zekâ Oyunları dersi

To the memories of my grandfather
&
My mother, father and brother
Sevim, Selçuk and Serkan KURBAL
who support and love me unconditionally throughout my life.

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LIST OF ABBREVIATIONS

MPT	Mathematical Problem Solving Test
MoNE	Ministry of National Education
NCTM	National Council of Teachers of Mathematics
NRC	National Research Council
PGCEF	Puzzles and Games Course Evaluation Forms
SPSS	Statistical Package for the Social Sciences

CHAPTER 1

INTRODUCTION

The need for using and understanding mathematics in daily life has gained importance in the recent years (Ministry of National Education (MoNE), 2009). In a changing world, those who understand and can do mathematics will have significantly improved opportunities for determining their futures (National Council of Teachers of Mathematics (NCTM), 2000). Since the teachers guide their students towards mathematics, teachers' considerations about how students make sense of mathematics underlie the way of teaching mathematics. According to NCTM (2000), developing students' mathematical problem solving and reasoning skills is one of the main goals of teaching mathematics. The NCTM standards (2000) indicated that students should be able to use variety of suitable strategies to solve problem, signify the process of problem solving, and justify their reasoning ways to the others.

The concept of *problem* is defined differently in related literature. According to Orton and Wain (1994), *problem* comes to mean a situation which attracts problem solver's interest, possesses problem solver's mind and directs problem solver to search to reach the solution of problem. Furthermore, *problem* is defined by Krulik ve Rudnick (1985) as an issue which solution is not known at the beginning. Baki (2006) stated that *problem* causes to disturb problem solver's balance of cognitive system. It is understood that if a situation is described as a problem, the problem solver needs to have a difficulty to achieve a solution.

Mathematical problems are categorized in two groups as routine problems and non-routine problems (Arslan & Altun, 2007). While routine problems are generally solved by directly applying common formulas and methods (Bayazit, 2013), non-routine problems need using different methods and strategies and forced problem solvers to think in different ways (Inoue, 2005). Non-routine problems

require some cognitive skills such as identifying the relationships between given data in problems, analyzing and synthesizing them and, some operational skills (Altun, 2005). According to Mayer, Sims and Tajika (1995), the process of solving problems such as producing different ideas or applying significant methods are more important than achieving the correct solution in non-routine problems. One of the examples of non-routine problems is real-world problems (Verschaffel, De Corte, & Vierstraete, 1999). Students have to use their knowledge and daily-life experiences to reach correct solutions of real-world problems (Nesher & Hershkovitz, 1997). In real-world problems, students need to have high level of comprehension; understanding the given data about problem explicitly, deciding the suitable methods to solve the problem, modeling, and finalizing the solution and interpretation of the result (Chacko, 2004). Additionally, real-world problems include reasoning deeply and implementation of mathematical knowledge to real-life experiences, and solution of the problems is not direct as in routine problems (Chacko, 2004). Therefore, solving real-world problems make using mathematical knowledge in real-life cases available for the students (Brown, 2001; NCTM, 1991).

In other respects, many of the problems that students encounter in mathematics class are generally word problems (Aladağ & Artut, 2012). Word problem means any mathematical practice that important information about the problem is given as text rather than mathematical expression (Verschaffel, Greer, & De Corte, 2000). Children at early ages have opportunities to improve their mathematical subjects and abilities with the help word problems (Gravemeijer, 1994). Furthermore, solving word problems provides a proper environment where students develop their reasoning skills and their communication skills with each other (Reusser & Stebler, 1997). MoNE (2013) and NCTM standards (2000) also support that solving word problem enhances students' communication, questioning, justification and reasoning.

Many researchers agree that good problem solvers build a well-connected relationship of mathematical ideas and they make sense of mathematics in the pursuit of a solution. They also get out of the routine while producing problem

solving strategies (Arcavi, Kessel, Meira, & Smith, 1998; Carlson, 1999; Carlson & Bloom, 2005; Santos-Trigo, 1998; Schoenfeld, 1985; Schoenfeld, 1992). Moreover, children who solve problems in developmentally suitable classrooms build different relationships mentally by communicating environment and peers (Bredekamp, 1987).

Mathematics is a tool which works with clear and logical analysis to define, abstract, and the deal with the world (Schoenfeld, 1982) and it always consists of thinking in logical and effective way (Yankelewitz, 2009). Davis and Maher (1996) stated that one of the aims of mathematics is to teach students thinking in a powerful way. Therefore, reasoning is the main goal of mathematics (Yankelewitz, 2009). According to NCTM (2000), reasoning and proof is seen as one of the five process standards in mathematics education. It is stated that "systematic reasoning is a defining feature of mathematics" (NCTM, 2000, p.57).

Yackel and Hanna (2003) argued incorporating reasoning at all levels of mathematics education and defined existence of reasoning as "a better understanding of how individuals come to know" (p.227). Reasoning means the process of organizing evidence, beliefs and ideas to come conclusions about its accuracy (Leighton, 2003). In other respects, Rips (1994) defines reasoning as an intellectual process which constructs new ideas by using old ones. Additionally, Webster (1986) stated that reasoning is a way of thinking and explaining something. That is, concept of mathematical understanding is incomplete without underlying reasoning (Ball & Bass, 2003). It is also stated that understanding mathematics is only procedural without reasoning (Ball & Bass, 2003). Therefore, mathematics educators should promote students' mathematical reasoning and justification to advance students' knowledge and understandings in mathematics (Yackel & Hanna, 2003). It can be claimed that reasoning is fundamental for teaching of mathematics to direct instructions from rote memorization to the strong and meaningful learning.

Reasoning is an important skill since it is fundamental to use mathematics. If mathematics is learned reasonably rather than clusters of calculations, the mathematical knowledge could be modified for the new situations from the old ones

(Ball & Bass, 2003). On the other side, according to National Research Council (1989), problem solving provides students to establish a relationship between what they have already learnt and new mathematical concepts.

In the light of these comments about reasoning and problem solving, literature review revealed that reasoning is connected with problem solving in some perspectives. Chang (2002) stated that there was a substantial correlation between students' problem solving and reasoning skills. Similarly, Chang (2010) emphasized in his study that not only domain specific knowledge but also reasoning skills have significant roles in students' problem solving skills. Kausler (1991) stated in his study that reasoning is an adequately special form of problem solving; especially logical reasoning comes insight when the logical relationships in the problem is given and the solution of the problem needs a situation of true or false, or solution response. Some students know few ways of how to solve word problems or what strategies they are supposed to choose. Therefore, teachers must emphasize the logic of solution and reasoning strategies and highlight these strategies in problem solving process (Cheves & Parks, 1984).

When the related literature was investigated about how to develop students' reasoning skills, which is one of the main characters of mathematics, it is revealed that researchers argued different assertions about reasoning. Lester (1975) claimed that reasoning skills could be taught in earlier ages and the quality could be improved by age. Many methods can be used to enhance reasoning skills in earlier ages. However, there is general agreement that reasoning skills could be improved by playing games (Kiili, 2007; McFarlane, Sparrowhawk & Heald, 2002).

Recently, many researchers, educators and teachers had been interested in use of games in classrooms. In relation to this, some studies aimed to investigate the functions of different games and playing them in children's developments (Sutton-Smith, 2001), while others considered the significance of not only playing games, but also making games for students' learning (Good & Robertson, 2004; Kafai, 2006). In other respects, Gee (2003) and Jenkins and Squire (2004) specifically studied about the effects of playing with video games in the sense of education and Egenfeldt-Nielsen (2005) considered playing with different games

as edutainment products. Using games in classrooms arouse interest of many education researches who examined the different effects of games in school environment. The positive effects of playing games on learning and motivation (Garris *et al.*, 2002; Rosas *et al*., 2003), and learning in small group (Lou *et al*., 2001) were studied. It is also concluded that multiplayer online gaming enhanced collaborative learning (Williamson & Facer, 2004). Similarly, Din and Calao (2001) found that children's spelling and decoding abilities can be developed by playing educational video games.

The use of mathematical games provides a classroom environment that students make debates with each other while improving their thinking skills (Baek et al., 2008; Bragg, 2007). Additionally, all games consist of different rules which increase students' motivation and enjoyment of investigating these rules and outcomes (Applebaum & Freiman, 2014). In this respect, games support an environment that students learn with the help of stimulated assignments; as follows, the context of the game provides students' learning in terms of knowledge and some abilities are improved at the end of the game (McFarlane *et al.*, 2002).

Game refers to "a problem solving activity, approached with a playful attitude" (Schell, 2008, p.37). There are extensive criteria recommending that "a game must be entered wilfully; have goals, conflict and rules; can be won or lost; is interactive; has challenge; can create its own internal value; can engage players; and is a closed formal system" (Schell, 2008, p.34). *Puzzle* is rule-based sytems, as games; however the main aim of puzzle is to reach solution, not to beat an opponent (Crawford, 1984). In this study, 'games and puzzles' will be used to adress games including strategy games, puzzles including reasoning and operation puzzles and problems. There are many types of games such as "action", "adventure", "fighting", "role-playing", "simulations" and "mind games" (Kirriemuir & McFarlane, 2004, p.7). Mind games are also called brainteasers or puzzles (Kebritchi et al., 2010; Milovanović et al, 2009; Prensky, 2005; Schiffler, 2006). Mind games "deeply require the enactment of thinking and reasoning skills and are almost independent from knowledge/competence in specific school subjects" (Bottino, Ott, & Tavella, 2013, p.62). In the literature, some games and puzzles which have been used in this

study correspond with the descriptions of mind games. Playing mind games promotes reasoning and logical skills (Kiili, 2007; McFarlane, Sparrowhawk & Heald, 2002; Rohde & Thompson, 2007). Moreover, some researchers stated that playing mind games may have positive effects on school performance (Franco et al, 2011; Robertson & Miller, 2009) and they could be used in classrooms as promoters of learning (Griffiths, 1996).

According to MoNE (2013), puzzles and games consist of five groups such as reasoning and operation puzzles, verbal games, geometric-mechanic games, memory games and strategy games. *Reasoning puzzles* are generally solo games as puzzles which require evaluations of given clues and making logical reasoning to come to a conclusion in the game (MoNE, 2013). *Operation puzzles* require using of operational skills as well as logical reasoning (MoNE, 2013). According to these definitions, Sudoku, Kendoku, Battleships, Tent, ABC Connection Puzzle, Shitherlink, Kakuro, Skyscrapers, Easy as ABC, Yin-Yang are examples of reasoning and operation puzzles. *Verbal games* are generally based on vocabulary and basic cultural knowledge as well as logical reasoning (MoNE, 2013). Scrabble, anagrams, word hunter and crossword are well-known as verbal games. Players use geometric thinking, geometric transformation, spatial reasoning, eye-hand coordination and motor skills in g*eometric-mechanic games* (MoNE, 2013). The examples of geometric-mechanic games are tangram, polyomino, rubic cubes, jenga, puzzles, mikado and labyrinth. *Memory games* are based on short and long terms memory (MoNE, 2013). Memory match games, navigation games and picture retrieval are some of the popular memory games. *Strategy games* refer to games that two or more player play with each other and there is/are loser(s) and winner(s) at the end of the game (MoNE, 2013). Since strategy games consist of many analyzable easy games and unanalyzable complex games, player needs to use guesstimate and others' experiences about the game as well as developing strategies and logical reasoning (MoNE, 2013). The best known strategy games are chess, go, reverse, mancala, Mastermind, checkers, and tik tak toe.

Many researchers examined the effects of some specific reasoning and operation puzzles, and strategy games on different skills. According to de Mestre

(2007), children need to use logical reasoning and deduction while solving sudoku which is one of the reasoning and operation puzzles. De Mestre (1997) also suggested that children should consider Sudoku as a problem because steps of solving Sudoku is similar to solving problem strategies recommend by Polya (1973). In addition to this, Sudoku is a natural experiment material which is a representer of reasoning skill (Cinan, 2010). Furthermore, Kenken (Kendoku), which is also an example of reasoning and operation puzzles, supports problem solving, reasoning and communication, and provide to think about reasonability of the answers of the problems in mathematics (Reiter, Thornton & Vennebush, 2014). In addition to the effects of reasoning and operation puzzles on different skills, strategy games also contribute some skills on children's developments. According to Applebaum and Freiman (2014), strategy games not only address enjoyable activities for children but also help to reveal mathematical thinking in normal classroom environment and to build new knowledge since students are involved in efficient learning materials. Engaging strategy games create an environment which causes an increase in students' curiosity and enthusiasm and this situation support the students' mathematical reasoning and investigation (Cañellas, 2008). Moreover, Applebaum and Freiman (2014) who used Bachet's games mentioned strategy game in the study stated that playing strategy games supports students' logical thinking skills and questioning. Similarly, students who play Nim game, which is a strategy game, obtained mathematical knowledge intuitively and improve students' ability of generalization in algebraic patterns (Shriki, 2009).

Puzzles and Games course as an elective course has been initiated in middle schools in 2012-2013 school year by the Ministry of National Education in Turkey. Within the frame of National Education Basic Law, it is intended in Puzzles and Games course that students will be able to recognize their potential of intelligence, develop different and original strategies with problems, improve systematic mentality and develop ability of working individually and in group. Puzzles and Games course provides that students develop the capacity of problem perception and evolution, gain different points of views, decide quickly and make right decisions on problems, develop getting into the habit of solution oriented and

enhance the capacity of usage of reasoning and logical skills effectively (MoNE, 2013). Puzzles and Games course curriculum is based on problem solving, reasoning, communication, self regulation and developing psychomotor skills and affective behaviors (MoNE, 2013). According to these skills, the curriculum of Puzzles and Games course is divided into six chapters which are reasoning and operation puzzles, verbal games, geometric-mechanic games, memory games, strategy games, and problems. Despite the importance of effects of these games on students' reasoning skills, the Puzzles and Games course has not been investigated much in Turkey in terms of its contribution.

1.1 Purpose of the Study

When studies regarding problem solving, reasoning, games and puzzles are investigated and the curriculum of Puzzles and Games course in Turkish education system is considered, it can be claimed that Puzzles and Games course can contribute to making sense with mathematics and learning it in a meaningful way. It has been observed by the researcher of this study, who is also the teacher of Puzzles and Games course, that students who take Puzzles and Games course can develop their problem solving and reasoning skills by playing different games and puzzles. Additionally, Puzzles and Games course has become widespread in Turkish both public and private middle schools. In this respect, understanding the contributions of this course for students' development becomes important For these reasons, the purpose of this study was to investigate the effects of Puzzles and Games course on 6^{th} grade students' problem solving and reasoning skills. Based on this purpose, it was also aimed to explore the students' views about effectiveness of Puzzles and Games course.

1.2 Research Questions

The following research questions were investigated in the present study:

1. To what extend Puzzles and Games course influence 6^{th} grade students' problem solving and reasoning skills?

1.1 Is there a statistically significant difference in students' scores on Mathematical Problem Solving Test (MPT) before and after the Puzzles and Games course?

1.2 Which problem solving strategies and underlying reasoning skills have been improved at the end of the Puzzles and Games course?

2. What are the students' views about the effectiveness of the Puzzles and Games course?

1.3 Significance of the Study

Investigation on students' problem solving and reasoning skills in Puzzles and Games course is significant in some perspectives.

Reasoning is a mental skill used with systematic problem solving skill by students (MoNE, 2013). Not only NCTM standards (2000) but also Turkish middle school mathematics curriculums emphasize the importance of students' problem solving and reasoning in every level of teaching mathematics. From this respect, there have been several studies conducted in terms of the relationship between problem solving and reasoning in different subject domains (Aladağ & Artut, 2012; Hadar & Henkin, 1978; Perrine, 2001). However, there are not sufficient studies which examine the effectiveness of using puzzles and games to develop problem solving and reasoning skills of middle school students. There have been few studies which addressed effects of Puzzles and Games on learning (such as Bottino, Ott & Tavella, 2013; Facer et al. 2007). From a different point of view, some researchers examined the cognitive levels of some digital and educational games (such as Milovanović et al. 2009, Shih & Su, 2008). From this point, it will be beneficial to investigate how puzzles and games influence students' problem solving and reasoning skills.

Puzzles and Games course has been added in middle school academic program in 2012-2013 academic year in Turkey. There are many different suggested games in the course program addressed developing different skills. Problem solving and reasoning skills underlie several games in Puzzles and Games course. In this respect, carrying out the present study can be useful for Puzzles and

Games course teachers while planning the games in terms of effects on students' problem solving and reasoning skills. Additionally, the results of this study will provide several viewpoints for curriculum developers. The views of Puzzles and Games course students about the effectiveness of Puzzles and Games course will provide insight in planning for Puzzles and Games teachers and curriculum developers. By this way, effective sides and deficiencies of lesson plans come to light for teachers to prepare more efficient course content. Finally, not many studies have been conducted about Puzzles and Games course and its effects in Turkey. Therefore, the aim of this study is to try to fill the gap in the area of puzzles and games education.

1.4 My Motivation for the Study

I have been working as a middle school mathematics teacher in a private school in Ankara for three years. In the same time, I have been the teacher of Puzzles and Games course in both 5^{th} and 6^{th} grades in the same school. I had a chance to observe my 5^{th} and 6^{th} grade students in Puzzles and Games course. I noticed that puzzles and games have some effects on students' problem solving and reasoning skills as they play different puzzles and games within the process. In this way, students started to develop new strategies when compared at the beginning and end of the semesters. They started to think in a different way and their thinking styles and justifications have been changed in the course of the time. These observations motivated me to start this study.

Teaching mathematics does not mean only instructing basic mathematics objectives. Mathematics teachers can direct their students to think in a different way, develop new strategies, and produce creative methods. As a mathematics teacher, I believe that mathematics teachers can open new doors in students' worlds. This may be possible by asking a challenging problem or differentiating lesson plans as adding some different puzzles and games in mathematics class. By this way, we can make our lecture more attractive, meaningful and enjoyable. I think this study will help me and other mathematics teachers who want to address students' understandings of mathematics in a different way.

1.5 Definitions of Important Terms

The constitutive definitions of the important terms guiding the research questions and the study are given below.

Problem solving is defined as solving problems in which there are no rules or memorized procedures to solve the problems and in which the direct path to solution is not known immediately (Brownwell, 1942; Kilpatrick, 1985; Polya, 1945; van de Walle, 2004).

Reasoning is defined as "a process to reach a conclusion by taking all related factors into account" (Umay, 2003, p.1). Similarly, Leighton (2003) stated that *reasoning* is the process of organizing evidence, beliefs and ideas to conclude what is accurate or true. In this study, reasoning is perceived as a process that students choose suitable problem solving strategies for the problems and underlying reasons of them.

Game refers to "a problem solving activity, approached with a playful attitude" (Schell, 2008, p.37). There are extensive criteria recommending that "a game must be entered wilfully; have goals, conflict and rules; can be won or lost; is interactive; has challenge; can create its own internal value; can engage players; and is a closed formal system" (Schell, 2008, p.34).

Puzzle is rule-based sytems, as games; however, the main aim of puzzle is to reach solution, not to beat an opponent (Crawford, 1984).

CHAPTER 2

LITERATURE REVIEW

The purpose of the present study was to investigate the effects of Puzzles and Games course on 6th grade students' problem solving and reasoning skills. Based on this aim, students' views about the effectiveness of Puzzles and Games course were also explored. In the following part, the literature review of this study is presented. Based on the content and main objectives of the study, this chapter is classified into three sections: related studies on problem solving, reasoning and puzzles and games.

2.1 Problem Solving

Problem solving has an important role at all levels of teaching mathematics (Posamentier, Smith & Stepelman, 2006). According to NCTM (2000), problem solving is to "develop a deep understanding of concepts and methods by trying of problematic tasks where the mathematics to be learned is embedded" (p.270). Schoenfeld (2007) described problem solving as dealing with the problems which have different solution ways. He also stated that solving problems provided being involved in mathematics in order to develop an understanding of mathematics as a discipline (Schoenfeld, 1980). Polya (1973, as cited in Wilson, Fernandez & Hadaway, 1993) emphasized that problem solving includes process of mathematical thinking, investigation, finding pattern and logical thinking. Martinez (2008) defined problem solving as the process of coming to a conclusion without knowing a specific solution strategy. Additionally, it was claimed that the problem solver should not know how to solve problem previously (Martinez, 2008).

Mathematical problem solving is an important ability for students (Günbaş, 2012). "Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their

knowledge, and through this process, they will often develop new mathematical understandings" (NCTM, 2000, p.51). According to NCTM standards (2000), students should be able to solve mathematical and other contexts' problems and use and modify suitable strategies while solving problems. Usage of problem solving for mathematics learning helps students to learn mathematics with understanding (Schoenfeld, 1992; Schroeder & Lester, 1989). Solving rich problems provides opportunities for students to develop understanding of connections in mathematical ideas (Deslauriers, 2008; Schroeder & Lester, 1989). Mathematical problem solving comes to mean for students to build their own mathematical understanding and develop their reasoning (Taplin, 2006) and it helps students to build relationships between what they have already known and new mathematical notions, instead of being taught (National Research Council, 1989; Sutton & Krueger, 2002). According to some researchers, problem solving is significant since it requires using and adapting determined mathematical skills and knowledge to cope with unexpected problem solving cases in students' daily lives (Bottge & Hasselbring, 1993; Taplin, 2006; van de Walle, 2004).

When the literature regarding problem solving is investigated, it is seen that there are different perspectives on problem solving. Studies can be classified as effects of world problem instruction and strategy training on students' problems solving ability, investigations of mathematical thinking in problem solving and students' problem solving behaviors.

Lester, Garofalo and Kroll (1989) studied about the effects of strategy, awareness and self-regulation training on mathematical problem solving of an instructional program. In this program, students were administered with the strategy training in which they used of some important heuristics, awareness training in which they learned to state and defend their problem-solving strategies and self-regulation training in which they learned to follow their problem solving activities. 7^{th} grade classes which were divided into two groups; regular level and advanced level, participated in the study for 15 hours in 12 weeks. The results of the study indicated that both regular and advance classes gained a basic acquisition according

to the total scores obtained from pretest and posttest. However, the students' progress was under the expected level.

Altun (1995) investigated the problem solving behaviors of the elementary school students in the 3rd, 4th and 5th grades and identified what differences were shown by students who were successful and unsuccessful in problem solving according to these behaviors. Several behaviors were determined in the 3rd, 4th and 5th grade students: writing what is given and asked, drawing pictures for the problem, writing down the operations which are necessary for the solution, doing operations respectively and solving the problem. However, students infrequently indicated anticipation the result of the problem, controlling the result and writing a similar problem.

Some researchers specifically studied about the real world problems and, routine and non-routine problems in relation to problem solving strategies. For example, Bayazit (2013) investigated middle school students' approaches and strategies while solving real world problems. Participants of the study were 116 7th and 8th grades students, in Kayseri, Turkey. Data of the study were collected by written examinations and semi-structured interviews. Findings of this study showed that students had serious difficulties while solving real world problems. It was observed that students could not evaluate the process of problem solving. They also did not take into account whether the results of the problems were meaningful or not. They only considered numerical results of the problems. Additionally, the findings indicated that students lacked producing alternative approaches and original strategies in the process of problem solving. Few students composed some models representing real world situations.

Erdoğan (2015) studied that what problem solving strategies were preferred by middle school students while solving non-routine problems. Eight 6th grade students solved rich problems during 5 weeks. Findings of the study showed that students' problem solving strategies were weak and inflexible. Pattern-seeking as strategy of problem solving was generally considered as regularity of problem solving process. Based on the similar idea, Nunokawa (2004) investigated making a drawing strategy as one of the problem solving strategies and how students

improved their drawings while solving problems. With these aims, students' drawings for three problems of the study were analyzed deeply. The results indicated that students could make significant drawings for the problems if the structure of the problems were similar to previous problems. It was also stated that students' drawings about the solutions indicated their understandings about the problem. In the same way, students' understandings of problems affected their use of drawings. Additionally, Yazgan and Bintaş (2005) investigated 4th and 5th grade students' learning and usage of problem solving strategies. They designed an experimental study with 4th and 5th grade students in Bursa. Specific problem solving strategies which were guessing and checking, finding a pattern, drawing, working backward, writing simpler problem, organizing and listing given data were investigated. During the study, students who were in control group were taught by traditional methods and students who were in experimental group were instructed under these specific problem solving strategies and solved the problems with those strategies. After pretest and posttest results were investigated, it was stated that the 4th and 5th grade students were able to use problem solving strategies without any exercises. Also, practicing with problem solving strategies had a positive effect on the 4th and 5th grade students' problem solving achievements.

Aladağ and Artut (2012) studied middle schools students' realistic problem solving skills and proportional reasoning skills. Five hundred seventy students from the 6th, 7th and 8th year classes of public schools (190 students selected from each grade) participated in the study. A test which consisted of four problems requiring proportional reasoning and four problems requiring realistic answers was constructed by the researchers. Also, a total of 30 students (10 students from each grade level) were interviewed. The results showed that although the students had high performance at solving problems which required proportional reasoning, they had difficulties to transfer their real life experiences into realistic problems.

2.2 Reasoning

Reasoning is one of the main goals of mathematics (Yankelewitz, 2009). According to NCTM (2000), reasoning and proof are one of five process standards

in mathematics education and "systematic reasoning is a defining feature of mathematics" (p.57). Reasoning, broadly defined, is the process of organizing evidence, beliefs and ideas to come conclusions about its accuracy (Leighton, 2003). Rips (1994) defines reasoning as an intellectual process which constructs new ideas by using old ones. Reasoning is a way of thinking and explaining something (Webster, 1986). According to Peresini and Webb (1999), reasoning is an activity consisting of different thinking styles.

In the literature, there are some reasoning forms existing. Adaptive, algebraic and representational reasoning forms are some of the examples of reasoning forms. In this study, it is expected that students might show some developments in these reasoning forms; *adaptive, algebraic* and *representational*. For this purpose, definitions of these reasoning forms will be given below.

Adaptive reasoning means "the capacity to think logically about the relationships among concepts and situations and to justify and ultimately prove the correctness of a mathematical procedure or assertion" (NRC, 2001, p.170). According to National Research Council (2001), adaptive reasoning addresses formal proof and deductive reasoning; however, it refers more than this, such that it consists of justifying problem solving and "inductive reasoning based on pattern, analogy and metaphor" (p.129). National Research Council (2001) suggests that students can be asked to determine their adaptive reasoning; one question might be about how they reason to build the relationship between numbers and their properties while solving problems and other question might be about how they justify and defend their solutions.

Algebraic reasoning refers to "a process in which students generalize mathematical ideas from a set of particular instances, establish those generalizations through the discourse of argumentation, and express them in increasingly formal and age-appropriate ways." (Kaput & Blanton, 2005, p.99). Similarly, Van de Walle, Karp, and Bay-Williams (2011) stated that "algebraic thinking or reasoning involves forming generalizations from experiences with number and computation, formalizing these ideas with the use of a meaningful symbol system, and exploring the concepts of pattern and functions." (p.262).

Representational reasoning provides visual information such as in a diagram, a graph, a map or a table to understand and makes sense mathematical properties and relationships (Long, DeTemple & Millman, 2009). Students generate different arrangements of data according to precise conventions with the help of representational reasoning (NRC, 2001).

Related literature reveals that there are other forms of reasoning studied by researchers. Mueller (2007) conducted a study in which the forms of reasoning were analyzed. Two focus groups of 6th grade students in an informal after-school program participated in this study. Four forms of reasoning as direct reasoning, reasoning by cases, reasoning using upper and lower bounds, and reasoning by contradiction were detected in focus group sessions. The results indicated that all students built arguments to draw conclusions and all forms of reasoning were prevailed. Also, students worked in groups and constructed arguments by asking questions, challenging and connecting each other's ideas.

Some studies indicated that reasoning is connected with problem solving in some sense. Reasoning and logical thinking can be seen as adequate skills for problem solving to prove the process of solution (Kausler, 1991). Students' reasoning ability improved over the time when they were engaged in environments and problems that promoted them to reason meaningfully and persuade others for their reasoning (Francisco & Maher, 2005; Maher, 2002; Maher & Martino, 1996). When students were implemented divergent thinking and reasoning problems, their logical reasoning was developed significantly (Markovits & Brunet, 2012). Students' conditional reasoning ability was developed with the help of carefully designed activities which included both problem solving and games (Hadar & Henkin, 1978).

Research on students' reasoning also focused on the effects of interventions on the reasoning. For example, Erdem (2015) studied the effects of enriched learning environment including different teaching styles on 7th grade students' mathematical reasoning skills and attitudes. The results of the study indicated that enrichment of learning environment in mathematics class helped students to improve their mathematical reasoning skills. Similarly, Küpçü (2008) studied the

effects of activity based learning on 7th and 8th grade students' problem solving achievements while solving related proportional reasoning problems. Findings indicated that activity based instruction significantly affected students both problem solving and proportional reasoning skills.

2.3 Puzzles and Games

Game refers to 'a problem solving activity, approached with a playful attitude' with the process that the designer of the game must propose: 'What problems does the game ask the player to solve?' (Schell, 2008, p.37). There are extensive criteria recommending that "a game must be entered wilfully; have goals, conflict and rules; can be won or lost; is interactive; has challenge; can create its own internal value; can engage players; and is a closed formal system" (Schell, 2008, p.34). *Puzzle* is rule-based sytems, as games; however, the main aim of puzzle is to reach solution, not to beat an opponent (Crawford, 1984).

Mind games "deeply require the enactment of thinking and reasoning skills and are almost independent from knowledge/competence in specific school subjects" (Bottino, Ott, & Tavella, 2013, p.62). Mind games are also defined as puzzles or brainteasers (Mitchell & Savill-Smith, 2004; Prensky, 2001; Schiffler, 2006). Definitions of mind games in the literature correspond with puzzles and games used in this study. According to MoNE (2013), puzzles and games consist of different games and puzzles; reasoning and operation puzzles, verbal games, geometric-mechanic games, memory games, and strategy games.

Few studies were conducted regarding puzzles and games and its' effects on problem solving and reasoning skills. For example, Bottino, Ott and Benigno (2009) investigated learning by playing digital games (such as Treetent, Mastermind, Tetravex, Brickshooter and Hexip) and what design and opportunities provided the best development of reasoning skills. The main aim of the study was to longitudinally observe improvements of 3rd, 4th and 5th grade students' strategic and reasoning skills by providing them use of number of computer based games in classroom. The results of this study indicated that several characteristics such as possibility of grading the essential cognitive effort, usability of clues assisting

cognitive effort, availability of facilities directing cognitive effort towards verification activities of the games supported and developed reasoning skills of the students. Playing puzzles and games improved students' cognitive skills, and also motivation, attention and concentration positively. Bottino, Ott, Tavella, and Benigno (2010) have also found that digital mind games could be used to assess students' logical and reasoning skills. In addition to these studies, Bottino and Ott (2006) stated in their study that playing mind games developed students' thinking skills, logical reasoning, and strategic thinking. Mathematic achievements of students who played these games were higher than mathematics achievement of students who did not experienced mind games.

In other respects, some researchers conducted studies about different types of puzzles and games such as reasoning and operational games, and strategy games, and their effects on different skills. Shriki (2009) stated that students who did not always enjoy mathematics class enjoyed being in a competitive setting while improving their mathematical thinking and reasoning by engaging strategy games in mathematics classrooms.

When the literature was analyzed, it was revealed that some puzzles and games such as Mastermind specifically arouse interests of researches. While Mastermind is seen as one of the strategy games (MoNE, 2013), it is also considered a problem solving game based on complex concept-problem with deciding a code and different group of feedback about it (Laughlin, Lange, & Adamopoulos, 1982). There are some studies regarding Mastermind and its strategy sides for children's cognitive developments (Best, 1990; Larsen & Garn, 1988; Laughlin, Lange, & Adamopoulos, 1982). Best (1990) stated in the study that participants showed some developments in strategies by playing Mastermind and they learnt from their experiences as they played Mastermind in time. It was revealed that subjects used two strategies; focusing and tactical, which were also discovered in one of the previous studies (Laughlin, Lange, & Adamopoulos, 1982). Strom and Barolo (2011) concluded in their study that Mastermind as a tool can be used in classroom to develop students' logical skills and scientific reasoning.

Applebaum and Freiman (2014) observed students from different age levels (8-17 years old) while playing Bachet's game which is also called Nim in the group of reasoning and operation puzzles. Students experienced "posing questions, conducting experiments, formulating hypothesis, verifying and validating, proving, and then starting a new cycle by formulating, new questions and adding more depth to their initial inquiry." (p.22). Researchers observed that students were in a significant mathematical environment which provided development of their understanding and reasoning.

Finally, Puzzles and Games course in Turkey have been initiated in middle school academic program in 2013. After implementing this course in Turkey, Turkish researchers have done few studies about the course. For example, Devecioğlu and Karadağ (2014) conducted a study regarding how students, teachers and principals considered the Puzzles and Games course. The sample of the study was 133 students (46 students taking Puzzles and Games course and 87 students not taking Puzzles and Games course), 15 teachers (four teachers teaching Puzzles and Games course and 11 teachers not teaching Puzzles and Games course) and three principles who were implemented five open-ended questions to reveal their views about the course. The findings of the study showed that students considered Puzzles and Games course as learning new games entertainingly and developing practical thinking. According to students, Puzzles and Games course helped them mostly to improve their problem solving skills.

2.4 Summary of Literate Review

The studies summarized above showed that students could exhibit limited problem solving strategies unless they were trained for strategies. Therefore, several studies have also investigated the effects of specific training on students' problem solving strategies and performance (such as Altun, 1995; Erdoğan, 2015; Lester, Garofalo & Kroll, 1989). Additionally, some aspects of the real world problems and routine and non-routine problems in relation to problem solving strategies were examined by the researchers (such as Bayazit, 2013; Erdoğan, 2015; Nunokawa, 2004; Yazgan & Bintaş, 2005). Finally, elementary schools students'

realistic problem solving skills and proportional reasoning skills were investigated (such as Aladağ & Artut, 2012).

The forms of reasoning and their effects on special mathematical abilities were studied by the researchers (Erdem, 2015; Francisco & Maher, 2005; Maher, 2002; Maher & Martino, 1996; Markovis & Brunet, 2012). Moreover, researchers have investigated the link between reasoning and problem solving skills and reached significant results (Chang, 2010 & Küpçü, 2008). Finally, Hadar and Henkin (1978) investigated reasoning skills with games in a problem solving environment.

There is not, however, sufficient number of studies concerning puzzles and games in relation with the problem solving and reasoning skills. Few studies were carried out about relationship between puzzles and games and reasoning ability, assessments of reasoning ability and school performance (Bottino & Ott, 2006; Bottino, Ott & Benigno, 2009; Bottino, Ott, Tavella & Benigno, 2010; Bottino, Ott & Tavella, 2013). In addition to these, the effects of some specific puzzles and games to problem solving and reasoning skills have been studied (Applebaum & Freiman, 2014; Best, 1990; Larsen & Garn, 1988; Laughlin, Lange & Adamopoulus, 1982; Shriki, 2009). Last, Devecioğlu and Karadağ (2014) conducted a study regarding perceptions of students, teachers and participants related to Puzzles and Games course. Yet, sparse literature has addressed the effect of puzzles and games on students' problem solving and reasoning skills. Since formats and some specific designs of puzzles and games is quite related to problem solving and they require reasoning skills to reach conclusions as problem solving (Bottino, Ott & Benigno, 2009), the current study is assumed to contribute to the literature in the context of problem solving and reasoning studies embedded in mind games.

CHAPTER 3

METHOD

The focus of this chapter is the methodology used to conduct this study. Information about the research design, population and sample, data collection instruments, pilot study, validity and reliability of the instruments, data collection procedures, data analysis, internal and external validity and lastly assumptions and limitations of the study are presented in this chapter.

3.1 Design of Study

The main purpose of the study was to investigate the effects of Puzzles and Games course on students' problem solving strategies and reasoning skills. The design of the study was first person inquiry with one group. "First-person" inquiry refers to being the researcher and the teacher at the same time and it also consists of multiple forms of research on teaching such as action research, teacher research, reflection in and on teaching, teacher narratives and researcher-teacher (Ball, 2000). There are many types of first-person inquiry which differs from other research types. In this first-person inquiry research method, the teacher has the questions about educational issuem, wants to answer the questions, plans the study, applies it, and comes to conclusions (Ball, 2000). According to Ball (2000), when the researcher is not the teacher of class, he/she sits, notes down, monitors students and teacher in the classroom. In this way, the researcher makes an effort to understand classroom environment and tries to analyze it and makes inferences. Ball (2000) stated that the researcher, who is from "outside", looks from a broad perspective than a person who has already spent time in the classroom. The outside researcher can see and recognize the routines of the classroom. However, from a different point of view, outsiders could easily miss depth of the classroom language and routines (Ball, 2000). Therefore, they have difficulties to understand classroom environment

comprehensively. Ball (2000) noticed in her study that being teacher and researcher at the same time provided an opportunity to determine the needs and deficiencies of students.

Similarly, the researcher -namely I (the teacher of Puzzles and Games course in 6th grade)- aimed to examine whether Puzzles and Games course influenced students' problem solving strategies and reasoning skills. It is plausible to claim that as a teacher who has been the teacher of Puzzles and Games course for more than two years, I am familiar with students' behaviors more than any researcher who has never been in Puzzles and Games course class before. Therefore, I, as the researcher of this study, had more experience in understanding the students' questions and reactions to the games and puzzles, using a first-person perspective.

This study is also an example of "weak experimental design" which means that there is no control group to control the threats to internal validity (Fraenkel & Wallen, 2006). One of the types of weak experimental design is "one-group pretest-posttest design" which fits in this study. The definition of the one-group pretest-posttest design emphasizes that single group is observed or measured not only before a treatment, but also after. In this study, I observed the group before, during and after the treatment. Details about data collection process will be presented below.

3.2 Context: Puzzles and Games Course

Puzzles and Games course has been initiated in middle schools in 2012-2013 academic years by the Ministry of National Education (MoNE) in Turkey. Puzzles and Games course is based on Layered Curriculum Model, which refers to a student centered method based on a triangular-shaped model of three layers (Nunley, 2001). This model was improved by Nunley who wanted to develop her students' variety of abilities, cultures, and languages and attach importance to the students' learning responsibilities and provide an environment that students take their own responsibilities about their learning (Blackwood, Brosnan & May, 2007). Layered Curriculuim Model based on three importants keys: choice, accountability

and higher level of thinking (Daniels, 2004). "To include all types of learners, layered curriculum takes the approach of modifying the entire curriculum rather than making individual accommodations" (Nunley, 2004, p.7).

In this model, students can choose their own learning activites based on three levels of curriculum objectives that center higher levels of understanding (Nunley, 2002). Namely, this model provides some activities as the baseline of from simple to complex, from easy to difficult, from concrete to abstract and from known to unknown (MoNE, 2013). To compose a layered lesson plan, the teacher analyzes the main concepts, tasks and abilities that are expected to teach in a lesson and divides them into three layers according to levels of difficulties, in the light of Bloom's Taxonomy (Nunley, 2003). That is, "basic concepts go into the C layer; more complex thinking skills in the B layer; and the most complex, higher level thinking skills go in the A layer" (Nunley, 2003, p.28). To clarify layers of C, B, A, students who are in the layer of C learn a specific number of basic knowledge and basic level of assignments; students who are in the layer of B finish the assignments in layer of C and additionally, these students practice more complex activities, such as carrying some information into a new format or perform new skills and students who are in the layer of A finish assignments in layer of C and B and additionally, these students think in high level and combine the assignmnents with ethics, values and opinions (Nunley, 2003). Each layer supplies a list of assignments that refers to different learning tasks and abilities. Students can prefer which assignment they would like to finish and each assignment includes tasks which are different levels of difficulties (Nunley, 2003).

It is expected that teachers organize a Puzzles and Games course lesson that involves games and puzzles consisting of three layers according to students' levels. Layered Curriculum Model in Puzzles and Games course predicts three layers based on hierarchical structure of simple to complex cognitive activities as stated below (MoNe, 2013):

C Layer-Beginner: This level consists of learning rules of games, gaining basic knowledge and skills, playing beginner levels of games and solving beginner levels of puzzles.

B Layer-Intermediate: This level consists of making logical reasoning, starting with significant point in games, applying basic strategies in strategy games, playing intermediate levels of games and solving intermediate levels of puzzles.

A Layer-Advanced: This level consists of creative thinking, analysis, developing original strategies, benefiting from others' experiences, evaluation, generalization, playing advanced levels of games, solving advanced levels of puzzles.

All the activity papers used in Puzzles and Games course were designed according to Layered Curriculium Model. As an example of an activity paper related to Sudoku was given in Appendix A.

Puzzles and Games course is also designed for different types of games, puzzles and problems such as *reasoning and operation puzzles, verbal games, geometric-mechanic games, memory games, strategy games,* and *problems* (MoNE, 2013). The distribution of games, puzzles and problems in two semesters in 2014-2015 academic years was the same. While the Fall semester of 2014-2015 academic years' 6th grade Mind Game Course Plan was based on generally reasoning and operation puzzles, strategy games and problems, the Spring semester 6th grade Mind Game Course Plan was based on verbal games, geometric mechanic games and reviews of reasoning and operation puzzles, strategy games and problems. Since the study was conducted in the Fall semester of 2014-2015 academic years, only the content of the activities applied in the Fall semester of 2014-2015 academic years in 6th grade Puzzles and Games course will be explained in detail below.

Each session of Puzzles and Games course was conducted in two periods (80 minutes) and was processed normatively in two Puzzles and Games classes by two teachers (one was the researcher). Power point presentations were prepared by the teachers and a program development specialist for each game and mind problem to explain games and problems clearly.

For reasoning and operation puzzles in Puzzles and Games course, the copies of papers with reasoning and operations games were made ready for each student before the sessions. After the teacher explained how the games are played openly through the instrument of power point presentations at the beginning of the lesson,

they solved at least one example on the board with the students. Then, the papers were distributed to students and they were given sufficient time (generally at least 25-30 minutes) to solve them. It was not expected that all the students solved all the games according to Layered Curriculum Model and the correct answers were projected on the board at the end of the given time. If there were wrong answers, some games which students made incorrect moves were played on the board. At the end of the session, students put the papers into their folders of Puzzles and Games course and kept them during the semester.

For strategy games in Puzzles and Games course, sufficient numbers of board games were made ready before the sessions. After the teacher described the features of the games and how to play them, by power point presentations and showing the materials of board games to all students, at least one example of game videos or animations that illustrated how to play the games was watched by the students. After students grouped in two or four according to the games, they were given at least 40 minutes to play the games. While they were playing the games, teacher visited all the groups and observed their games. If the students played the games with an incorrect procedure, teacher interfered the play and corrected it. The teacher sometimes played the games with students to make the sessions more enjoyable and excited. While the students and the teacher were playing the game, other students watched the play and suitable strategies for the move in the game were discussed by all the students. Students delivered the board games to their teachers at the end of the sessions.

For problems in Puzzles and Games course, the copies of problem papers were made ready before the sessions. After the teacher distributed the papers at the beginning of the lesson, the problems which were also projected on the board were read by the teacher loudly. Teacher made sure that all the students understood the problem and what was expected in the problem clearly. Then, sufficient time (at least 15-20 minutes) was given students to solve problems. In this process, students generally tried to solve the problem on their own. In some cases, the teacher gave some clues to increase students' motivation while solving the problem. After that, nearly all students shared their ideas about the solutions of the mind problem.

Students were not expected to reach the correct answers in any case. The teacher provided an environment that students could share their ideas and discuss their solutions. After the discussions, correct solutions of the problems were shown on the board by the students or the teacher. If the reasoning and operations games and problems were played with strategy games in one session, reasoning and operations games or problems were played in the first period of session and after, the strategy games were played in the second session.

Finally, students were asked "What did you learn today?", "What is new for you today?", "What strategies you have developed while playing games and solving problems?", "Did you enjoy?", and "Why did not you like this game?" in the last ten minutes in every session. Moreover, some evaluation forms which consisted of similar questions were distributed end of the sessions and after they filled out them, students gave them back. Teachers read each of them to have more detailed information about students' development in the course.

3.2.1 Context of Reasoning and Operation puzzles, Strategy Games and Problems in 6th grade Puzzles and Games Course

Each session (two periods) of the 6th grade Puzzles and Games course in the first period was generally planned in such a way that it consisted of at least one game. According to difficulty levels of games and problems, while some sessions consisted of only one game, some sessions involved combinations of games and problems such as strategy game-reasoning and operation puzzle, strategy game-problems, and reasoning and operation puzzle-problems. All puzzles, games and problems implemented in the classroom are given in appendixs. One example for each type of games is given below.

3.2.1.1 Reasoning and Operation Puzzles

Reasoning puzzles are generally solo games as puzzles which require evaluations of given clues and making logical reasoning to come to a conclusion in the game (MoNE, 2013). *Operation puzzles* require to use of operation skills as well as logical reasoning (MoNE, 2013). According to (MoNE, 2013), in these games;

- all required information about the games is given at the beginning of the games,
- although the solutions are generally obvious, deciding the order of evaluation of the clues might be difficult, and
- the player does not need to have any special knowledge and appointments to solve games.

Sudoku, Kendoku, Battleships, Tent, ABC Connection Puzzle, Shitherlink and Digital Operations which are suggested by MoNE (2013) applied as reasoning and operation puzzles in the 6th grade Puzzles and Games course. Some of the reasoning and operation puzzles were taken from "Akıl Oyunları" magazine which was issued by Turkish Agency of World Puzzle Federation (Türk Beyin Takımı) every three months. Some of them also were taken from mathematics education websites.

Sudoku is given as an example for reasoning and operation puzzles below. Other reasoning and operation puzzles implemented in the classroom are given in Appendix B.

3.2.1.1.1 Sudoku

Player: 1

Rule: Sudoku is played on a grid of 9x9 spaces. Within the rows and columns are 9 "squares" (made up of 3 x 3 spaces). Each row, column and square (9 spaces each) needs to be filled out with the numbers 1-9, without repeating any numbers within the row, column or square ("Sudoku Rules for Complete Beginners", 2013).

Sudoku can be played on a grid of 6 x 6 spaces with the numbers 1-6. Since the Puzzles and Games course curriculum based on Layered Curriculum Model, problems of 6 x 6 Sudoku were also solved at the beginning of the semester. In addition to these, all difficulty levels (1-5) of Sudoku problems were put in the weekly activities. An example of easy level 9 x 9 Sudoku is given in Figure 1.

Figure 1 An example of Easy Level of 9 x 9 Sudoku

3.2.1.2 Strategy Games

Strategy games refer to games that two or more players play with each other and there is/are loser(s) and winner(s) at the end of the game (MoNE, 2013). Strategy games consist of many games easy or difficult to analyze, and the player needs to use guesstimate and others' experiences about the game as well as developing strategies and logical reasoning (MoNE, 2013). According to MoNE (2013), in these games;

- sides might be solo or team,
- there might be some probabilistic factors, and
- some materials can be used as board games.

Mastermind, Mancala, Quoridor, Turkish Checkers which are suggested by MoNE (2013) and also Quixo and Quarto applied as strategy games in the 6th grade Puzzles and Games course. Instructions about the games were taken from their websites or some mathematics education websites. Mastermind is given as an example for strategy games below. Other strategy games implemented in the classroom are given in Appendix C.

3.2.1.2.1 Mastermind

Player: 2

Materials: 72 large pegs in six colors, 15 small pegs in red, 15 small pegs in white and a game board founded 9 rows of large holes, 9 rows of small holes and 4 holes for code. The picture of the materials is given in Figure 2 below.

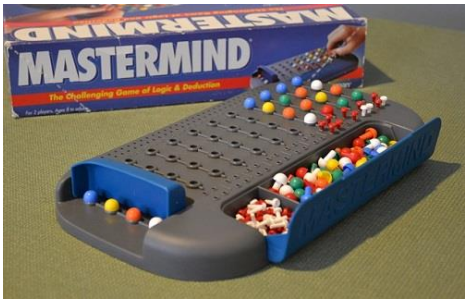


Figure 2 Mastermind

Rule: The object of the games is that the code breaker guesses the secret code composed by the code maker. In mastermind, there are two players that one is the code maker and the other is the code breaker. At the beginning of the game, the code maker secretly composes the code in the hidden compartment by using large pegs in any combination of six colors. After, the code breaker guesses by putting large pegs at the bottom row, the code maker gives feedback about the code breaker's guess that if the code breaker puts the pegs in right color and position, the code maker puts red small pegs in the small holes for each; if the code breaker puts the pegs in right color but wrong position, the code maker puts white pegs for each. At each guess, the code breaker should evaluate the code maker's feedback logically. The winner of the game is the player who breaks the code in the fewest turns ("How to Play Mastermind", n.d.).

3.2.1.3 Problems

Problems refer to problems that players can find the correct answer with the help of using given clues and the solution of the problem is not straightforward at the beginning (MoNE, 2013). Problems do not have to have only one solution and

nearly all the problems have the key part and who get this key part easily can reach the correct answer. Also, they are not based on any specific subjects of mathematics curriculum. “Wolf, sheep and cabbage”, “Measuring volume of container by the containers whose volume are different and known”, “Einstein Puzzle”, and “The liar and the truth teller” which are suggested by MoNE (2013) and other problems were applied as problems in the 6th grade Puzzles and Games course. All the problems were taken from mathematics education websites.

“Wolf, sheep and cabbage” is given as an example for problems below. Other problems implemented in the classroom are given in Appendix D.

3.2.1.3.1 Mind Problem 1: Wolf, sheep and cabbage

“A farmer needs to bring a wolf, a sheep and a cabbage across the river. Since the boat is tiny, it can only carry one passenger at a time. If he leaves the wolf and the sheep together, the wolf will eat the sheep. If he leaves the sheep and the cabbage together, the sheep eat the cabbage. How can he bring all three safely across the river?” (“The activity Wolf Sheep Cabbage”, n.d.).

3.3 Population and Sample

Convenience sampling method was used in this study. Convenience sample consists of individuals who are available, however, this sample cannot be considered as representative of any population (Fraenkel & Wallen, 2006). The sample of the study was middle school students (6th grade) in a private school in Gölbaşı, Ankara. There were 580 6th grade students in the school at the time of the study and 40 of them voluntarily chose Puzzles and Games course as elective course in 2014-2015 school year. The participants (40 students) were divided into two classes by the school management. The researcher was the Puzzles and Games course teacher for one of the classes and the second class’s teacher was one of the mathematics teachers who had one year experience in teaching Puzzles and Games course. Both of them received training about how to teach Puzzles and Games course from Turkish Agency of World Puzzle Federation (Türk Beyin Takımı). The

data were collected from these two classes. In other words, there was no control group in the study.

3.4 Data Collection Instruments

The data for this study were collected through Mathematical Problem Solving Test, Puzzles and Games course evaluation forms and semi-structured interviews. The data collection instruments are explained below in detail.

3.4.1 Mathematical Problem Solving Test (MPT)

"Mathematical Problem Solving Test" (MPT) was developed as the data collection instrument to measure the effect of Puzzles and Games course on students' problem solving strategies and reasoning skills. The tool was implemented both as the pre-test and the post-test.

It was partially developed by the researcher of this study. MPT (see Appendix F) consisted of eight open-ended items taken or adapted from the literature. Before preparing problems for the tests, related literature was reviewed. It was found that problems in problem solving tests in the literature were generally categorized as non-routine, real world and word. These required the use of problem solving strategies and mathematical reasoning and they did not involve only mathematical computation. 1st, 2nd, and 8th problems in MPT were taken from Karaoğlan (2009) and 2nd problem was recomposed to render the problem more complicated. By this way, students were forced to think in different ways and use more than one problem strategies to reach true answer. The 3rd, 4th, 5th, 6th and 7th problems in MPT were taken from Yıldız (2008). Items 3 and 7 were recomposed. The story of the 3rd item was changed to render the problem more attractive for the students. Moreover, 7th item was a problem which required estimating skill about daily life. Since Puzzles and Games course objectives did not aim to develop any skill like that, the item was made into a problem which required using logical reasoning and finding a pattern of problem solving strategies. Hereby, all the problems in MPT fall into the categories of non-routine and real world problems.

There are several problem solving strategies such as organizing data, intelligent guessing and testing, solving a simpler equivalent problem, finding a pattern, logical reasoning and making a drawing for the correct solution (Posamentier & Krulik, 2009). The items were reviewed in relation to the problem solving strategies by two elementary mathematics teachers and a mathematics education researcher. The distribution of the items according to these problem solving strategies as agreed by the mentioned reviewers was given in Table 1.

Table 1 MPT Content Related to Problem Solving Strategies

	P1	P2	P3	P4	P5	P6	P7	P8
Organizing Data						x		
Intelligent Guessing and Testing			x					
Solving a Simpler Equivalent Problem	x							
Logical Reasoning	x	x	x		x		x	x
Making a Drawing	x			x				x
Finding a Pattern				x			x	

The problems in MPT requiring these problem solving strategies shown in Table 1 were preferred deliberatively. The objectives in Puzzles and Games course related to strategy games, reasoning and operation puzzles and problems address these problem solving strategies shown in Table 1. For instance, the objectives related to strategy games might influence students' logical reasoning, organizing data, intelligent guessing and testing and solving a simpler equivalent problem strategies. Similarly, the objectives related to reasoning and operation puzzles might influence students' logical reasoning, finding a pattern and intelligent guessing and testing strategies. Furthermore, the objectives related to problems might influence students' logical reasoning, making a drawing and organizing data strategies. Therefore, it might be expected that students who engage these games, puzzles and problems show some developments in these problem solving strategies. By this way, it might be measured students' improvements in problem solving

strategies and reasoning skills by MPT applied before and after Puzzles and Games course.

3.4.1.1 Pilot Study of the MPT

MPT was piloted with 6th grade students taking Puzzles and Games course in 2013-1014 academic years. The aim of this implementation was to check the comprehensiveness and difficulty of items, suitability of duration, and the potential difficulties that might appear. There were 61 students taking Puzzles and Games course in the pilot study who attended the same private elementary school in Gölbaşı district. Students were given 40 minutes for the Mathematical Problem Solving Test. No difficulties were observed during the implementation. After the pilot study, analyses were conducted with data to check the usability and reliability of instrument. Student comments about the problems during the administration process and analysis of the student answers in the pilot study provided significant insight to the data collection tool before the actual data collection process. Some correction and adjustment were done with the help of those feedbacks.

First of all, it was observed in the 5th problem that students was challenging while multiplying decimals by a whole number. Since the objective of the problem was not about multiplying whole numbers by decimals, all decimals in the problem were replaced by suitable whole numbers. Also, only few students could answer the 8th problem correctly. Therefore, a picture of equal arm scale was put in order to provide visual help for the students. Last, the story of 7th problem was rewritten to make the problem more understandable.

For the possible solutions of Mathematical Problem Solving Test (MPT), a holistic rubric was constituted by the researcher. Before developing this rubric, literature was examined. Students' answers were coded as wrong answers (0 point), calculation errors (1 point), wrong answers with proper problem solving strategy (1 point) and correct answers with proper problem solving strategy (2 points). The rubric was checked by two mathematics teachers and a mathematics education researcher. The comments and evaluations of them were examined by the researcher and through the suggestion of one of the mathematics teachers; one

possible solution of the second problem was added in the rubric. After this revision, the rubric was put into the final form (See Appendix F). MPT was scored out of 18 points.

Solutions of the students in MPT were checked by the researcher and a mathematics teacher individually based on this rubric. Since all problems were open-ended in the test, scoring agreement which refers to inter-rater reliability should be satisfied (Crocker & Algina, 1986). In order to check inter-rater reliability, the Pearson Correlation was calculated between two scorers. This correlation coefficient which should be .80 and higher (Gravetter & Wallnau, 2006) and it was found as .97 for the pilot study. It indicated the high consistency between scorers. This result reflects the reliability of the scoring for MPT.

3.4.1.2 Validity and Reliability of the MPT

Validity means "appropriateness, correctness, meaningfulness and usefulness of the inferences" (Fraenkel & Wallen, 2006, p.151) based on the procedure of constituting instrument. To provide content validity of MPT, appropriateness of content, comprehensiveness, structure of the items were controlled. Namely, after the problems were brought together by the researcher, the tool was examined by one mathematics education researcher and two mathematics teachers for the level of difficulties for 6^{th} grade students, appropriateness for the mathematics curriculum and then, one Turkish teacher controlled the problems for wording and miswriting. Additionally, students' solutions in pilot study of MPT supported the Table 1. Namely, problems' solving strategies which are presented in Table 1 were revealed in the pilot study.

Reliability is referred to as "the consistency of the scores obtained" (Fraenkel & Wallen, 2006, p.157). To check data collection instrument's reliability, students' answers in MPT were checked according to the rubric by the researcher and a mathematics teacher individually. As done in the pilot study of MPT, the Pearson Correlation was calculated between scorers to check inter-rater reliability. The correlation coefficient in the pre-test found as .92 and the correlation

coefficient in the post-test found as .94 showing high consistency between scorers (Gravetter & Wallnau, 2006), it also indicated the reliability of the scoring MPT.

3.4.2 Puzzles and Games Course Evaluation Forms (PGCEF)

The evaluation form was developed to get deeper information about the effectiveness of Puzzles and Games course. Also, the aim of Puzzles and Games Course Evaluation Forms was to have an initial idea about what students thought about Puzzles and Games course, whether they developed different strategies while playing games or solving problems, whether Puzzles and Games course caused some changes in their daily life and what they thought about games which they played during semester (such as challenging, boring, interesting, fun, or useful).

The PGCEF consisted of eight open-ended questions. All the questions were developed by the researcher (Puzzles and Games course teacher), a Puzzles and Games course teacher and a program development specialist working in the private school the study was conducted. This form was not developed specifically for the study but modified from an existing form used in the school. Students who took the course in the previous years were asked to fill a similar form as a course requirement. These kinds of Puzzles and Games course evaluation forms were implemented to all Puzzles and Games course students at the end of the 2012-2013 and 2013-2014 academic years to improve the course content according to students' views. The forms which students filled were evaluated by the Puzzles and Games course teachers and program development specialist and according to these evaluations, required changes in lesson plans were made by the teachers. The form is presented in Appendix G.

3.4.3 Interview Protocol

A semi-structured interview protocol was designed to investigate students' thinking process while solving problems and how they reasoned to use their chosen problem solving strategies at the beginning of the study. The first part of the interview protocol aimed to get deeper information on students' reasoning skills. The second part aimed to have more information about how students thought about

the effectiveness of the Puzzles and Games course simply by asking the questions in the evaluation form (PGCEF) because students provided very short responses to the questions in the form.

A draft of interview questions for the protocol were prepared by the researcher of the study after the pilot study and the mathematics teacher who was the other teacher of Puzzles and Games course also helped in developing the interview questions. The questions were reviewed by a researcher in the field of mathematics education and a doctoral student in the field for its purpose. The pilot study of the interview protocol was conducted with one 6^{th} grade students who attended the Puzzles and Games course in 2014-2015 academic years but who was not included in interview participants. No problems were faced during the pilot interview by the student. The interview protocol is given in Appendix H. A summary of the research questions and the data gathering instruments are given in Table 2.

Table 2 The Research Questions and Data Gathering Instruments

Research Questions	Data Gathering Instruments
1. To what extend Puzzles and Games course influenced 6th grade students' problem solving and reasoning skills? 1.1 Is there statistically significant difference between students' scores on Mathematical Problem Solving Test (MPT) before and after the Puzzles and Games course? 1.2 Which problem solving strategies and underlying reasoning skills have been improved at the end of Puzzles and Games course?	• Pretest • Posttest • Interviews with selected students
2. What are the students' views about the effectiveness of the Puzzles and Games course?	• Evaluation forms • Interviews with selected students

3.5 Variables

In this study, there was one independent variable. It was the treatment which taking Puzzles and Games course during one semester. Dependent variable of the study was students' scores on mathematical problem solving test (MPT).

3.6 Data Collection Procedures

Each session (two periods) of 6th grade Puzzles and Games course was planned by the researcher and a curriculum development specialist in 2013-2014

academic year. After each lesson plan was implemented in the 6th grade Puzzles and Games course during 2013-2014 school year, some of the activities were revised according to researcher's (the teacher of the course) and students' feedbacks, and they were prepared for the 2014-2015 academic year. The course outline of 6th grade Mind Game course implemented in the 2014-2015 academic year is presented in Appendix I.

In the fall of 2014, the necessary permissions were taken from Middle East Technical University Human Subjects Ethics Committee (see Appendix J) and then, official permissions needed for conducting the study were taken from the Ministry of National Education (see Appendix K). Then, school administrators' permission was obtained. All data were collected during the Fall semester of 2014-2015 academic year in 19 weeks. The pretest (MPT) was implemented to two Puzzles and Games classes, which were totally 40 students, at the 2nd week of the semester. After this, the course proceeded as planned. The posttest (MPT) was implemented to two Puzzles and Games classes, which were totally 40 students, at the 18th week of the semester. Puzzles and Games course evaluation forms were filled by 40 students at the 19th week.

After the implementation of the Mathematical Problem Solving Test, the researcher analyzed all students' solutions in the pre and posttest. The problem solving strategies students preferred were determined. Seven students (three girls, four boys) who have made progress in the posttest on the basis of problems compared to the pretest were chosen for the interview. The first aim of choosing these students was to support the results of pre and posttest comparison since there was a statistically significant increase in scores from pretest to posttest. The second aim was to understand students' developments in problem solving strategies and underlying reasoning skills in detail and to have an idea about Puzzles and Games course's effects on students' problem solving strategies and reasoning skills better.

Carrying out interviews was necessary in this study because interviews provided a better understanding of students' problem solving strategies and underlying reasons for choosing these strategies and process of applying them. Cobb and Steffe (1983) also stated that interviews ensured to observe students while

solving problems and by this way, their strategies and intuitions were better observed. Therefore, each student was asked about how he/she thought and applied problem solving strategies. In this way, students' answers to the problems were understood better.

Before the interviews, students were informed about the purposes of the study and the interview. The interviews took approximately 25-30 minutes. Students were asked to clearly explain their answers and problem solving stages by reviewing their responses in the posttest. During the interviews, open-ended questions addressed students' responses to understand their problem solving strategies and underlying reasons for their answers. The researcher, I, probed students' answers by asking such questions "How did you get this answer?", "Why did you make this operation first?", "Why did you prefer this strategy?" Students were asked these kinds of questions for each problem that they made progress. In addition to this, in the second part of the interview, all the questions in Puzzles and Games Evaluation form were asked each participant and they were asked to explain their ideas about the course clearly. Extensive notes were taken by the researcher during all interviews. Interviews were conducted in empty classrooms in the school during lunch breaks based on students' free time.

3.7 Data Analysis

The first research question was sought through the analysis and comparison of the pre and posttest responses and the interviews conducted with the selected students. A holistic rubric (See Appendix E) was prepared by the researcher after the pilot study in order to analyze students' solutions for the items in the MPT and students' answers were checked according to this rubric by the researcher. A paired samples t-test was conducted to compare students' problem solving and reasoning skills before Puzzles and Games course and after Puzzles and Games course. A paired samples t-test was run to compare students' scores in the pre and posttest by SPSS 20.

In order to have deeper opinion about students' reasoning skills, students who made progress in posttest compared to pretest were interviewed. Interviews

with the selected students specifically focused on their responses in the posttest and the rationale behind those responses. Students' interviews were analyzed to understand students' solutions in deep and how they reasoned to come to these solutions. Specifically, their responses to how and why questions asked during the interviews were analyzed with respect to the types of reasoning skills they employed.

The 2nd research question was examined through the analysis of Puzzles and Games Course Evaluation Forms and the interviews conducted with the selected students. Evaluation forms and interview questions were same since students wrote on the forms very shortly; therefore, students were interviewed by the same questions in order to have more information about their ideas about the course. Their responses were first read by the researcher several times. Then, they were categorized based on the recurring ideas about the effectiveness of the course and about games and problems.

3.8 Internal and External Validity

3.8.1 Internal Validity

Internal validity means that only independent variables caused the differences on the dependent variables not due to any unintended variables (Fraenkel & Wallen, 2006). In general, for the one group pretest-posttest design, possible internal validity threats are subject characteristics, data collector characteristics, data collector bias, testing, maturation and implementation (Fraenkel & Wallen, 2006). Therefore, the following threats were considered during the study.

Subject characteristics threat refers that the participants in the sample may differ from each other in some unintended individual variables. In this study, the sample was 6th grade Puzzles and Games course students who were at the same age and from the same private school. Furthermore, it was assumed that participants of this study had the same mathematical experiences since they were in the same

school which strictly implements the same instruction. Therefore, the subject characteristics threat was reduced.

A data collector characteristics is one of the internal threats for this study. According to Fraenkel and Wallen (2006), this threat comes up if the instruments are administered by different persons. In this study, data were collected by the teachers of the Puzzles and Games course including the researcher and another teacher. Both teachers were female in similar ages and have been teaching in the school for at least two years at the time of the study, which partially eliminated this threat.

Another threat for the study is data collector bias. The researcher collected half of the data and the teacher of second classroom, who collected the other half, was carefully informed about the data collection procedures to conduct the implementation in the similar way. Similar guidance was provided for the students in both classrooms. Therefore, this threat was partially eliminated.

Testing effect means the effects of instruments on each other (Fraenkel & Wallen, 2006) and it may be a threat for this study. However, the instruments such pre and posttest, Puzzles and Games Evaluation Forms and all the interviews conducted in different time intervals. There were 15 weeks between the pre and posttest. Although the students might remember some of the items, since course content were not directly about the items and it included several problems and games that students handled, it was assumed that pretest did not affect posttest performance.

Maturation means that the reason of changes in intervention is not due to the intervention, it is because of the time passed (Fraenkel & Wallen, 2006). The time interval was 15 weeks between pre and posttest. The mental skills of students in this grade level might have developed within 15 weeks. However, this development might not have as much influence as the treatment on participants' responses in the posttest.

Implementation can be one of the internal threats for this study. According to (Fraenkel & Wallen, 2006), implementation threat occurs when different people implement different methods. This threat did not occur in this study because

different teachers implemented same lesson plans in two 6th grade Puzzles and Games classes. Also, to overcome this threat, two teachers of 6th grade Puzzles and Games course met every week before the course to talk about lesson content. By this way, teachers tried to provide similar lessons in two classes.

3.8.2 External Validity

External validity is defined as "the extent to which the results of a study can be generalized from a sample to a population" (Fraenkel & Wallen, 2006, p.108). In order to generalize the results of the study to a population, the sample should be representative of the population. Therefore, the results of this study could not be generalized to a population since the sampling method was convenience sampling and the data were collected from only one private school's students. In addition, Fraenkel and Wallen (2006) stated that ecological generalizability is "the extent to which the results of a study can be generalized to conditions or settings other than those that prevailed in particular study" (p.108). This means that if the similar conditions are provided, the results of this study can be generalized to a larger population. That is, this study may result in similar outcomes with students who have similar academic achievement and social characteristics in other regions. Therefore, the results of this study can be generalized to a population who has the similar settings.

3.9 Assumptions and Limitations

First of all, one of the limitations of the recent study was that the selection of the participants was not random sampling. However, students chose this course voluntarily and the classes were formed randomly. Second, first person inquiry was the design of study (Ball, 2000). One of the two Puzzles and Games classes in the school was taught by the researcher. That is, the researcher was the teacher at the same time. Since this situation made the research process considerably subjective, I tried to be objective as much as I could do. However, the results should be interpreted considering this limitation. Third, the time interval between pre and posttest was 15 weeks. There is a remote possibility that students might have

remembered the items. However, it was not much possible that students solved the problems by memorizing their solutions in the posttest. Finally, there was no control group in this study due to the regulations of the schools in which the study was conducted.

The participants of the study were assumed to answer the problems in the instruments sincerely and accurately. The researcher (the teacher of Puzzles and Games course) did not conduct any activities which directed students' answers in the instruments since all the lesson plans and activities were prepared previously. Also, findings of this study are limited by the course content and the instruments.

CHAPTER 4

FINDINGS

The purpose of this study was to investigate the effects of Puzzles and Games course on students' problem solving and reasoning skills. For this purpose, this study explored problem solving strategies and underlying reasoning skills in the beginning and at the end of the course. This study also aimed to determine students' views about the effectiveness of the Puzzles and Games course.

In this chapter, the results of data analysis are presented in detail according to research questions. The findings of Mathematical Problem Solving Test's scores, Puzzles and Games Course Evolution forms filled by all the students who took Puzzles and Games course, and interviews conducted with Student1 (S1), Student2 (S2), Student4 (S4), Student6 (S6), Student10 (S10), Student16 (S16), Student22 (S22), are given in detail, and then, all the results are summarized.

The research questions that were sought in this study are given below:

1. To what extend Puzzles and Games course influenced 6^{th} grade students' problem solving and reasoning skills?
   - 1.1 Is there statistically significant difference between students' scores on Mathematical Problem Solving Test (MPT) before and after the Puzzles and Games course?
   - 1.2 Which problem solving strategies and underlying reasoning skills have been improved at the end of the Puzzles and Games course?
2. What are students' views about the effectiveness of the Puzzles and Games course?

4.1 Analysis of Pretest and Posttest Results

One of the aims of the present study was to examine how Puzzles and Games course influenced 6th grade students' problem solving and reasoning skills. This research question was sought by the comparison of mean scores of pre and posttests of Mathematical Problem Solving Test by paired samples t-test. Prior to running the analysis, the assumptions of paired samples t-test were checked for MPT scores. In the next sections, descriptive statistics of pre and posttest, assumptions and analysis of results were summarized.

4.1.1 Descriptive Statistics of Pretest and Posttest for Comparison

Descriptive statistics related to the pretest and the posttests (Mathematical Problem Solving Test (MPT)) for comparison were presented in Table 3.

Table 3 Descriptive statistics related to the pretest and the posttest

	N	Mean	Std. Deviation	Std. Error Mean
Pretest	40	11,60	2,649	,419
Posttest	40	15,65	2,304	,364

Note. N= Number of participants

Table 4.1 is an overall summary of the descriptive statistics gathered from pretest and posttest. As shown in the table, while the mean score of pretest was 11,60 (*SD*= 2,65), the mean score of posttest was 15,65 (*SD*= 2,30). It can be understood that the mean score of posttest is higher than the mean score of pretest.

4.1.2 Assumptions of Paired Sample T-Test

The assumptions of paired sample t-test are independence of observations and normal distributions (Pallant, 2013). Independence of observations assumptions was assured since the posttest was not influenced by the pretest. Table 4 shows skewness and kurtosis values of the MPT.

Table 4 Skewness and Kurtosis Values of MPT

Instrument	Skewness	Kurtosis	Number
MPT (Pretest)	-,449	-,050	40
MPT (Posttest)	-1,771	4,387	40

In addition to this, skewness and kurtosis values of MPT were checked to examine normality. If skewness and kurtosis values are between -2 and +2, the normality of the sample is assured (Pallant, 2013). Since the values shown in Table 4 were between -2 and +2, the normality assumption was ensured. Only the kurtosis value for the MPT (Posttest) was above +2; however this could be ignorable since the sample size was over 30.

4.1.3 The Results of Paired Sample T-Test for MPT

The results of paired sample t-test for MPT in terms of pretest and posttest are given in Table 5.

Table 5 The results of Paired Sample T-test for MPT

MPT	Mean	SD	t	df	Sig.
Pretest-Posttest	-4,050	2,449	-10,459	39	,000

Note. SD= Standart Deviation. t= t value. df= Degree of freedom. Sig.= Signifcance.

As seen on Table 5, there was a statistically significant increase in the scores from pretest (*M*=11.60, *SD*=2.65) to posttest (*M*=15.65, *SD*=2.30), t(39)= -10,459, p=.000. The mean of 6th grade students' scores in the posttest was higher than the mean of 6th grade students' scores in the pretest. This increase in students' mean scores might be due to the improvements in their problem solving strategies and underlying reasoning skills because of Puzzles and Games course experiences. The

effect size, eta squared value, refers the amount of intervention effect (Pallant, 2013). Eta squared value was .7 which refers to a large effect size (Cohen, 1988). The mean difference (4.05, 95% CI [3.267, 4.833]) also demonstrated a large effect size, d= 1,65.

4.1.4 Analysis of Students' Solutions on the Basis of Problems in Pretest and Posttest for Comparison

In the pre and posttest, students were asked the same eight problems not related to any specific subject in mathematics curriculum. These problems required students to analyze problems and use some of the problem solving strategies to reach solutions of the problems. The analyses of the pretest and posttest supported by the analysis of the interview transcripts revealed which reasoning forms used by the students in problem solving process. These problem solving strategies were *intelligent guessing and testing, logical reasoning, solving a simpler equivalent problem, making a drawing, organizing data,* and *finding a pattern* and the underlying reasoning forms are *adaptive, algebraic and representational*. The strategies and reasoning forms are defined below.

4.1.4.1 Definitions of Problems Solving Strategies Revealed in Students' Solutions to Problems in Pre and Posttest

Intelligent guessing and testing refers to "the method of trial-and-error" (Posamentier & Krulik, 1998, p.165). According to Posamentier and Krulik (1998), this technique is useful when there are too many values for one variable; by this strategy, students can narrow down the possible values for the correct answer. Although intelligent guessing and testing strategy does not look like mathematical, it has some sophisticated aspects (Posamentier & Krulik, 2009). This method also teaches students the process of guessing and how to rethink if the guess is not true for the problem (Long, DeTemple & Millman, 2009). That is, students are expected to make a guess but an intelligent one and apply it to the problem (Posamentier & Krulik, 2009, p.165). If it does not work, students make any other intelligent guess and test it.

Logical reasoning refers to "logical thinking or reasoning" as prior strategy for solving problems (Posamentier & Krulik, 2009, p.88). Logical reasoning is kind of "logical chain of inferences" which begins from first step of problem solving and lasts until the final step of problem solving (Posamentier & Krulik, 2009, p.88,). In mathematical problem, logical reasoning means to consider between lines and interpret the relationship between them (Posamentier & Krulik, 1998). In other respects, logical reasoning is used while discussing any topic with friends, buying the cheapest items in market or trying to park your car in parking area in the background of problem solving, that is; it is part of our daily life as well as mathematical problem solving.

Solving a simpler equivalent problem is a method that changing the problem in an easier or equivalent one to make problem more manageable (Posamentier & Krulik, 2009). Posamentier and Krulik (2009) stated that this strategy generally used when the solution of the problem is complicated by numbers. Students use easy number for their level to solve problem in solving a simpler equivalent problem strategy, that is; they adapt the problem in a simpler model. After this process, they perform the same way in the complex problem.

Making a drawing strategy helps to solve not only geometric problems but also non-geometric problems (Posamentier & Krulik, 2009). Drawing a figure or making an illustration makes data see clearer, by this way; reaching the correct answer can be easier (Posamentier & Krulik, 1998).

Organizing data is seen as a significant problem solving strategy to examine any set of data (Posamentier & Krulik, 2009). Data organization helps to classify and arrange the given data in problems. According to Posamentier and Krulik (2009), constructing a table and organizing list are important steps of organizing data.

Finding a pattern strategy provides "pattern recognition" in the problem to find out right answer (Posamentier & Krulik, 1998, p.37). The pattern might be numbers, geometric blocks, license plates, combination locks and similar representations.

4.1.4.2 Definitions of Reasoning Forms Revealed in Students' Solutions to Problems in Pre and Posttest

The reasoning forms which have been revealed in students' solutions will be explained below. Therefore, definitions of reasoning forms will be reminded in this section.

Adaptive reasoning means "the capacity to think logically about the relationships among concepts and situations and to justify and ultimately prove the correctness of a mathematical procedure or assertion" (NRC, 2001, p.170). *Algebraic reasoning* refers to "a process in which students generalize mathematical ideas from a set of particular instances, establish those generalizations through the discourse of argumentation, and express them in increasingly formal and age-appropriate ways" (Kaput & Blanton, 2005, p.99). *Representational reasoning* provides visual information such as in a diagram, a graph, a map or a table to understand and makes sense mathematical properties and relationships (Long, DeTemple & Millman, 2009).

4.1.4.3 Analysis of Students' Solutions to the 1st Problem in Pretest and Posttest

The first problem in the pretest and posttest is given in Figure 3 below.

> Erdal teacher plans an activity for math class. To do this, he cuts a rope by 25 scissors moves into pieces that are equal in length and he distributes all the equal pieces to the students. If each student has a piece of rope, how many students are there in Erdal teacher's class?

Figure 3 First problem in the pretest and posttest

Students' solutions in both pre and posttest showed that there was not much change in the number of students with correct solutions. Thirty students in pretest and 33 students in posttest among 40 students answered the first problem correctly. In addition to this, while 7 students solved the first problem incorrectly in the pretest, this number decreased to 3 students in the posttest. The frequencies of

correct, partially correct and incorrect solutions in the pre and posttest for the first problem are provided in Table 6.

Table 6 Correctness of Students' Solutions for the First Problem in Pre and Posttest

	Pre-test	Post-test
Correct	30	33
Partially Correct	3	4
Incorrect	7	3
Sum	40	40

The given problem in MPT was not related to any specific subject in elementary mathematics curriculum. Therefore, students should use some of the problem solving strategies in order to solve this problem. Twenty students used *making a drawing* strategy in posttest. They drew a long line and put 25 short lines to represent 25 scissor moves. After this, they counted 26 small pieces composed and they concluded that there were 26 students in Erdal teacher's classroom. S14's solution in the posttest (Figure 4) can be an example for this strategy is given below. Pretest drawings were similar to posttest drawings.

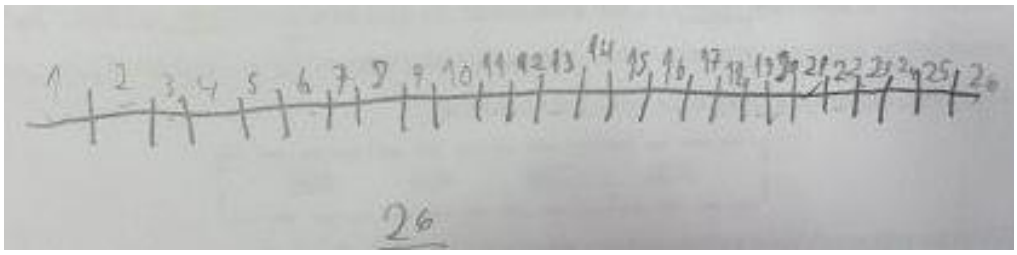


Figure 4 Making a drawing strategy for the first problem in the posttest by S14.

Most of the students, on the other hand, preferred to solve this question in the posttest by *solving a simpler equivalent problem* and *logical reasoning* strategies. Nineteen students used *solving a simpler equivalent problem* strategy

and six students preferred *logical reasoning* strategy to solve the first problem in the posttest. Students who used solving a simpler equivalent problem strategy drew a line and put such as three short lines instead of scissor moves. They got four pieces and they reasoned that the number of small pieces can be found by adding "1" to the number of scissor moves. S22's solution in Figure 5 is an example for the solving a simpler equivalent problem strategy in the first problem in the posttest as given below.

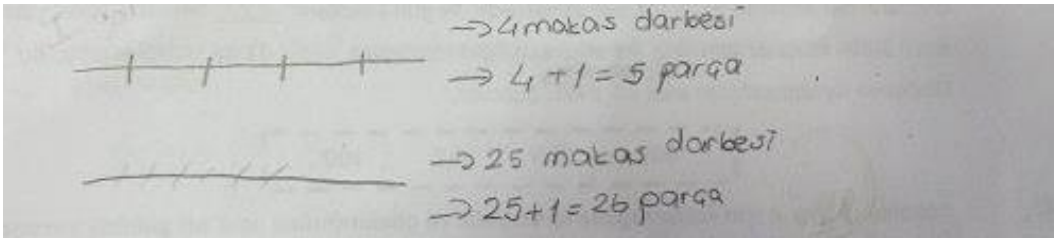


Figure 5 Solving a simpler equivalent problem strategy for the first problem in posttest by S22

Students who used logical reasoning strategy for this problem followed a different way to find the correct answer. They reasoned without drawing that one scissor move forms two pieces. Accordingly, they formulated a relationship such as "the number of pieces = the number of scissor moves + 1". Thus, they added 1 to 25 and they concluded that there were 26 students in Erdal teachers' classroom. S10's solution in Figure 6 is an example for the logical reasoning strategy at the first problem in the posttest is given below.

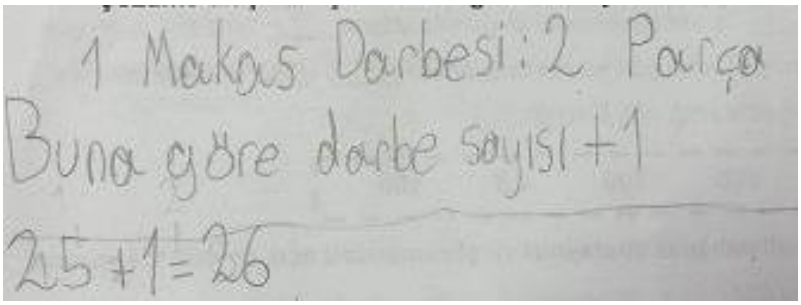


Figure 6 Logical reasoning strategy for the first problem in posttest by S10

As seen, students used different problem solving strategies for the first problem. However, some students changed their strategies in the first problem when their solutions in the pre and posttest were compared. S22 found the correct answer with solving a simpler problem (Figure 5) while she solved the same problem in pretest with making a drawing strategy. In the interview, S22 explained that:

> "…. I drew a short line instead of rope. I do not want to draw 25 short lines for the 25 scissors moves. Therefore, I drew 4 short lines to just try and I saw that there were 5 pieces. I understood that 5 pieces were formed by 4 scissors moves. It means that I need to add 1 to the number of scissors moves to find how many pieces are formed. So, I added 1 to 25 and I understood that there were 26 students in Erdal teacher's class."

In addition to this, S3 who solved the first problem with solving a simpler problem strategy in the posttest said that:

> "… I thought that my hand has 5 fingers. When I stretch my fingers, 4 gaps occur. I understood that this situation is the same as what is asked in this question. Gap matches with scissor move and the number of fingers matches the number of pieces of rope. I understood that I need to add the number of scissor moves to find the number of pieces of rope. Because of that I added 1 to 25; I found 26 pieces of rope."

According to the definition of Van de Walle, Karp, and Bay-Williams (2011)'s *algebraic reasoning,* it seemed that S22 and S3 algebraically reasoned about their problem solving strategies. Namely, they examined given data, interpreted them with some calculations and generalized their solutions to the problem context.

Furthermore, S14 who could not answer this problem in the pretest correctly used the making a drawing strategy in the posttest. In the interview, he stated that "*I drew a long line and I drew 25 short lines on it. I counted there are 26 pieces. It means that there are 26 students.*" She also said that she chose this method since it was easy to draw. However, the interviewer asked what if Erdal teacher had cut a rope into pieces that were equal in length by 100 scissors moves and she said that she would not know.

It seems that S14 used *representational reasoning* which refers to form visual information such as a drawing in her solution to find out relationship and make meaningful mathematical process (Long, DeTemple & Millman, 2009).

4.1.4.4 Analysis of Students' Solutions to the 2nd Problem in Pretest and Posttest

The second problem in the pretest and posttest is given in Figure 7 below.

> Three types of pencils are sold in Barış Stationery. A lead pencil costs 3 Turkish Liras, a ballpoint pen costs 5 Turkish Liras and a pilot pen costs 10 Turkish Liras. Ceren, who had 39 Turkish Liras, spent all her money by purchasing at least one pencil of each type. How many pencils could Ceren buy at most?

Figure 7 Second problem in the pretest and posttest

As seen in the Table 7, the number of students with correct solutions (17 students) in the pretest increased in the posttest (28 students). Furthermore, while 20 students answered the second problem in the pretest partially correctly, 11 students answered it partially correctly in the posttest. The frequencies of correct, partially correct and incorrect solutions for the second problem are provided in Table 7.

Table 7 Correctness of Students' Solutions for the Second Problem in Pre and Posttest

	Pre-test	Post-test
Correct	17	28
Partially Correct	20	11
Incorrect	3	1
Sum	40	40

There were some basic mathematical operations that students needed to solve in the second problem in the test. It was expected that students took into

consideration some phrases in the problem such as "Ceren, who had 39 Turkish Liras, **spent all her money** by purchasing **at least one pencil of each type**" and "How many pencils could Ceren buy **at most**" to reach correct solutions. It was observed that students who considered these phrases carefully with the help of *logical reasoning* strategy solved the problem correctly. S2's solution in the posttest is an example for this strategy.

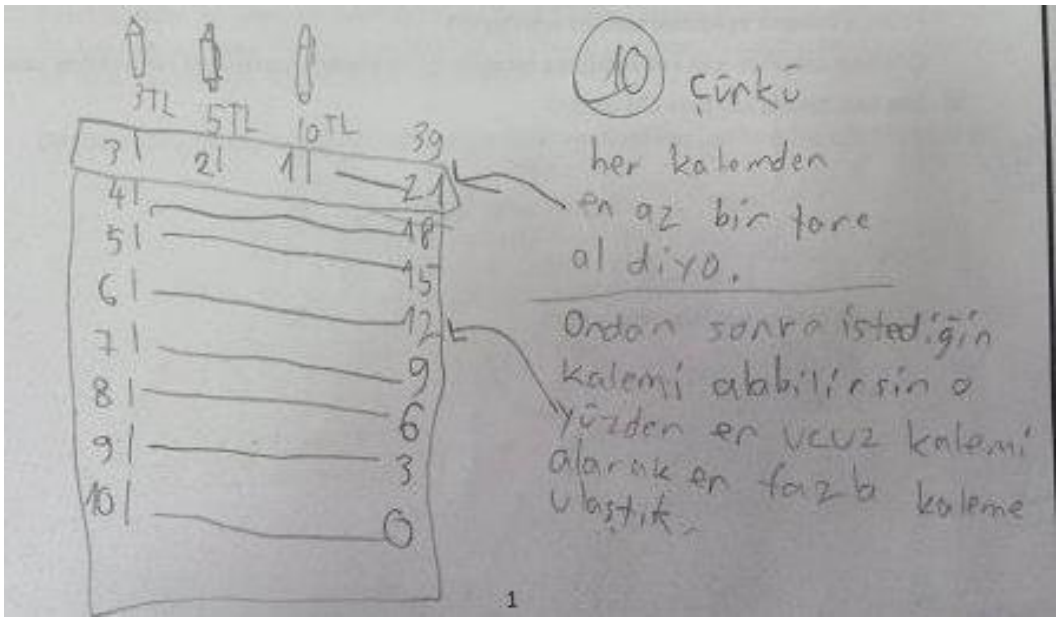


Figure 8 Logical reasoning strategy for the second problem in posttest by S2

S2, whose solution is presented in Figure 8 was asked how she decided that Ceren could buy 10 pencils at most and the reason. S2 stated:

> "First, she buys one lead pencil, one ballpoint pencil and one pilot pen. […] Because it is stated in the problem that Ceren purchases at least one pencil of each type. After she purchased at least one pencil of each type, 21 TL remain. Then, since she wants to purchase maximum number of pencils, she should buy the cheapest pencil which costs 3 TL. I divided 21TL by 3TL and found 7 pencils. As she already has 3 pencils, I added 3 pencils to 7 pencils and I found the answer, 10 pencils."

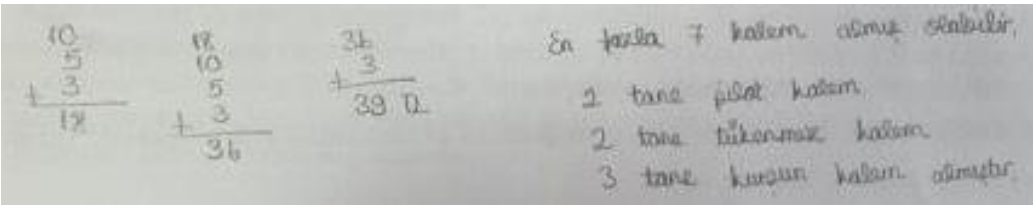


Figure 9 Partially correct logical reasoning strategy for the second problem in pretest by S3

Students who solved this problem partially correctly could not consider all the key points and therefore, they could not apply the logical reasoning strategy accurately. For example, although S3 whose solution is given in Figure 9 considered that "Ceren spent her all money by purchasing at least one pencil of each type," he could not take into account "How many pencils could Ceren buy at most?" As shown in the Figure 9, he thought that Ceren bought one of each pencil type and calculated the amount she spent as 10TL + 5TL + 3TL = 18TL for 3 pencils. Since he could not consider the requirement of buying pencils at most, he bought one of each pencil type again. Then, 3TL were left and he bought one more pencil. As a result, he found the answer as 3+3+1=7 pencils.

It was noticed that some students who answered this problem partially correctly or incorrectly in the pretest improved their logical reasoning strategy in the posttest and they reached the correct answer. Although these students used the same strategy, some of them thought in a different way to solve problem. One of those students, S1, solved the second problem with a different point of view as presented in Figure 10 below.

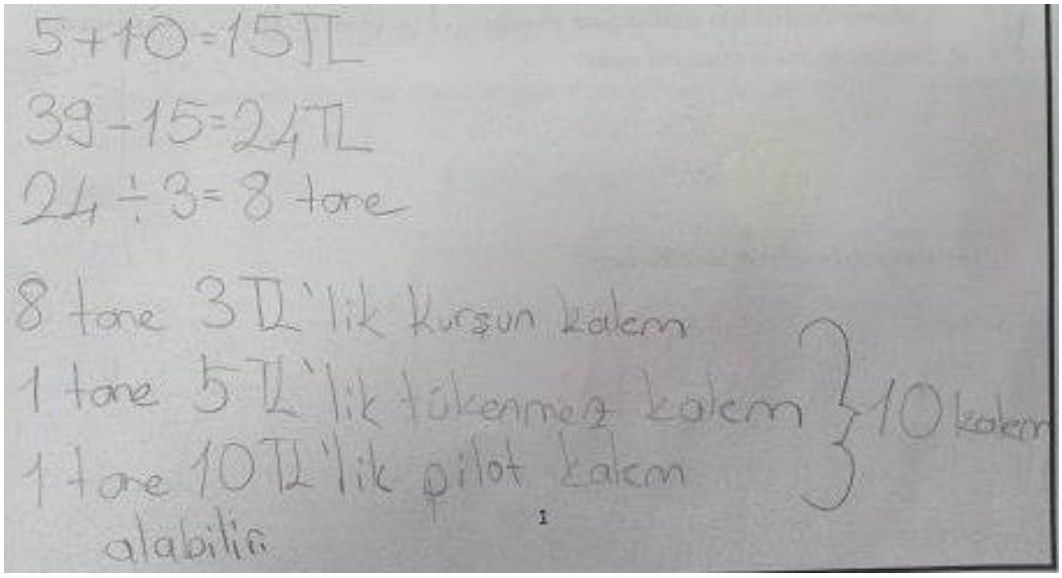


Figure 10 Logical reasoning strategy for the second problem in posttest by S1

In the interview, S1 stated as:

"I thought that she should buy the most expensive ones at least since she wants to buy pencils at most. So, I added 5TL to 10TL which costs 15 TL. Now, she has 2 pencils and she has 39TL – 15TL = 24TL. She can buy 8 pencils which is the cheapest one with 24TL. That is, she can buy 2 + 8 = 10 pencils at most."

When S1 and S2's interviews were analyzed, it seemed that students justified their solutions with their explanations as mentioned in the definition of NRC's (2001), *adaptive reasoning* used in students' problem solving process. Namely, they recognized the key words in the problem and after they logically examined the relationship among them, correct answer came out with some necessary calculations.

4.1.4.5 Analysis of Students' Solutions to the 3rd Problem in Pretest and Posttest

The third problem in the pretest and posttest is given in Figure 11 below.

All the numbers were removed from the story below. Write the given numbers in the gaps reasonably. (It requires using all the numbers once. The numbers are not given in the same order as the order of the numbers in the story).

"There are _____ Harry Potter books in a book store. The book seller makes _____TL profit from each book. First day, he sold _____ books, and second day he sold rest of them. If the book seller made _____TL profit from the books sold on the second day, find how much profit the book seller made in total."

900 **300** **4,5** **100**

Figure 11 Third problem in the pretest and posttest

When students' solutions for the third problem in pre and posttest were compared, it is seen that there was a considerable change in the number of students with correct solutions. While only 7 students solved the third problem correctly in pretest, this number increased to 31 students in the posttest. Twenty-eight students who answered the problem partially correctly in pretest developed some problem solving strategies and 21 of 28 students who had partial solutions in the pretest solved the problem correctly in the posttest. The frequencies of correct, partially correct and incorrect solutions for the third problem are provided in Table 8 below.

Table 8 Correctness of Students' Solutions for the Third Problem in Pre and Posttest

	Pre-test	Post-test
Correct	7	31
Partially Correct	28	7
Incorrect	5	2
Sum	40	40

This problem needed application of some of the problem solving strategies and some basic mathematical operations. Analysis of the responses revealed that students used two problem solving strategies, i*ntelligent guessing and testing and logical reasoning*, while solving the problem.

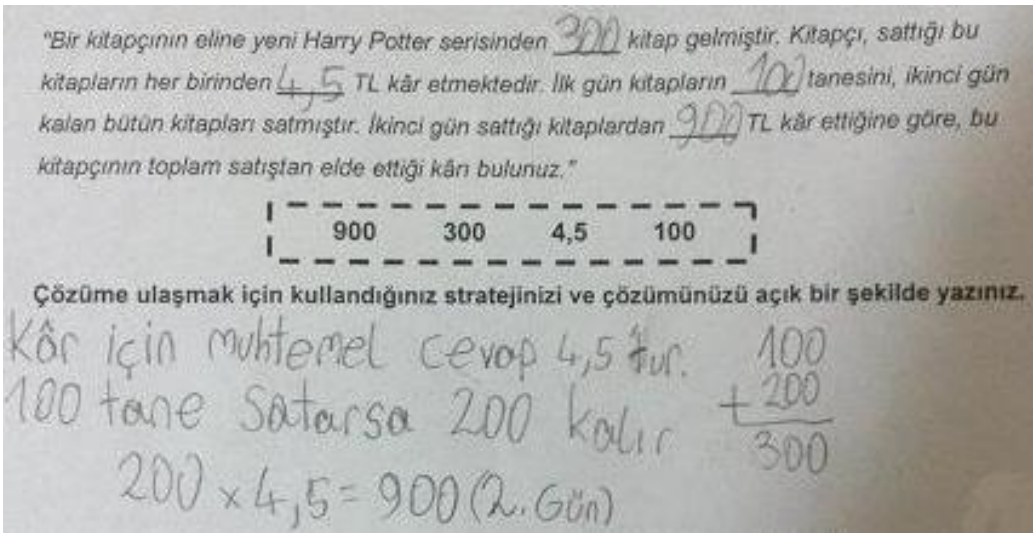


Figure 12 Intelligent guessing and testing and logical reasoning strategies for the third problem in posttest by S4

S4, who could not find the correct answer for the third problem in pretest, applied the intelligent guessing and testing, and logical reasoning strategies together

correctly in the posttest as in Figure 12. In the interview, S4 was asked how he decided the order of numbers in the story. He stated that:

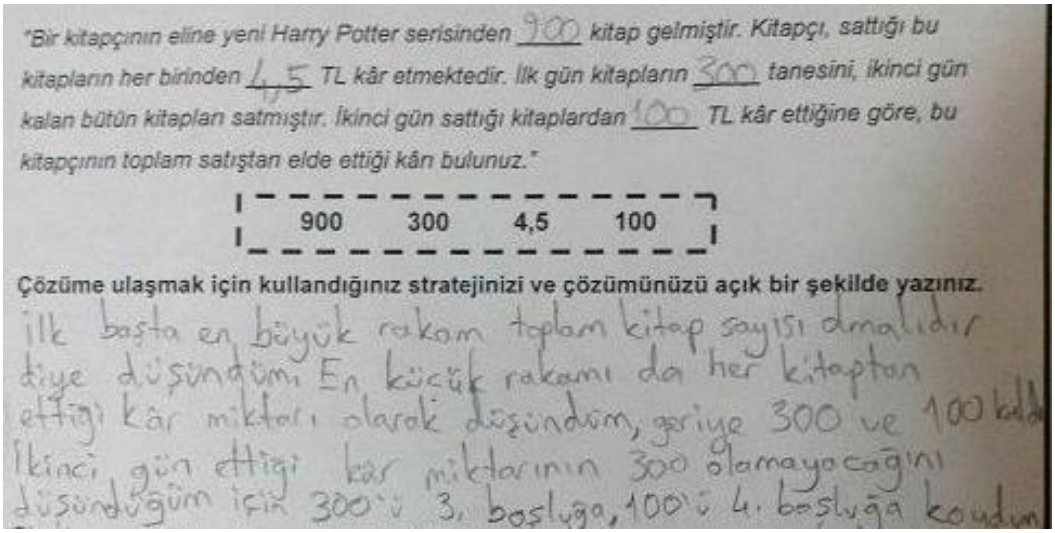
> "First of all, I read the story and looked at the numbers. I tried to find a clue to put a number in the story… Then, I noticed that the profit from one book sold should be a small number and there is only one number, 4,5 TL, could be possible for the second gap. So, I put 4,5 TL for second gap. After this, it was hard to put rest of the numbers because the story does not tell everything directly. I thought that if he sells 100 books on the first day and 200 books leaves. It means that he has 100+200=300 books at the beginning. If he sells 200 books on the second day, he gets 200x4,5=900 TL on the second day."

S6 who answered this problem correctly in the posttest stated an argument different from S4 in the interview:

> "I decided that 4,5 TL must be the profit one book sold since other numbers are so big for the profit. Then, I put the numbers randomly like that:
>
> *"There are **900** Harry Potter books in a book store. The book seller makes **4,5** TL profit from each book. First day, he sold **300** books, and second day he sold rest of them. If the book seller made **100** TL profit from the books sold on the second day, find how much profit the book seller made in total."*
>
> After this, I crosschecked the numbers if the story was logically correct. I noticed that if he sells 300 books on the first day, it means that 600 book are sold on the second day since he has 900 books at the beginning. So, he gets 600x4,5=2700TL profit. I understood that I made a mistake since I wrote 100TL for profit from the books sold on the second day. I, then, reasoned that he had 300 books at the beginning and he sold 100 books on the first day. Since there are 200 books left for the second day, he gets 200x4,5=900TL profit."

When interview findings of S4 and S6 were analyzed, according to definition of NRC (2001)'s adaptive reasoning, they showed that both of them used *adaptive reasoning* while applying logical reasoning and intelligent guessing and testing strategies. It is observed that students rationally built the relationships

between numbers and the situation given the problem and also justified their solution logically which refers to adaptive reasoning.


"Bir kitapçının eline yeni Harry Potter serisinden 900 kitap gelmiştir. Kitapçı, sattığı bu kitapların her birinden 4,5 TL kâr etmektedir. İlk gün kitapların 300 tanesini, ikinci gün kalan bütün kitapları satmıştır. İkinci gün sattığı kitaplardan 100 TL kâr ettiğine göre, bu kitapçının toplam satıştan elde ettiği kârı bulunuz."

900 300 4,5 100

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

ilk başta en büyük rakam toplam kitap sayısı olmalıdır diye düşündüm. En küçük rakamı da her kitaptan elde ettiği kâr miktarı olarak düşündüm, geriye 300 ve 100 kaldı. İkinci gün ettiği kâr miktarının 300 olamayacağını düşündüğüm için 300'ü 3. boşluğa, 100'ü 4. boşluğa koydum.

Figure 13 Partially correct intelligent guessing and testing, and logical reasoning strategies for the third problem in pretest by S38

Some students who solved this problem partially correctly in pre and posttest had some difficulties to apply i*ntelligent guessing and testing and logical reasoning* properly. S38, whose solution is given in Figure 13, solved the third problem partially correctly. S38 thought that the largest number should be total number of books and the smallest number should be the profit from one book sold. Then, 300 and 100 left to put the gaps. He also decided that since the profit from the books sold in the second day should not be 300, he put 300 in third gap and 100 in last gap. He used the intelligent guessing and testing and logical testing strategy partially correctly. He reasoned that 4,5 TL could be the profit from one book sold by intelligent guessing. However, he did not examine the correctness of the order of number in the story after he put all the numbers in the gaps. In this case, the student could not apply the intelligent guessing and testing strategy properly. He also could not use logical reasoning since 100 TL profit from any number of book sold was not possible by any multiple of 4.5.

In brief, it is concluded that while some students used only intelligent guessing and testing strategy, some of them used both intelligent guessing and testing and logical reasoning strategies in this problem. In addition, students' explanations in the interviews showed that they used adaptive reasoning in the background of problem solving process.

4.1.4.6 Analysis of Students' Solutions to the 4th Problem in Pretest and Posttest

The fourth problem in the pretest and posttest is given below.

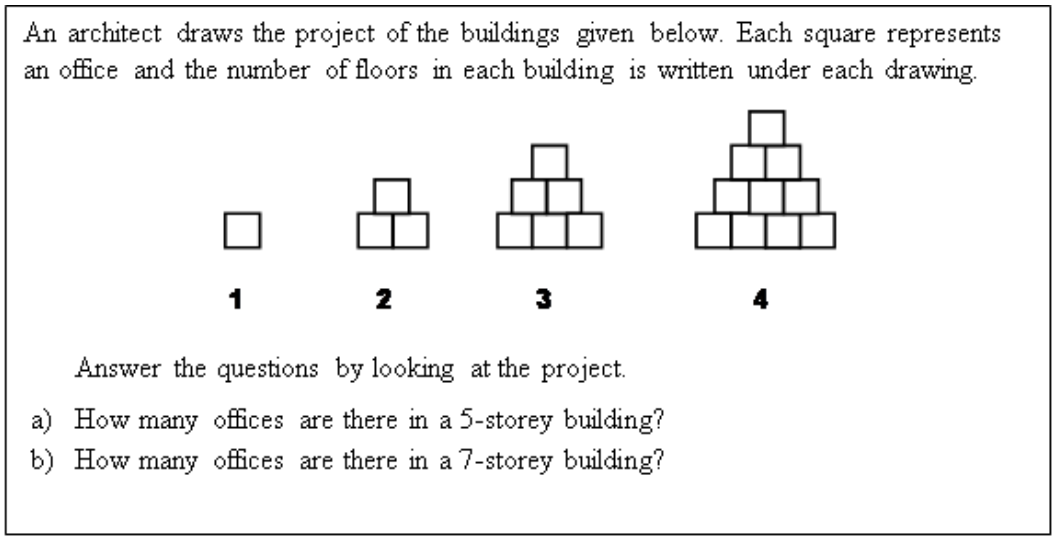


Figure 14 Fourth problem in the pretest and posttest

When students' fourth problem solutions in pre and posttest were compared, it is seen that there was not much change in the number of students' correct solutions. While 31 students solved the third problem correctly in the pretest, this number increased 33 students in the posttest. The frequencies of correct, partially correct and incorrect solutions for the fourth problem are provided in Table 9.

Table 9 Correctness of Students' Solutions for the Fourth Problem in Pre and Posttest

	Pre-test	Post-test
Correct	31	33
Partially Correct	6	4
Incorrect	3	3
Sum	40	40

Students preferred to solve this problem by *making a drawing* and *finding a pattern* strategies. While only five students chose the making a drawing strategy in the pretest, 11 students preferred the same strategy in the posttest. On the other hand, 26 students in pretest and 22 students in posttest used finding a pattern strategy.

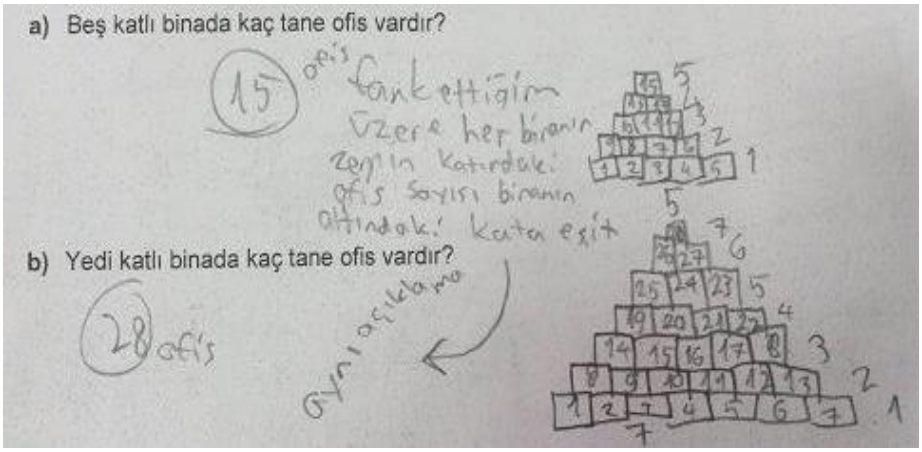


Figure 15 Making a drawing strategy for the fourth problem in the posttest by S16

S16 who could not answer this problem correctly in the pretest used making a drawing strategy in the posttest (Figure 15) and reached the correct answer. S16 was interviewed to get an in depth idea about how he practiced the making a drawing strategy correctly. In the interview, that the following conversation took place:

S16: Firstly, I looked at the each drawing and I notice that the number of offices in the first floor of each building is the same the number of floors in each building. Therefore, I drew 5 offices in the first floor in 5-storey building and I drew offices in the other floors by looking given drawings of buildings.

Researcher: What do you mean "by looking given drawings of buildings?" You decided the number of offices in the first floor and how do you make a decision to draw other floors' offices?"

S16: "I recognized that the number of offices in each floor decreases one by one in each floor. Therefore, I drew 5 offices in the first floor, 4 offices in the second floor, 3 offices in the third floor, 2 offices in fourth floor and only one office in the fifth floor. Lastly, I add all the offices in the each floor like 1+2+3+4+5 = 15 offices in the 5-storey building. I found 28 offices in the 7-storey building by drawing the offices with the same strategy."

From his explanations about the solution to reach true answers, it was understood that he used making a drawing strategy by using *representative reasoning* since according to Long, DeTemple and Millman (2009), representational reasoning refers to use visual explanations by constructing a diagram, a graph, a map or a table to understand mathematical properties and relationships.

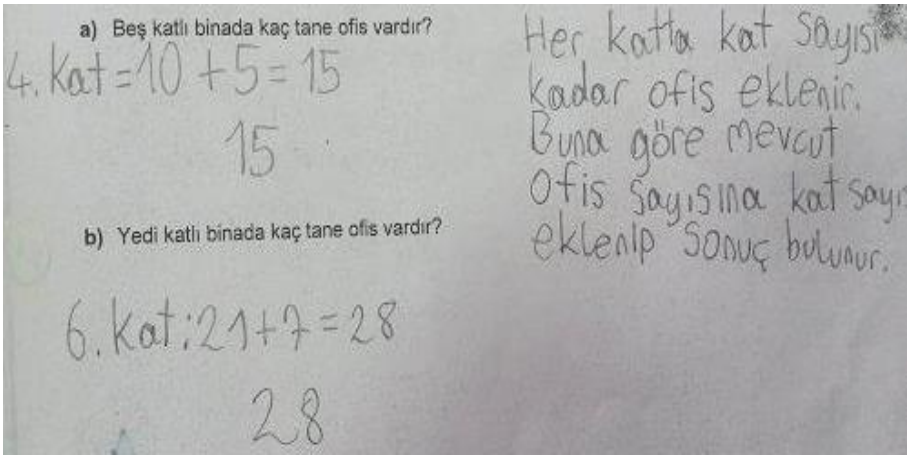


Figure 16 Finding a pattern strategy for the third problem in posttest by S22

Furthermore, S22 whose solution in posttest was coded as finding a pattern strategy was interviewed to learn his solution way in detail. His solution is given in Figure 16. In the interview, he said:

> "As I wrote on my paper; when I examined the given drawings in the problem, I understood that the offices are added to the previous one as the number of floors. It means that I need to add 5 offices to total number of offices in the four-storey building to find total number of offices in the 5-storey building. So, I first found the total number of offices in the 4-storey building by adding the offices on the drawing.
>
> 1+2+3+4 = 10 offices in the 4-storey building.
>
> Then, I added 5 offices to 10 offices.
>
> 10+5 = 15 offices in the 5-storey building.
>
> To find the 7-storey building, I found total number of offices in the 6-storey building by adding 15 to 6 which is 21 offices. Since there are 21 offices in the 6-storey buildings, 21+7 = 28 offices were founded in the 7-storey building."

S22's solution and his justification for the solution imply that he used *algebraic reasoning* to find the correct answer while applying finding a pattern strategy since according to Van de Walle, Karp, and Bay-Williams (2011), one side of algebraic reasoning needs to generalize experiences with number and computation, reach a conclusion with these experiences and show it meaningfully. S22 reached a general rule by recognizing the pattern in the problem.

To summarize, although many of the students developed making a drawing strategy, some of them used finding a pattern strategy in this problem. In addition to this, students' justifications in the interviews refer that representative reasoning and algebraic reasoning were used in the process of solving this problem.

4.1.4.7 Analysis of Students' Solutions to the 5th Problem in Pretest and Posttest

The fifth problem in the pretest and posttest is given below.

You would like to work in your leisure time after school. A book store owner suggests you sell Bilim ve Çocuk magazines (3 Turkish Liras each) after school and offers 3 options concerning the profit you will make from selling the magazines.

a) 230TL monthly

b) Supposing that you will sell 5 magazines every weekday; monthly 200TL, and 1TL profit for each magazine.
(1 month = 4 weeks)

c) Supposing that you will sell 5 magazines every weekday, monthly 160TL, and 2TL profit for each magazine.
(1 month = 4 weeks)

Which option do you choose? Why?

Figure 17 Fifth problem in the pretest and posttest

Table 10 illustrates that the number of students with correct solutions (2 students) in the pretest increased when compared to the number of students with correct solutions (20 students) in the posttest. Although there was not a change in the number of partially correct answers in comparison with pre and posttest, 31 students gave incorrect answers in the pretest and 10 students gave incorrect answers in the posttest. The frequencies of correct, partially correct and incorrect solutions for the fifth problem are provided in Table 10.

Table 10 Correctness of Students' Solutions for the Fifth Problem in Pre and Posttest

	Pre-test	Post-test
Correct	2	20
Partially Correct	7	10
Incorrect	31	10
Sum	40	40

When students' solutions in the pre and posttest were compared, it was seen that all students used *logical reasoning strategy* in the pre and posttest to solve the fifth problem. This problem falls into the category of daily life problem. A possible daily life case was given and some options were provided about it in the problem. According to these, students were asked to choose the most suitable one. Therefore, this problem required combining some skills. Students needed to calculate all the options and this required paying attention to some phrases in the problem such as **every week day, the amount of money for monthly and profit for the each magazine** and **1month = 4 weeks.** After the calculations, students were asked to write the reason of choosing which option they chose.

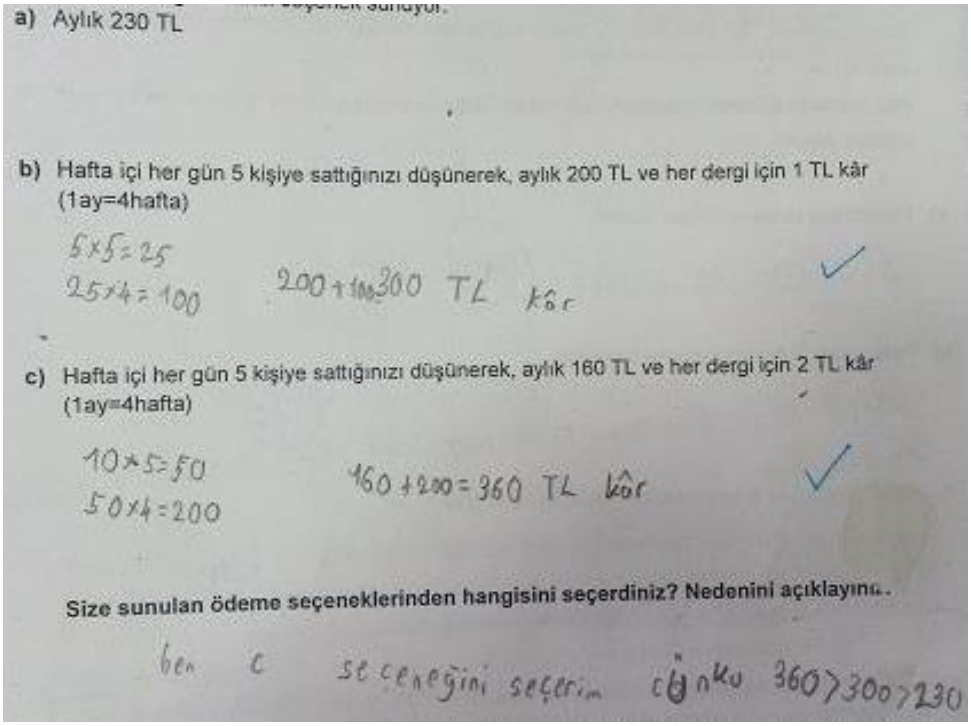


Figure 18 Logical reasoning strategy for the fifth problem in posttest given by S2

S2 had partially correct answers in the pretest for this problem and he was interviewed to understand how he reached the correct answer in the posttest. The solution of S2 in the posttest is presented in Figure 18. S2 stated in the interview that:

"When I looked at the monthly outcomes in each option, the sensible option seemed to be option (a) since the monthly outcome was 230TL which was higher than others. Then, I however thought that I needed to consider other information in option (b) and (c).

Option (b): Since week day is 5 days, I multiplied 5 by 5. I found that 25 magazines are sold in each week. Then, I multiplied 25 by 4 since one month is 4 weeks. It concluded that 100 magazines are sold in one month. It is given 1TL profit for each magazine. So,

100x1TL= 100TL profit for magazine selling

200TL+100TL= **300TL total profit for option (b)**

Option (c): I mentally multiplied 2TL by 5. I found 10TL profit for each day in each week. Then I multiplied 10TL by 5 since week day is 5 days and I got 50TL profit for each week. Then,

50TLx4= 200TL profit for magazine selling

200TL+160TL= **360TL total profit for option (c)**

After I calculated profits for each option, I concluded that I should prefer option (c) since the maximum profit is in option (c) as **360TL** > 300TL > 230TL."

According to NRC (2001), S2's explanation and justification about his solution in the interview addressed that *adaptive reasoning* was used while solving this problem.

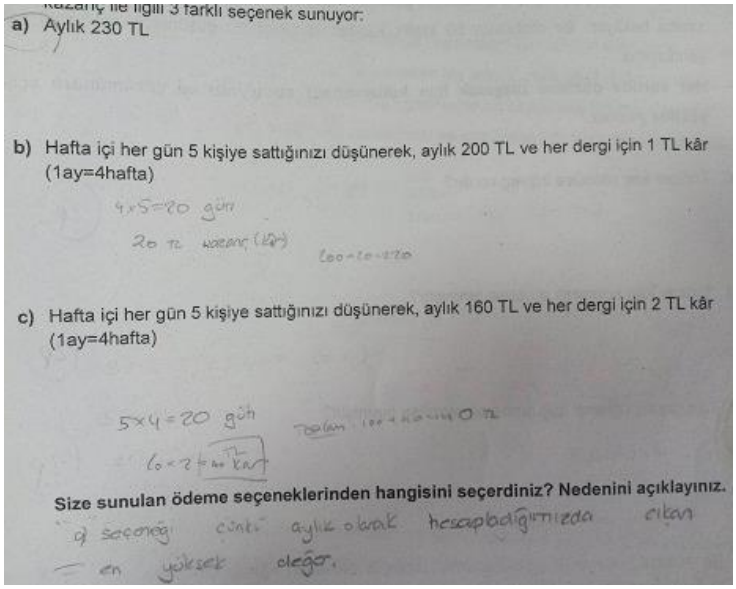


Figure 19 Partially Correct Logical reasoning strategy for the fifth problem in pretest by S40

S40 who could not reach the correct answer in the pretest forgot some steps of problem solving although he used the logical reasoning strategy. The solution of S40 in the pretest is given in Figure 19. As seen on his solution, he could not consider that 5 magazines were sold every week day. So, he skipped over to calculate this "5x5= 25 magazines every week". Although he was on the right line to reach true answer, he chose the wrong option (a).

Finally, students used logical reasoning strategy for this problem in both pre and posttest and their solutions and justifications for their solutions addressed adaptive reasoning in background of the problem solving.

4.1.4.8 Analysis of Students' Solutions to the 6th Problem in Pretest and Posttest

The sixth problem in the pretest and posttest is given below.

Ali, Burak ve Emel play a game. The game consists of 3 sections and the player who racks up most by the end of the game wins the game. In the 1st section, Ali scores 4 points, Burak scores 6 points and Emel cannot score any points. In the 2nd section, Emel scores 3 points, Burak loses 3 points and Ali cannot score any points. In the 3rd section, Ali loses 2 points, Burak scores 5 points and Emel cannot score any points. Who is the winner of the game?

Figure 20 Sixth problem in the pretest and posttest

The analyses of students' the sixth problem solutions revealed that the number of correct solutions in pretest (38 students) and posttest (39 students) were almost the same and no students were in the group of partially correct answers in both pre and posttest. In addition to these, few of the students solved this problem in pretest (2 students) and posttest (1 student) incorrectly. The frequencies of correct, partially correct and incorrect solutions for the sixth problem are provided in Table 11.

Table 11 Correctness of Students' Solutions for the Sixth Problem in Pre and Posttest

	Pre-test	Post-test
Correct	38	39
Partially Correct	0	0
Incorrect	2	1
Sum	40	40

All the students in the study used *organizing data strategy* in the pre and posttest to solve this problem. Generally, students inclined to constitute a *table* to organize given data in the problem. At the same time, they used the *organized list* in the table. By this way, forming a table and listing helped students to track of data in the problem and they reached the correct answer.

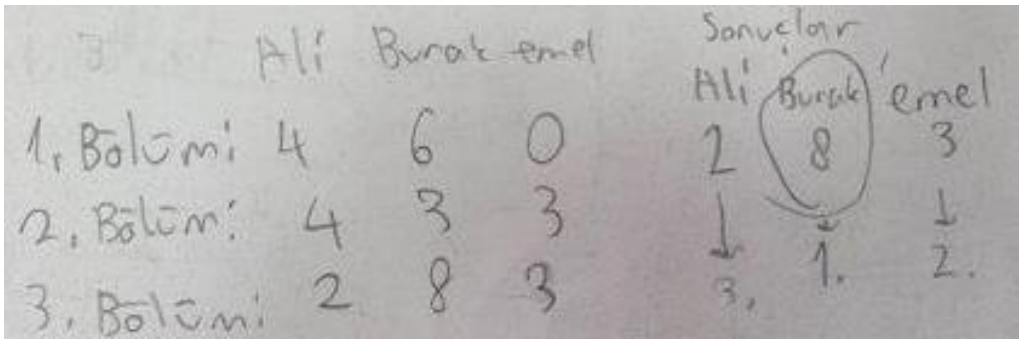


Figure 21 Organizing data strategy for the sixth problem in posttest by S10

S10 who answered the problem in the pretest incorrectly solved the problem correctly with the help of organizing data strategy in the posttest (Figure 21). In the interview, she stated that:

> "…Scoring method in this problem is very similar with our games' scoring method that I play with my friends. We (she and her friends) write the names of player and sections respectively as I wrote here. I wrote how many points players win or lose in each section under the each player's name.

… In the first section, Ali scores 4, Burak scores 6 and Emel scores 0. As shown in Table 12.

Table 12 Scores in the 1st section for the 6th problem

Players	Ali	Burak	Emel
Scores	4	6	0

In the second section, I added 3 points to Emel's score (0+3=3 points), I subtract 3 points from Burak's score (6-3=3 points) and I did not touch Ali's score since he could get any point in this section. As shown in Table 13.

Table 13 Scores in the 2nd section for the 6th problem

Players	Ali	Burak	Emel
Scores	4	3	3

In the third section, I subtracted 2 points from Ali's score; I added 5 points to Burak's score and Emel's score stayed same. As shown in Table 14.

Table 14 Scores in the 3rd section for the 6th problem

Players	Ali	**Burak**	Emel
Scores	2	**8**	3

When I looked at the last scores at the end of the third section, I noticed that the highest score belongs to Burak who is the winner of the game."

In conclusion, organizing data strategy was used by all the students for 6th problem. From the student's justification about her solution, it was understood that *representational reasoning* were used in solving the sixth problem and the students used a table to organize given data in the problem and reached the correct answer with the help of this.

4.1.4.9 Analysis of Students' Solutions to the 7th Problem in Pretest and Posttest

The seventh problem in the pretest and posttest is given in Figure 22 below.

500 students go on a picnic in Lake Eymir at the weekend. All the buses are numbered starting from 1 and students take the bus starting from the bus number 1. Tuncay is the 249th in the line. Each bus has a capacity of 50 people.

a) How many buses are needed in total?

b) What is the number of the bus that Tuncay took?

c) What is the number of the bus that 70th student in the line took?

Figure 22 Seventh problem in the pretest and posttest

The analyses of students' seventh problem solutions revealed that 19 students solved the problem in the pretest correctly. This number increased to 28 students in the posttest. 18 students in the pretest and 11 students in posttest were in the group of partially correct answers. In addition to these, very few students solved the problem in the pretest (three students) and in the posttest (one student) incorrectly. The frequencies of correct, partially correct and incorrect solutions for the seventh problem are provided in Table 15.

Table 15 Correctness of Students' Solutions for the Seventh Problem in Pre and Posttest

	Pre-test	Post-test
Correct	19	28
Partially Correct	18	11
Incorrect	3	1
Sum	40	40

When students' solutions for the problem were examined, it was seen that students used *logical reasoning and making a drawing strategies*. S22 who solved the problem with the help of logical reasoning strategy in posttest and S40 who solved the problem with the help of making a drawing strategy in the posttest were interviewed to get deeper information about their solutions strategies.

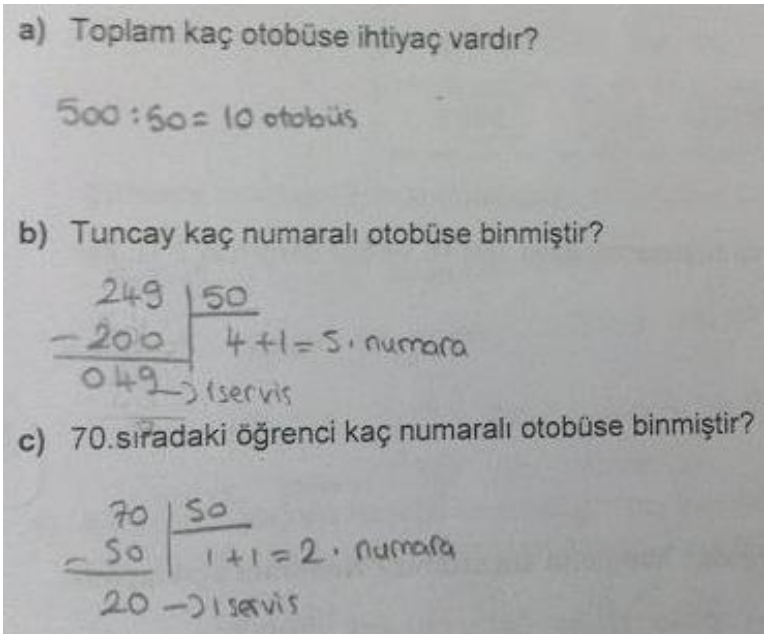


Figure 23 Logical reasoning strategy for the seventh problem in posttest by S22

S22 whose solution is given in Figure 23 stated in the interview that:

"I solved all the options in same way.

In option (a): Since there are 500 students needed to take bus and each bus is a capacity of 50 people, I divided 500 by 50 and I got 10. That is, 10 buses are needed to get 500 students.

In option (b): Tuncay is waiting the 249th in the line. So, I divided 249 by 50 because each bus takes 50 people.

249 | 50
− 200 | 4 buses
49 students → 1 bus

We need one more bus for 49 students.

So, 4 + 1 = **5th bus Tuncay took**

In option (c): This is the same problem with the problem in option (b). Therefore, I divided 70 by 50. However, 70 is not divided by 50 without reminder. I added one bus to quotient.

70 | 50
50 | 1 bus
20 students → 1 bus

One more bus is needed for 20 students.

So, 1 + 1 = **2nd bus**"

From his justifying of the solution, it was concluded that according to NRC (2001), S22 used *adaptive reasoning* while applying logical reasoning strategy. S22 comprehended the relationship between the number of students and buses and also defended his solution built on logical bases.

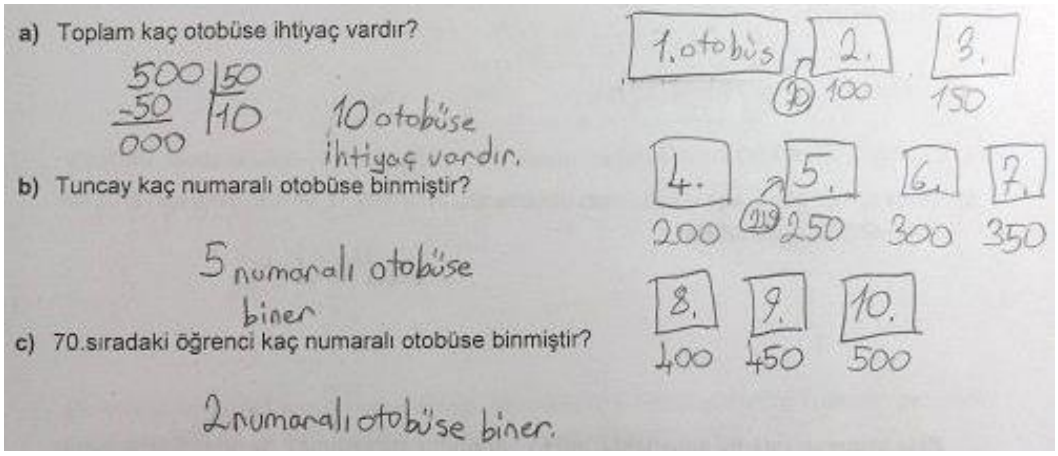


Figure 24 Making a drawing strategy for the seventh problem in posttest by S40

S40 solved the problem in a different way compared with S22's solution. S40's solution is given in Figure 24. In the interview, S40 said that:

"When I read the problem, I thought that option (a) is so easy because 500 is divided by 50 without reminder. The answer is 10 buses. However, in option (b), I could not divide 249 by 50 without reminder. Therefore, I drew buses. Then, I thought that

From 1st student to 50th student takes 1st bus,

From 51st student to 100th student takes 2nd bus, **(70th student takes 2nd bus.)**

From 101st students to 150th student takes 3rd bus,

From 151st students to 200th student takes 4th bus,

From 201st students to 250th student takes 5th bus, **(Tuncay who is 249th takes 5th bus.)**

....

I easily found that Tuncay takes 5th bus after I showed the buses and which number in the line takes which bus. This drawing made my job easy. So, I found that the 70th student takes 2nd bus."

Long, DeTemple and Millman (2009) stated that representational reasoning referred to visual information such as a drawing in S40's solution provided an understanding of the relationship among the given data in the problem. Therefore, explanations and drawings of S40, who used making a drawing strategy, were considered as *representational reasoning*.

On the other hand, 18 students in the pretest and 11 students in the posttest who used logical reasoning strategy solved the problem partially correctly and all students made the same mistakes in options (b) and (c). In option (b); the students divided 249 by 50; quotient was 4 and reminder was 49. They could not consider that one more bus was needed for 49 people. So, they stated that Tuncay took 4th bus although the true answer was 4+1=5th bus. They made the same mistake in option (c).

In summary, logical reasoning and making a drawing strategy were preferred by the students for the solution of 7th problem. From the students' justifications about their solutions, it was understood that adaptive reasoning and representational reasoning were used in this problem's solutions.

4.1.4.10 Analysis of Students' Solutions to the 8th Problem in Pretest and Posttest

The eighth problem in the pretest and posttest is given below.

There are 6 similar shaped balls in a box. 5 of the balls are same weight, and one of them is heavier than the others. What is the minimum number of weights required (by using an equal arm scale) to spot the heaviest ball?

Equal arm scale

Figure 25 Eighth problem in the pretest and posttest

As seen in Table 16 that the number of students' correct solutions (3 students) in the pretest increased when compared to the number of students' correct solutions (34 students) in the posttest. There was no student in the group of partially correct answers in the pre and posttest. The frequencies of correct, partially correct and incorrect solutions for the second problem are provided in Table 16.

Table 16 Correctness of Students' Solutions for the Eighth Problem in Pre and Posttest

	Pre-test	Post-test
Correct	3	34
Partially Correct	0	0
Incorrect	37	6
Sum	40	40

After students' solution for the eighth problem in the pre and posttest were compared, it was observed that although students used logical reasoning strategy to solve this problem in the pretest, they could not reach the correct answer especially in the pretest. When students' solutions in the posttest were examined, it was revealed that students used making a drawing strategy besides logical reasoning strategy in the posttest. This situation might clarify the reason of high increase in the number of correct answers from the pretest (3 students) to the posttest (34 students).

To have more detailed information about students' solutions to the eighth problem, S4 and S10 who solved the problem correctly in the posttest were interviewed although their solutions in the pretest were incorrect. Moreover, they solved the problem in two different ways by using logical reasoning and making drawing strategies in the posttest.

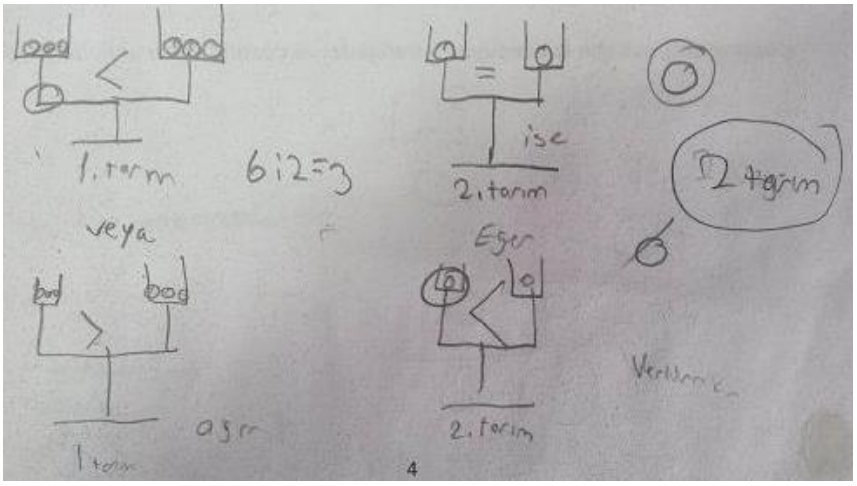


Figure 26 Logical reasoning and making a drawing strategies for the eighth problem in posttest by S4

In the interview, S4, whose solution is given in Figure 26 stated that:

"I divided 6 balls into two groups. I imagined that I put one group in the first pan and one group in the second pan. Since one ball is heavier than the others, first or second pan will be heavier (1st weight) and I drew two possibilities here. By this way, I eliminated three balls. Now, I have three balls and one ball is heavier than two balls. After this, I put each ball in each pan and one ball is out. I noticed that there are two possibilities to spot the heavier ball in the 2nd weight. As follow in Table 17.

Table 17 Possibilities in the 2nd weight for the 8th problem in S4's solution

At the second weight	
1st possibility	**2nd possibility**
If the equal arm scale is balance, the ball which is out is **heavier** one.	If the equal arm scale is not balance, the **heavier** ball is in the pan.

In this way, I found the heavier ball by two weights. I tried to think all the possibilities."

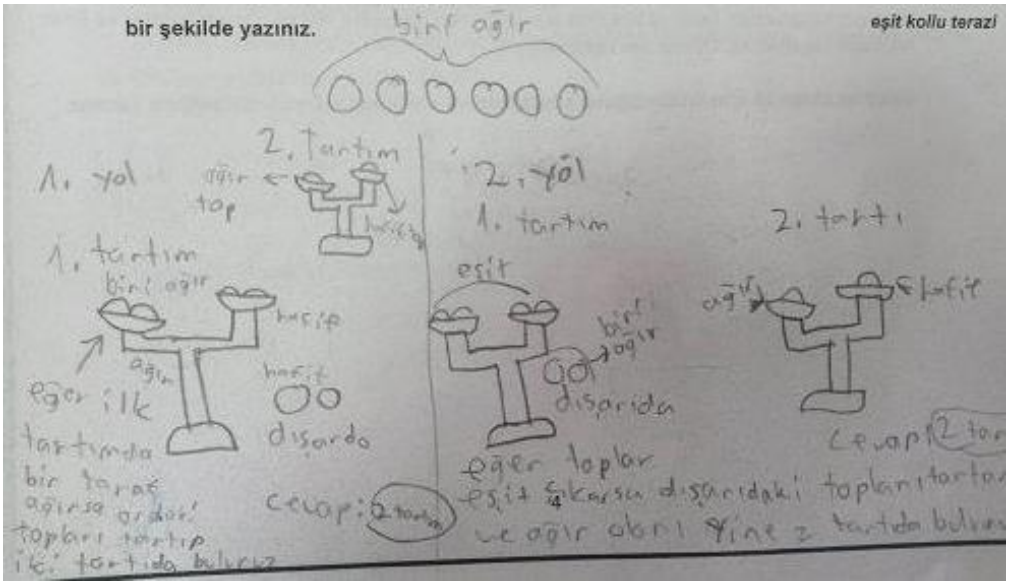


Figure 27 Logical reasoning and making a drawing strategies for the eighth problem in posttest by S10

S10 who solved this problem in a different way (Figure 27) was interviewed to gain deep information about his solution. In the interview, he stated that:

"… I separated balls into 3 groups and two balls in each group were formed. I drew equal arm scales to show my solution easier. At the 1st weight, I put two for each ball in each pan and two balls are out. Now, there are two possibilities that should be considered. (Table 18 shows two possibilities in S10's solution.)

Table 18 Possibilities in the 1st weight and 2nd weight for the 8th problem in S10's solution

At the first weight	
1st possibility	**2nd possibility**
If the arm is not balance, the **heavier** ball is in the pan. Now, there are two balls that one is heavier than the other.	If the equal arm scale is balance, the **heavier** ball is in the group which is out. Now, there are two balls that one is heavier than the other.
At the second weight	
To spot the heavier one, I put one ball in the first pan and one ball in the second pan.	

By this way, I found the heavier one. That is, I got the heavier ball by weighting two times."

In summary, logical reasoning strategy was used by students in this problem. However, students who were interviewed also used the making a drawing strategy to reach the correct answer. In addition to this, students' justifications showed that they used *adaptive* and *representational reasoning* in the background of the problem solving.

4.1.4.11 Summary of Students' Solutions to the Problems in Pretest and Posttest

The findings about students' solutions in the pre and posttest showed that while some of the students had some difficulties to apply problem strategies in some problems in the pretest, they have practiced problem strategies correctly in the posttest and reached the correct answers of the problems which were not solved correctly in the pretest. Namely, the numbers of correct solutions in 2nd, 3rd, 5th, 7th and 8th problems in the posttest increased compared with the numbers of correct answers of same problems in the pretest.

In the 2nd problem, which was a real life and non-routine problem, students developed logical reasoning strategy by using adaptive reasoning in the posttest. Interviews with the students who solved the 2nd problem correctly in the posttest revealed that students learnt to use given important phrases in the 2nd problem. They considered critical information in the problem statement such as "Ceren, who had 39 Turkish Liras, **spent all her money** by purchasing **at least one pencil of each type**" and "How many pencils could Ceren buy **at most**" carefully. They understood the relationships between given information in the problem and used their adaptive reasoning.

While very few students solved the 3rd problem correctly in the pretest, the number of students who solved it correctly in the posttest increased dramatically. Some students used intelligent guessing and testing strategy, some of them preferred to apply logical reasoning strategy to solve the problem. Student solutions and the interviews revealed that students recognized the relationships between the given numbers and the story of the problem, and made some calculations according to these relationships, which referred to adaptive reasoning. Even though they used intelligent guessing and testing strategy, they tried to make guessing logically by considering the relationships in the problem.

In the 5th problem, which was a real life problem, there was a change compared to the numbers of students' solutions in the pre and posttest. Students examined three options in the problem and reached the correct answers in the posttest. In this process, they used logical reasoning strategy. Similar to the 2nd problem, they considered some phrases in the problem such as **every week day, the amount of money for monthly and profit for the each magazine** and **1month = 4 weeks.** It seemed that students who understood the given information and the relationships between them solved the problem correctly by adaptive reasoning.

In the 7th problem, which was a non-routine and real life problem, the number of correct solutions in the posttest increased compared to students' solution in the pretest. Some students used making a drawing strategy to solve the problem while the others preferred the logical reasoning strategy. In both strategies, students

considered the **one more bus** for the last students by reasoning adaptively and visually.

In the 8th problem, there was a change in the number of correct solutions in posttest. This problem, which was a non-routine real life problem, required considering all possibilities besides examining the given information in the problem such as "the **minimum number of weights** required (by using an equal arm scale) to spot the heaviest ball". Students solved the problem by logical reasoning strategy with the help of making a drawing strategy.

The frequencies of problem solving strategies used by the students in pre and posttest were given in Table 19.

Table 19 The frequencies of problem solving strategies used by the students in pre and posttest

	Pretest	**Posttest**
Intelligent guessing and testing	**7**	**31**
Logical reasoning	**43**	**133**
Solving a simpler equivalent problem	20	19
Making a drawing	**42**	**73**
Organizing data	38	39
Finding a pattern	26	22

Table 19 also reveals that there was a quite number of increase the frequiences of *intelligent guessing and testing*, *logical reasoning* and *making a drawing* strategies which used by the students.

The frequencies of reasoning forms revealed in the students' solutions in pre and posttest were given in Table 20.

Table 20 The frequencies of reasoning forms revealed in the students' solutions in pre and posttest

	Pretest	**Posttest**
Adaptive	**50**	**164**
Algebraic	46	41
Representational	**74**	**118**

Table 20 shows that there was a quite number of increase the frequiences of *adaptive* and *representational reasoning forms* revealed in the students' solutions in pre and posttest.

4.2 Analysis of Puzzles and Games Course Evaluation Forms (PGCEF) and Interviews

In the study, Puzzles and Games course evaluation forms consisting of nine questions were filled by two classes of Puzzles and Games course students (40 students) at the end of the Fall semester of 2014-2015 academic year. These data were supported by interviews that were conducted by seven students with the same questions in PGCEF.

Students' answers to questions in PGCEF were categorized into two main groups: students' views about activities in Puzzles and Games course and students' views about contributions of Puzzles and Games course.

4.2.1 Students' Views about Activities in Puzzles and Games Course

4.2.1.1 Students' General Views about Activities in Puzzles and Games Course

Students mostly had positive views about the Puzzles and Games course. Twenty three of 40 students expressed that activities in the course were enjoyable:

> "I think it is fun. Some of them, especially problems, are hard for me but I enjoy while I'm solving them. Also, when I play with the opponent in some strategy games, I like the case of losing and winning." (S22, interview)

> "Some of the games look like hard at the beginning. However, as I played them, I found all the games enjoyable." (S37)

> "I like all the games out of Mastermind. Many of the games are enjoyable. Developing new strategies makes this course enjoyable." (S2, interview).

> "The games and problems are generally puzzling. When I understand the rules of the games or get the clues of the problems, I felt like I am solving puzzles. This made me excited. So, I can say that the activities are enjoyful." (S14)

Some of the students addressed that some activities were boring but some were more enjoyable. Nine students wrote down that strategy games were enjoyable; however, reasoning and operations games and problems were boring. One of those students, S10, emphasized in the interview that:

> "…many of the games were boring because developing strategy is hard. Reasoning and operations games were so boring. You have to concentrate on it and you cannot talk to anyone. However, strategy games are not like this. I like competition at strategy games. You try to win the game and understand the competitor's strategy."

Apart from these, some students stated that the activities helped to learn time usage well and develop new strategies. Sixteen students especially wrote down that they liked strategy games and these kinds of games forced them to think deeply.

4.2.1.2 Students' Views about Difficulty Levels of Activities

Concerning students' ideas about difficulty levels of strategy games (board games), reasoning and operation puzzles and problems, almost one third of the students (14 of 40) thought that all the games and problems were easy. However, 18 of 40 students had a different idea that while generally strategy games were easy, reasoning and operations games and problems were hard as in the following**:**

> "I think problems are so hard. Also, Sudoku at level 5 compelled me because there are a few clues. However, strategy games like Checker, Quixo and Mastermind are also hard, but if you concentrate while playing, they are easy." (S2, interview)

> "Strategy games are easier than reasoning and operation puzzles. In strategy games, you can discuss the rules or next move with the opponent. In this way, I overcome to difficulties of strategy games. However, while playing high levels of Sudoku, Kendoku or ABC connection puzzle, I could not proceed at some point and I could not finish many of them." (S29)

> "I don't like problems. They are not like problems in mathematics class. They are so hard. I could not solve them without clues. But, I love board games (strategy games), they are easy." (S32)

Different from other students, 8 of 40 students thought that reasoning and operations games had different level of difficulty. Some of them were easy and some of them were difficult**:**

> "Some of the reasoning and operations games are easy, some of them are difficult. I mean that difficulty about reasoning and operations games depends on you; it depends on your level." (S4, interview)

"I think it is medium because there are different sides of easiness and difficulties in each game. For example, while 6x6 Sudoku at level 3 is easy, 9x9 Sudoku at level 4 is so hard." (S10, interview)

As seen on the students' interviews, students in Puzzles and Games course had different views about the difficulty levels of activities.

4.2.1.3 Students' Views about Beneficial Aspects of Activities

Most of the students in Puzzles and Games course had positive ideas about benefits of the course and they stated the different aspects of benefits of the course. Thirty three of 40 students stated that the activities were beneficial while seven students thought that they did not gain any benefit of the activities. Eleven of 33 students wrote down that the activities helped them to develop new strategies. S2 and S9 stated her earnings from games and problems:

"… Games and problems proved me that I can think in different ways. For example, before taking this course, I had thought that there is only one way to solve problems or one way to win games. However, now I can think other ways and I share new ways with my father and I teach them to him. This increases my self-confidence."

"I developed decision making ability by the help of playing Sudoku and Kendoku. There are many possibilities for only one box in these games. I learnt to eliminate the impossible ones and decide correct number by considering other possibilities." (S9)

"I learnt to concentrate on reasoning and operation puzzles by myself. The time I can concentrate on something increased by playing these games." (S40)

Some of the students had different perspective about developing strategies, such as S10:

> "I learnt that if I have a competitor, I need to think her/his strategy. If you understand the competitor's strategy, you can develop a new strategy according to the competitor's strategy and this makes winning the games easier. This situation may occur in the real life… In addition to this, I asked my mother the problems which I learnt in Puzzles and Games course and of course she cannot solve them. I teach her how to solve them. I like teaching something new to my mother. This makes me happy." (S10, interview)

Moreover, 8 of 33 students stated that they improved different point of views when they played games and solve problems. One of those students, S22, emphasized in the interview that:

> "All of the games are beneficial. I developed different point of views in each game. Especially problems force you to look from different perspectives. This helped me to develop my own strategies for strategy games (board games). By this way, I do not need to keep other's strategies."

Other students wrote down that the activities in Puzzles and Games course provided opportunity to use time efficiently, decision making, making reasoning, finding a clue, taking a care and anticipation.

4.2.2 Students' Views about Contributions of Puzzles and Games Course

4.2.2.1 Contributions of Puzzles and Games Course to Students' Developments of Distinctive Strategies

Majority of the Puzzles and Games course students developed their own distinctive strategies while playing both reasoning and operation puzzles and strategy games and solving problems. Only 10 of 40 students stated that they did

not develop any new strategy; they used only suggested strategies during the course. Some students mentioned their own strategies while playing some strategy games and reasoning and operation puzzles and solving problems:

> "For example, I look for the most digits in Sudoku. For instance, 1 (one) is the most founded digit in Sudoku. I try to put into place 1 in the (2x3) regions. That is, I look for the most found digit at first. By this way, I finish to place all the digits. This way makes solving Sudoku easiest. In addition to this, when I am the code maker in Mastermind, I do not put the four pegs in different color. I prefer to put at least two pegs in same color because my friends generally think that all the pegs are different in colors." (S2, interview)

> "I get the competitor's strategy and I start to play like him/her. In this way, I make him/her ineffective. This helps to stand a good chance of the game. (S10, interview)"

> "I try to make possible digits count in Sudoku. For example, I eliminate impossible digits in some (2x3) regions and I write them other (2x3) regions. Similarly, I guess impossible places for tents in Tent game. This strategy, that is, eliminating impossible answers, makes some games easier. Additionally, I use the same strategy in Mastermind. I mean that if the competitor put white small pegs, I put different big pegs or I change the place of existing big pegs. By the way, I love Mastermind, so challenging game. You have to think all the possibilities to break code." (S16, interview)

> "I learnt to use table while solving problems. This makes it easy. When I read the problems, it always looks complicated. Only when I organize the data, I can solve the problems. Also, I force myself to think in a different way when I come across the problems. Solutions of them always make me surprise." (S37)

"Placing similar pieces in one area is my strategy in Quarto. This way confuses the competitor. This game needs to be watchful. If you do not concentrate on the whole game board, you probably lose." (S1, interview)

"… I love Turkish Mancala. I always count competitor's pieces in her/his pits that I can make them even and I collect them. Also, I collect my pieces on my side, then, I distribute them to competitor's pits." (S29)

4.2.2.2 Contributions of Puzzles and Games Course to Students' Daily Life

More than half of the students were in the opinion that Puzzles and Games course did not affect their daily life in any way. Eighteen of 40 students wrote down that Puzzles and Games course resulted in some positive chances in their daily life:

"I play some games in my leisure time at home. For example, Sudoku, Kendoku, battleships… Also, I teach them my family. I enjoy teaching games to my family." (S2, interview)

"We bought Turkish Mancala. My mother, my father and my sister play it and we organize Mancala tournament at some weekend. That is so enjoyable." (S10, interview)

"I started to buy "Puzzles" magazine which is published quarterly. By this way, I have learnt new reasoning and operation puzzles other than I learnt in Puzzles and Games course. I got a new habit with the help of this course. My mother is so happy about this." (S1)

"I downloaded the application of Mastermind to my phone. I play Mastermind when I am on the way in the mornings. Moreover, I can decide faster and more rational compare to past. Mastermind and Mancala provided me to develop this skill." (S22, interview)

"I have developed empathy. I started to think in her/his way when playing with competitor. By this way, I learnt to put myself in her/his place. This helps me to establish good friendship." (S9)

"Some games like Quarto, Mastermind, Mancala improved my attention. I am more careful compared to past. In addition to this, my multiplication skills developed with the help of Kendoku." (S4, interview)

"I learnt to crosscheck. For example, I finish a Sudoku and I saw at final move that I made something wrong in somewhere. Bombs!!!… I had to go back! In this way, I started to crosscheck in every move in Sudoku, Kendoku, Tent… I also started to crosscheck while solving problems in the mathematics class." (S16, interview)

4.2.2.3 Contributions of Puzzles and Games Course to Development of Students' Different Viewpoints

While some students thought that they did not develop any different viewpoints, more than half of the students (25 out of 40) stated that Puzzles and Games course helped them to improve different views:

"Nearly all the problems look like insolvable. When you get the clues, the solutions of them come easily and quickly. However, it is not enough to find clue, in addition to this, you need to look from a different perspective." (S4, interview)

"While playing Mastermind, I always put myself in the opponent's place. I started to think in her/his way. I noticed that I learnt new perspectives from my opponents." (S7)

"Especially problems changed my perspectives. They were all both hard and easy. Also, they were not like problems in mathematics class. Because of these, while solving problems, I gained different point of views." (S27)

"Board games (strategy games) helped me improve different point of views. When I played them, I tried to change my strategies. If not, it is so boring. By this way, I force myself to change my mind." (S18)

Many students stated that this course provided improvement in various views. Moreover, students emphasized that after they solved the problems, discussions about the problem and sharing different ideas about the solution facilitated development of different ways to reach solutions. Additionally, students wrote down that strategy games, which were based on competition, made it available to learn others' ways. By this way, they discovered their friends' strategies and learned how to cope with these strategies. This situation also made contribution to the development of different viewpoints.

4.2.2.4 Contributions of Puzzles and Games Course to Students' Problem Solving in Mathematics Class

Almost half of the students generally had positive views about the effects of Puzzles and Games course experiences on mathematics lesson experiences while the other half thought that Puzzles and Games course did not make any contributions to their problem solving in the mathematics class. Seven of 40 students indicated that they solved problems in the mathematics class faster compared to past. One of those students, S16, stated in the interview that:

"My operation skills, especially multiplication and division, are improved by Kendoku. By this way, I have started to solve mathematical problems more quickly."

Eight of 40 students claimed that Puzzles and Games course had a different effect on their problem solving in mathematics class. One of those students, (S1), wrote down in his evaluation form that:

> "Since I learnt new strategies in Puzzles and Games course while solving problems, I try to apply them in mathematical problems. Even though they do not work in some problems, I learnt in Puzzles and Games course that there is always a way to reach solution and I just need to look from a different perspective. Also, I learnt my friends' solution ways in the course with the help of discussion environment. I remember their strategies in mathematics class."

Furthermore, four of 40 students wrote down that they improved their estimation skills by playing Sudoku, Kendoku, Battleship and Tent in Puzzles and Games course. Hereby, they claimed that when they solved the problems in mathematics class, they could guess possible and impossible answers for the problems. Finally, 3 of 40 students emphasized in their evaluation forms that Puzzles and Games course helped them to solve problems by drawing figures and organizing data such as constructing table. They noted down that complicated problems or problems which consisted of too many data could be solved easier by showing them in table or figure.

Students who thought that the Puzzles and Games course did not have any effect on their mathematics lesson experiences stated that:

> "Puzzles and Games course did not affect my problem solving in mathematics class. I do not like problem solving in mathematics; it is boring. However, I like solving problems in Puzzles and Games course. They are different than the others. They are enjoyable. " (S24)

"I think there is no relationship between Puzzles and Games course and mathematics lesson. Some games and problems involve some mathematical operations but this did not influence my mathematical problem solving. (S5)

"Maybe games and problems have some impact on my mathematics. However, I did not notice. My mathematics exam score did not increase." (S30)

As seen from students' comments that some students could not experience any benefit from Puzzles and Games course in terms of mathematical problem solving.

4.2.2.5 Summary of Analysis of Puzzles and Games Course Evaluation Forms (PGCEF) and Interviews

Analysis of Puzzles and Games course evaluation forms and interviews showed that many of the students considered that Puzzles and Games course consisted of enjoyable activities such as strategy games, reasoning and operations games and problems. Although some students thought that some games and problems were boring, Puzzles and Games course was seen as one of the favorite courses in school. When the forms and interviews were analyzed in detail, it was observed that half of the students considered the activities easy. On the other hand, other half of the students thought that strategy games were easy and reasoning and operations games and problems were difficult. However, some students pointed the levels of reasoning and operations games, thereby; they did not think that all the reasoning and operations games were difficult. Even though few students mentioned that they did not get any benefits from Puzzles and Games course, majority of the students addressed some benefits of the course in the forms and interviews. Developing new strategies, estimating competitor's strategy and realizing different viewpoints were the most expressed benefits of the course.

Similarly, few students stated that they did not develop any distinctive strategy during the course. Many of the students addressed different strategies that

they improved in different games and problems. Developing new strategies according to competitor's strategy, eliminating impossible answers in games and problems, scanning the most digits in Sudoku, choosing four pegs of the same color for code in Mastermind, hiding the fences for last moves in Quoridor, collecting many pieces in one pit in Turkish Mancala and solving problems by organizing data in table and drawing figures were the most common improved strategies by the students.

More than half of the students thought that this course did not make any contributions to their daily life although some students had positive views about the effects of Puzzles and Games course to their daily life. Most of the students stated that they played some games that they learnt in the course in their leisure time with their family. In a similar way, nearly half of the students considered that they developed different viewpoints with the help Puzzles and Games course. Strategy games, reasoning and operations games and problems provided some students development of different views. Finally, some students stated that they improved their operation skills, especially multiplication and division in mathematics classroom, after taking Puzzles and Games course. Moreover, they started to develop new ways for solving problems in mathematics classrooms.

CHAPTER 5

DISCUSSIONS

The motivation for this study was to investigate the 6th grade students' problem solving strategies and reasoning skills at the end of the Puzzles and Games course. The study also aimed to release students' ideas about Puzzles and Games course's effectiveness. This final chapter will focus on the research questions in light of the quantitative and qualitative findings. Furthermore, some implications for educational practices will be suggested and some recommendations will be given for future studies.

5.1 Discussion of the Findings

This chapter is organized based on the research questions. To be more specific, in the first section, the comparison of participants' achievement levels in pre and posttest is discussed. Next, students' problem solving strategies and reasoning skills revealed in the problems are discussed with emphasis on their frequencies in the pre and posttest. Finally, students' responses in evaluation forms and interviews for the questions about their views of Puzzles and Games course were discussed. The findings are also compared and contrasted with previous research studies in the literature.

5.1.1 Descriptive Statistics of Pretest and Posttest for Comparison

The comparison of descriptive statistics for pre and posttest included eight open-ended and non-routine and real life context problems showed that the mean scores of students in the posttest (*M = 15.65*) was higher than their mean scores in the pretest (*M = 11.60*). This result showed that 6th grade students in Puzzles and Games course have made progress in problem solving strategies and reasoning skills. Related literature also shows that most of the students engaged with puzzles

and games have developed their problem solving strategies and reasoning skills (Bottino, Ott & Benigno, 2009; Bottino, Ott, Tavella & Benigno, 2010; Bottino, Ott & Tavella, 2013).

When the students' solutions in pre and posttest were compared, it was seen that while some students who solved some of the problems partially correctly in the pretest developed their problem solving strategies and reached the correct answers in the posttest, those who solved the problems correctly in pretest changed their problem solving strategies and reasoning, and found the correct solutions in the posttest. In addition to this, some students who had incorrect answers in pretest used some problem solving strategies and reached the correct answers in the posttest.

These changes might be due to the games which students have played and problems covered in Puzzles and Games course during the semester (15 weeks). The reasoning and operation puzzles, strategy games and problems might have influenced the students' problem solving strategies and their reasoning skills. Since reasoning and operation puzzles are based on evaluations of given clues in games and developing logical reasoning to reach correct solutions, students who play reasoning and operation puzzles might be expected to improve strategies and logical reasoning (MoNE, 2013). In addition to characteristics of these games, one needs to use given clues in problems to reach correct answer which is not obvious in the start (MoNE, 2013). It is seen that reasoning and operation puzzles, strategy games and problems have similar characteristics which are using given clues, improving logical reasoning and developing strategies which may influence students' problem solving strategies and reasoning skills positively.

In addition to this, Bottino, Ott and Benigno (2009), Bottino, Ott, Tavella and Benigno (2010) and Bottino, Ott and Tavella (2013) have found similar results in their studies that some characteristics of the puzzles and games help students to improve their problem solving and reasoning skills. Similarly, Bachet game, which is an example of strategy game, is found to promote students' mathematical reasoning (Applebaum & Freiman, 2014).

Along these lines, it is stated that strategy games can be seen as problems conducted in mathematics classrooms (Corbalán, 1998) such that Polya's problem

solving steps (1957) are similar to steps of playing strategy games (Cañellas, 2008). To be more precise, first of all, understanding the problem and the game rules are crucial for beginning of problem solving and playing strategy games. Second, there is a need to have a plan to reach correct answer for the problem similar to developing a game strategy for the strategy games. Third, the plan of the problem solving is applied and the strategy of the game is performed and finally, after finding the correct answers, the solution way of the problem is examined and the strategy of the game is analyzed at the end of the game. From another angle, according to Tyson, Venville, Harrison and Treagust (1997, p.402), students who are successful can make advantages of "different conceptions in appropriate contexts." Therefore, students could learn to utilize problem solving strategies and reasoning skills that they practiced by playing these games and solving problems.

From the same point of view, Shriki (2009) implies that students can develop their mathematical thinking and reasoning skills by playing strategy games since students are in a competitive environment through the instruments of strategy games. Therefore, it can be claimed that students who play strategy games force themselves to win the games or overcome to opponent's strategy. Thus, these conditions cause problematic situations for the students and they improve their problem solving and reasoning skills.

On the other hand, this finding might be because of other activities in and out of school. In other words, this development of 6^{th} grade students' achievement in the test might be due to students' experiences and familiarity with problem solving instruction which is emphasized in 6^{th} grade mathematics curriculum (Öztuncay, 2005). In addition to this, children store their experiences over the years and by this way, they keep their ability of constructing solutions to problems based on number, geometry, and measurement (NRC, 2009). Therefore, this finding might be due to the fact that students' skills and experiences with mathematics are accumulated throughout time and the development in their problem solving and reasoning skills could be supported by the reasoning and operation puzzles, strategy games and problems in the Puzzles and Games course.

5.1.2 Improved Problem Solving Strategies and Reasoning Skills

Cai (2003) stated that analyzing students' problem solving strategies gives information about students' levels of improvements in mathematical thinking and reasoning. Turkish students who were not trained spefically for problem solving were found to have difficulties and inflexibility in solving problems (Bayazit, 2013; Erdoğan, 2015). In a similar manner, the findings regarding students' solutions in the pretest in this study showed that 6th grade Puzzles and Games course students had some difficulties to apply some problem solving strategies in real world non-routine problems at the beginning of Puzzles and Games course. However, when the students' solutions in the pre and posttest were compared, it was revealed that students generally practiced problem solving strategies correctly and reached the correct answers of the problems at the end of the course. Considering that competence in problem solving is attached to attainment, selection and application of problem solving strategies (Pressley, 1990; Simon, 1989) and students' proficiency in selecting and applying suitable problem solving strategies indicates students' levels of competence in mathematics (Cai, 2003); the findings of the study might address that Puzzles and Games course contributed students' problem solving competencies and eventually their mathematics learning.

Comparison of the students' solutions at the beginning and end of the course ensued that students improved mostly logical reasoning and, intelligent guessing and testing strategies and they usually underlined adaptive reasoning while solving real world non-routine problems. This result might be due to the reasoning and operation puzzles, strategy games and problems played in the Puzzles and Games course. Namely, reasoning and operational games which are Sudoku, Kendoku, Tree Tent, Battleship, Slitherlink, ABC Connection and Digital Operations, are based on consideration of given hints, interpreting these hints by making logical reasoning and completing the games (MoNE, 2013). In addition to this, strategy games which are Mastermind, Mancala, Quoridor, Turkish Checkers, Quixo and Quarto need to guesstimate and use others' experiences while improving strategies and logical reasoning (MoNE, 2013). Therefore, the characteristics of these games might have contributed students' problem solving strategies and their reasoning.

Besides, students developed organizing data strategy that is, making a drawing strategy by using representational reasoning. The main reason of the change at the end of the course might be solving problems in Puzzles and Games course. Students got used to facing problems which looked like unsolvable at first during the semester. In each of the mind problem solving session, it was emphasized to students by the course teachers that every mind problem had solutions; however, they needed to look from a different viewpoint. Also, it was stated in every solution of mind problems that using making a list or table and making a drawing would help to understand the problems in detail. Additionally, every solution of problems was supported by making a list or making a drawing on the blackboard during the class discussions. Therefore, students had a chance to improve their problem solving and reasoning skill visually. It can be claimed that not only the problems, but also the Puzzles and Games course teachers' productive guidance and emphasis on problem solving strategies might have contributed to the development of problem solving strategies and reasoning.

Cai (2003) claimed that students' reasoning could be revealed by investigating their justifications for the problem solutions. From this point of view, students' solutions and interviews about them were examined in detail and it was revealed that students learnt to consider the given critical information in the problem, estimate possibilities and make some inferences at the end of the course. The main reason of this result could be that students went through a mental process such as evaluating possible moves and deciding suitable moves while playing Sudoku, Kendoku, Tree Tent, Battleship Mastermind, Mancala, Quoridor. Therefore, it can be claimed that playing reasoning and operation puzzles and strategy games provided a thinking process for the students to experience evaluating important data in the problem, predicting suitable possibilities and coming to conclusions with the help of problem solving strategies and reasoning skill.

5.1.3 Students' Views about Puzzles and Games Course

The findings about students' views regarding the activities revealed that many of the students had positive views about activities in Puzzles and Games

course. They stated that puzzles, games and mind problem were enjoyable. This finding also supports the finding of Devecioğlu and Karadağ (2014) who concluded that students considered Puzzles and Games course as enjoyable. Besides, some students found reasoning and operation puzzles, and problems boring while strategy games were enjoyable. The main reason of this might be that reasoning and operational games are solo games; they are unrivaled and they are played by paper and pencil. There are not any other materials for these types of games. Moreover, problems seem difficult and unsolvable at first. However, strategy games are generally played on game boards and students played these games against an opponent which provides a competition environment. Because of these, students might think that strategy games were enjoyable compared with reasoning and operational games, and problems. This finding is similar to the finding of Devecioğlu and Karadağ (2014)'s study that students perceived Sudoku as boring since it is played by paper and pencil. In the same study, nearly half of the students stated that strategy games made them reflect on developing strategies and helped them improve new strategies.

Students' views regarding the difficulty levels of activities in Puzzles and Games course differed that while some students thought all the games and problems were easy, some of them stated that only reasoning and operational games, and problems were difficult. Apart from all these, some students noticed the different difficulty levels of reasoning and operation puzzles in the activity papers. The reason of this inference might be that all the activity papers consisting of reasoning and operation puzzles included all difficulty levels of games namely easy, medium and difficult. Therefore, all the reasoning and operation puzzles addressed all the students who were in different levels in Puzzles and Games course. Students were more competent in some aspects and felt more challenged in other aspects. This finding showed that the variety of games and problems in the Puzzles and Games course seemed balanced for all students who took the course.

Most of the students mentioned different aspects of Puzzles and Games course's benefits. Students mostly stated that they learned to develop new strategies while playing games and solving problems. They emphasized that they learnt

different ways of completing games and solving problems. Especially strategy games helped them improve different strategies since students had a chance to learn the opponent's strategy while playing these games. Discussion sessions at the end of the each lesson might bridge over this result that students shared their strategies with friends. By this way, they had a chance to learn others' strategies.

Discussion and questioning in classroom are seen as significant instructional methods which help students improve their critical thinking and problem solving skills (Robitaille, Maldonado & Fort Lauderdale, 2015). Discussions provide an environment that students share, identify, clarify and justify their ideas (Kosko, 2012). Discussion environments were provided by the Puzzles and Games course teachers where all the students shared their ideas about the solutions while solving problems which generally seemed difficult and unsolvable at first. After they brought clues close together, they solved the problems under the guidance of teachers. Therefore, some students mentioned that solving problems thought them to look different points of view and gaining this ability helped them in strategy games to cope with the opponent's strategy. Apart from all these, other students had benefits in terms of usage of time efficiently, decision making, finding a clue and anticipation.

Majority of the Puzzles and Games course students improved their own distinctive strategies while playing reasoning and operational games, strategy games and solving problems. Students mostly developed different strategies in Sudoku, as students in similar studies did (Cinan, 2010). They explored the opponents' perception in Mastermind and learnt to evaluate all the possibilities revealed during the play. Similarly, Bottino, Ott and Benigno (2009) mentioned that their participants thought possibilities and made logical guesses in the process of deciding the next move in Mastermind. Apart from strategies improved in some specific games by students, many of them stated that they generally either guessed the opponent's strategy to beat him/her or applied opponent's strategy. They claimed that the opponent was made ineffective by this method. Last, analysis of students' answers showed that problems which generally seemed insolvable at first opened a new door in students' cognitive process. Students indicated that problems

could be solved by organizing data as drawing pictures or making table and looking from a different point of views.

Many of the students had positive views about contributions of Puzzles and Games course to their daily life while some of them thought that it did not influence their daily life in any way. Both positive effects and no effect of Puzzles and Games course on students' daily life have been reported where playing the games that they learned in Puzzles and Games course in their leisure time was emphasized (Devecioğlu & Karadağ, 2014). Moreover, some students started to buy "Akıl Oyunları" (Puzzles) magazine and solved the reasoning and operation puzzles and problems in these magazines in their leisure time. They also carried the games they played in the Puzzles and Games course to their families. Therefore, it can be claimed that the Puzzles and Games course improved students' positive attitude towards reasoning and operation puzzles as indicated by their increased interest in out-of-school contexts.

Students' views about the effects of Puzzles and Games course to their problem solving in mathematics class varied. While some of them had positive views about it, many of them thought that Puzzles and Games course did not make any contributions to their problem solving in mathematics class. The most specified effect of Puzzles and Games course stated by the students to problem solving skill was about operation skills, especially multiplication and division, which were developed by playing Kendoku. This and similar games have been known to "allow students to explore basic operations, factors, parity, symmetry, modular arithmetic, congruence, isomorphism, and algebraic thinking" (Reiter, Thornton & Vennebush, 2014, p.342). Moreover, some students noticed that playing Sudoku, Kendoku, Battleship, Tree Tent, and Mastermind developed their estimation skills and helped them to guess possible and impossible answers in the problems. Additionally, Sudoku, Kendoku, Battleship and Tree Tent provided students to crosscheck their moves and some students mentioned that they started to crosscheck their solutions while solving problems in mathematics class.

5.2 Implications, Recommendations and Limitations

The findings of this study have the potential to provide some new perspectives to Puzzles and Games course teachers, mathematics teachers, curriculum developers, instructors, and Ministry of National Education. Therefore, some implications for these stakeholders are explained in this section.

It was revealed that the puzzles, games and problems which are parts of Puzzles and Games course have positive effects of students' problem solving strategies and reasoning skills. In this respect, Ministry of National Education and mathematics teachers should be aware of the importance of Puzzles and Games course in the school program. This course might have significant contributions to students' problem solving and reasoning skills which are lifelong fundamental abilities. Therefore, Puzzles and Games course should be initiated in not only middle school program but also primary school and high school program. Moreover, Puzzles and Games course might be a compulsory course in every education level. In such a case, Ministry of National Education should supply at least some games for every school to help teachers practice this course as required.

Additionally, Ministry of National Education should support seminars and workshops which aim to provide Puzzles and Games course teachers to learn puzzles and games suggested in Puzzles and Games course curriculum. Some seminars are organized by Turkish Agency of World Puzzle Federation (Türk Beyin Takımı) that consulted Ministry of National Education while composing the curriculum of Puzzles and Games course at certain intervals. Puzzles and Games course teachers should be encouraged participating these seminars. In this way, the effectiveness of Puzzles and Games course can be increased by the teachers who have comprehensive knowledge of puzzles and games. Furthermore, Ministry of National Education should provide source books and magazines for Puzzles and Games course students freely.

This finding can open a new door for mathematics and Puzzles and Games course teachers who want to help students develop their problem solving and reasoning skills. In every grade level, especially reasoning and operation puzzles (such as Sudoku, Kendoku, Tree Tent, Battleship, and ABC Connection puzzle)

and strategy games can be taught in the mathematics class to the extent permitted by mathematics curriculums. Playing these games and solving problems as extracurricular activities might awaken students' interest to the mathematics. By this way, students' problem solving and reasoning skills might be influenced positively.

In other respects, specific results of the study indicated that Puzzles and Games course teachers should prepare lesson plans that include different games and mind problem in each session. Namely, students can get bored with some reasoning and operation puzzles, and problems since they are paper and pencil games. The participants of Devecioğlu and Karadağ's study (2014) stated that they were bored to play same games such as Sudoku in every session of Puzzles and Games course. From this point, right along with reasoning and operation puzzles and problems, strategy games which are generally played on game boards should be included in the lesson plans. Furthermore, Puzzles and Games course teachers can organize some tournaments of strategy games such as Mancala, Mastermind and Turkish Checkers in the school environment and these tournaments may attract some students' interest. From these tournaments, students who are successful may be encouraged to attend national tournaments in Turkey. The mathematics department in the school where this study was conducted organized Mancala Tournament among 5^{th} grade students in 2014-2015 academic year independent of this study. It was observed that this tournament caught many students' interests and increased their motivation. Similarly, Puzzles Tournament was implemented in the same school in 2014-2015 academic year and it was seen that students were willing to learn puzzles and games and competed in this tournament. In addition to this, Turkish Agency of World Puzzle Federation (Türk Beyin Takımı) organizes Puzzles Tournaments (Akıl Oyunları Yarışması) in some schools. Students, who are good at puzzles and games, especially reasoning and operation puzzles, should be encouraged to join these tournaments by their teachers. Therefore, Puzzles and Games course teachers should observe their students carefully to distinguish these eager students.

On the other respects, this study was conducted in one private school. Therefore, as a researcher, I had a chance to have all required strategy games (Mastermind, Mancala, Checkers, Quixo, Quarto) for the course. However, budgets of some schools may not support to buy some strategy games. If Puzzles and Games course teachers face such a situation, they can find websites of strategy games (Mastermind, Mancala, Turkish Checkers, Quixo and Quarto) which provide an environment that students play these games as an online, if schools have computer labs.

Puzzles and Games course teachers are generally mathematics teachers; therefore, the curriculum of mathematics teacher education programs should include a course about puzzles and games for pre-service mathematics teachers. This course may help them learn puzzles and games and problems. By this way, pre-service teachers have a chance to prepare Puzzles and Games lesson plans before they teach Puzzles and Games course class.

The result of the study showed that Puzzles and Games course had effects on problem solving and reasoning skills. However, this study has some limitations for generalizability. Namely, the sampling method was convenience sampling which refers that the study was conducted only one private school. Therefore, the result of the study could not be generalized to the other schools. In this respect, further studies can be conducted in more than one school and public schools. Thus, effects of Puzzles and Games course on students' problem solving and reasoning skills can be seen in different samples by other studies. Also, the sample of this study is only 6^{th} grade students. 5^{th}, 7^{th} and 8^{th} grades students can be added to the sample for future studies.

The present study was conducted during one semester. The time can be allocated to the whole year and similar study can be carried out during two semesters in the future studies. Geometric mechanics games, word games and memory games which are in the curriculum of Puzzles and Games course can be played during the second semester. Thus, further studies can look for the effects of these games from different perspectives. Namely, the effects of Puzzles and Games

course to students' critical thinking, motivation, attitude, belief and communication of mathematical ideas can be investigated in the future studies.

5.3 Last Words

First of all, I did not know many of puzzles and games before being the Puzzles and Games course teacher three years ago. Puzzles and Games course created a change in my world, besides my profession as a teacher. I believed that this course might influence students' cognitive developments when I examined the curriculum of Puzzles and Games course. As both a mathematics teacher and researcher, I have been observing my 5^{th} and 6^{th} grades Puzzles and Games course students for more than two years and I had a chance to monitor their developments in the course. After they started to learn different puzzles and games and problems in every session, I saw how they improved different strategies and how their perspectives of games have been changed. Similarly, this study showed that puzzles, games and problems have undeniable effects on students' problem solving and reasoning skills. Being aware of this, hereafter I will create an environment that puzzles, games and problems are the part of my lecture in mathematics class.

Besides, Puzzles and Games course students, as revealed by what they said in the interviews and wrote down in the evaluation forms, were the best observers in the class. They explored themselves with their own words and analyzed their improvements and the changes in their viewpoint. From this angle, as a teacher, my duty is to take consideration of students' views and help students open new doors in their cognitive developments by puzzles and games.

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APPENDICES

A. Sudoku

Sevgili öğrenciler, öncelikle kolay seviyedeki sudokudan başlayın. Daha sonra sıra ile orta ve zor seviyedeki sudokuları verilen süre içinde çözmeye çalışın. Sudoku çözerken kendinize özgü bir çözüm stratejisi geliştirebilirsiniz. Geliştirdiğiniz çözüm stratejinizi sıra arkadaşınızla paylaşın.

1. Adım: Kolay seviye

3	7		6		9		2	1
4				8				3
		6	3		5	7		
6		4				3		9
	9			3			8	
2		7				1		4
		1	9		8	4		
5				6				7
8	2		1		4		9	5

8				1				9
	5		8		7		1	
		4		9		7		
	6		7		1		2	
5		8		6		1		7
	1		5		2		9	
		7		4		6		
	8		3		9		4	
3				5				8

2. Adım: Orta Seviye

							1	7
			9	5				4
	4	5						
		4		2				6
	3	6					5	
	7				1	3	4	
	9	8						
	5		8	7			6	3
7			6				9	8

3. Adım: Zor Seviye

							1	7
			9	5				4
	4	5						
		4		2				6
	3							
	7				1	3	4	
	9	8						
	5		8	7			6	3
7			6				9	

B. Reasoning and Operation Puzzles

B.1 Reasoning and Operation Puzzles

B.1.1 Kendoku

Player: 1

Rule: The numbers 1-4 are used in 4 x 4 Kendoku (6 x6 Kendoku requires the numbers 1-6.). All required numbers must appear in every row and column. Each "cage" (region bounded by a heavy border) contains a "target number." If there is more than one cell in the cage, the target is also accompanied by an arithmetic operation. You must fill the cage with numbers that produce the target number, using only the specified arithmetic operation. Numbers may be repeated within a cage, if necessary, as long as they do not repeat within a single row or column. In a one-cell cage, only the target number is written in that cell (“Introducing Kenken Puzzles”, 2014).

Kendoku also called Kenken puzzles that invented in 2004 by Japanese math teacher and this game is used in many elementary schools to develop students’ addition, subtraction, and multiplication and division skills (“Math Games from Japan”, n.d.)

All difficulty levels of Kendoku problems were put in the weekly activities. An example of medium level of 4 x 4 Kendoku is given in Figure B.1.

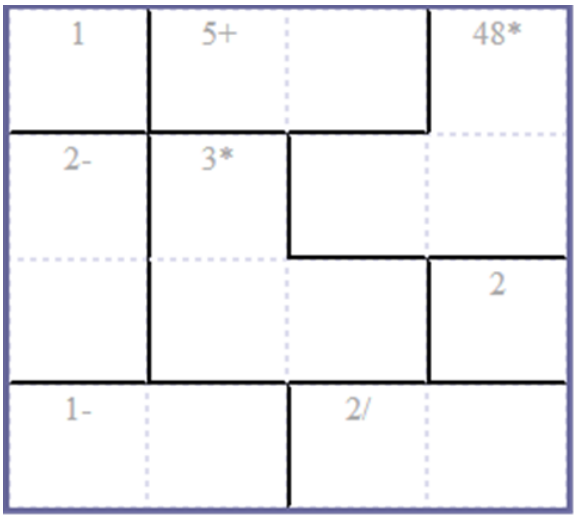


Figure B 1 An example of medium level of 4 x 4 Kendoku

B.1.2 Battleships

Player: 1

Rule: Battleships puzzle is played on a 6 x 6, 8 x 8 or 10 x 10 grid consisting of a hidden fleet of some known ships. How many ships segments are in each row and column and some given ship segments in different places in the grid are given. The aim of the puzzle is to find out where all the segments of ships are located in the grid. (“Battleships”, n.d.)

Battleship puzzles on 6 x 6 and 8 x 8 grids were put in the weekly activities. An example of 8 x 8 Battleship is given in Figure B.2

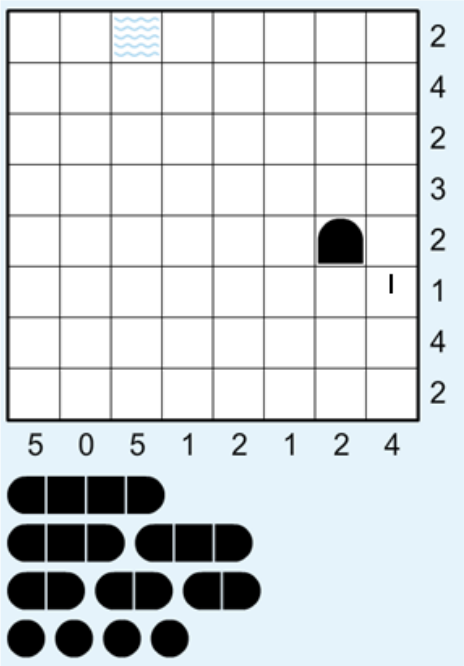


Figure B 2 An example of 8 x 8 Battleship

B.1.3 Tree Tent

Player: 1

Rule: Tree Tent is played on a grid that the numbers on the right and bottom indicates how many tent are in the each row and column. Each tent has to touch a tree adjacent horizontally or vertically and any tent does not touch another tent orthogonally or diagonally adjacent (“Tents”, 2013).

Different difficulty levels of Tree Tent were put in the weekly activities. An example of 6 x 6 Tree Tent is given in Figure B.3

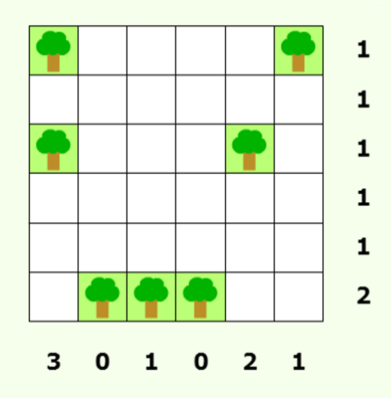


Figure B 3 An example of 6 x 6 Tree Tent

B.1.4 ABC Connection Puzzle

Player: 1

Rule: It requires linking same letters by using vertical and horizontal lines that cannot collide with another. All the squares in the grid have to be used ("4. Akıl Oyunları Yarışması", 2012).

Different difficulty levels of ABC Connection Puzzle were put in the weekly activities. An example of ABC Connection Puzzle is given in Figure B.4.

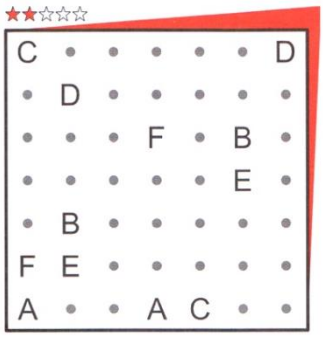


Figure B 4 An example of ABC Connection Puzzle

B.1.5 Shithlerlink

Player: 1

Rule: Slitherlink is played on a rectangular grid of dots and four them in a square format stands for a cell which consist of a number. The number in the cell represents how many lines that must surround the cell. If the cell does not consist of any number, it can be surrounded by any number of lines such as 0,1,2,3 ("What is Shithlerlink?", n.d.).

Different difficulty levels of Slitherlink were put in the weekly activities. An example of easy level of Slitherlink is given in Figure B.5.

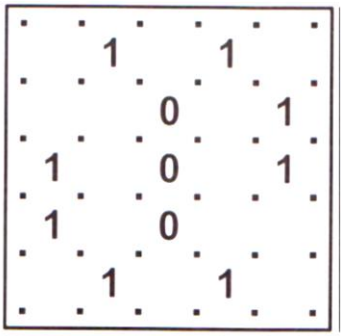


Figure B 5 An example of easy level of Slitherlink

B.1.6 Digital Operations

Player: 1

Rule: Numbers and symbols of mathematical operations on streamers are given to players. The aim of the game is to find a correct mathematical operation by using streamers that can be rotated ("6. Akıl Oyunları Yarışması", 2013).

Five levels of digital operations sets were prepared by the researcher according the level of 6^{th} grade students. An example of streamers of Digital operations is given in Figure B.6.

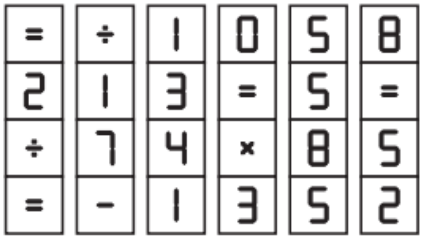


Figure B 6 An example of streamers of Digital operations

Players used these streamers by rotation or not and they found the correct answers given in Figure B.7.

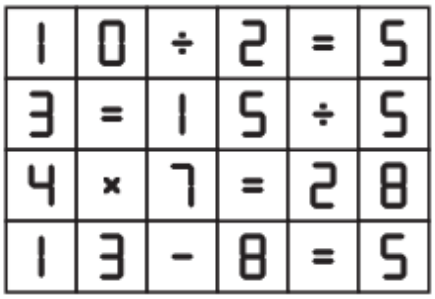


Figure B 7 Correct answers of Digital Operations' streamer

C. Strategy Games

C.1 Strategy Games

C.1.1 Mancala

Player: 2

Materials: 48 pieces, a game board consisting of 12 small pits arranged in two parallel rows with 6 pits in each row and each player has one big treasury to collect their pieces. Materials of Mancala show in Figure C.1.

Rule: The aim of the game is to collect as many pieces as in player's treasury. Each pit has 4 pieces at the beginning of the game. There are 6 small pits in front of each player. A draw determines the first player. The game has 4 main rules:

- The player takes 4 pieces from any pit in his own side. After putting one piece into the pit where he begins to take 4 pieces, he distributes all the pieces in his hand one by one in the counter clock wise direction until all the pieces in his hand are finished. If the final piece comes up his treasury, then *the player gains the right to play again*. If the player has only one piece in his pit, he can move this piece to the pit on its right when it is his turn.
- When the player distributes the pieces taken from his pit, if there are still pieces in the player's hand, he goes on distributing pieces into the pits in the other player's side. If the final piece in the player's hand comes to a pit in the opponent's area and makes the number of pieces in that pit even (such as 2, 4, 6, 8), the player takes all the pieces in that pit and put them into his own treasury.
- While the player is distributing the pieces, if he puts the final piece in empty pit in his own area and if there are pieces in the opposite pit, the player takes the pieces in the opponent's pit and the piece that he left into his own empty pit and put them into his treasury. Then it is the opponent's turn to move his pieces.

- The game set is over when there is no piece left in one of the players' areas. The player who empties all the pits in his own area first also takes the pieces in the pits of the opponent player (“How to Play Mangala Game?”, n.d.).

Figure C 1 Mancala

C1.2 Quoridor

Player: 2 or 4

Materials: 20 fences, 4 pawns and a game board with 81 squares (Figure C.2).

Rule: The aim of the game is to reach one of the nine squares opposite of opponent’s base line. 10 fences are put in their storage areas by each player and the pawn is placed in the centre of each player’s line by each player at the beginning of the game. A draw determines the first player. Players can play either their own pawns or fences. While the pawns are acted one square at a time horizontally, vertically, forwards or backwards, the fences must be put between 2 sets of 2 squares. The aim of using fences is to make easy to reach other side or block the opponent’s of progression (“How to Play Quoridor Game?”, n.d.).

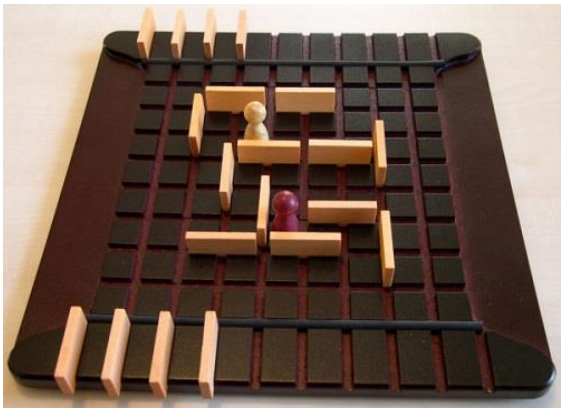


Figure C 2 Quoridor

C.1.3 Turkish Checkers

Player: 2

Materials: 32 checkers, 8 x 8 game board (chess board can be used)

Rule: The object of the games is to block the opponent from making any moves by either capturing all his pieces or by preventing to move other checkers on the board. Each player has 16 checkers in different colors (black-white). The checkers are placed on the board as shown in Figure C.3. Each player puts their all checkers in the second and third rows of the game board. The checkers can move one square horizontally or vertically, but never backwards. When the checker reaches the opponent's first row, this checker that is called "king" can move or jump horizontally and vertically in any distance and captures all the checkers on its way ("Turkish Checkers Game", n.d.).

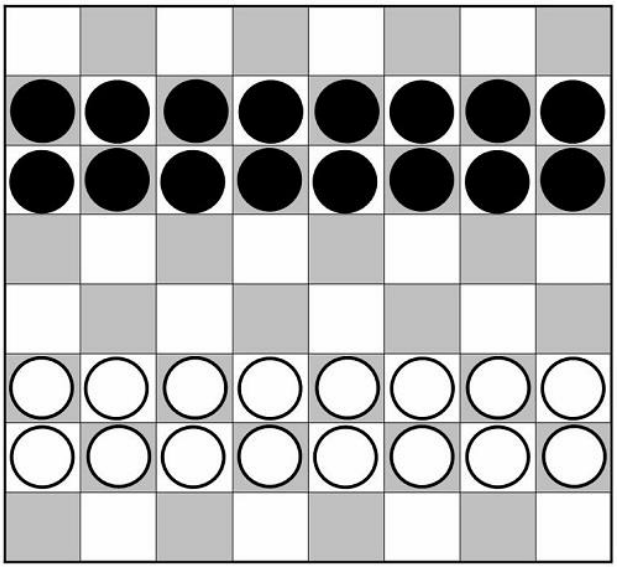


Figure C 3 Turkish Checkers

C.1.4 Quixo

Player: 2 or 4

Materials: 25 cubes and 5 x 5 grid of game board (Figure C 4)

Rule: The aim of the game is to have 5 X or 5 O in a row horizontally, vertically, or diagonally. Each cube has blank, an X and an O faces according to orientation. Players choose X or O face of the cube and all the blank faces of cubes are put at the beginning of the game. In turn, each player takes either a blank cube or one their cubes (X or O) from the *periphery* of the game board. If the player choose blank cube, the player turns the face of cube that becomes the player's face (X or O) and push the cube horizontally and vertically; never put it back where the cube is taken from ("Quixo", n.d.).

Figure C 4 Quixo

C.1.5 Quarto

Player: 2

Materials: 16 different pieces with four different characteristics: light-dark, round-square, tall-short, solid-hollow, a game board with 16 squares. (Figure C 5)

Rule: The aim of the game is to establish a line vertically, horizontally or diagonally with four pieces that has at least one common characteristic such as four tall pieces, four short pieces, four light pieces, four dark pieces, four round pieces, four square pieces, four solid pieces and four hollow pieces. All the pieces are ranged out of the game board at the beginning of the game. The first player chooses one of the 16 pieces and gives it to the opponent and the opponent put the pieces on the game board. Then, the opponent chooses one of rest pieces and gives it to first player and he put it on the board game. The game goes like that until one of the players who put four same characteristic pieces on the board shouts "QUARTO" ("How to Play Quarto Game?", n.d.).

Figure C 5 Quarto

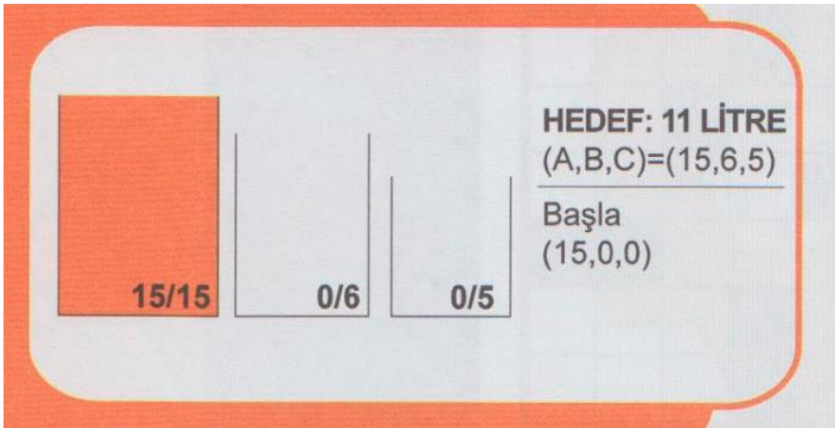
D. Problems

D.1 Problems

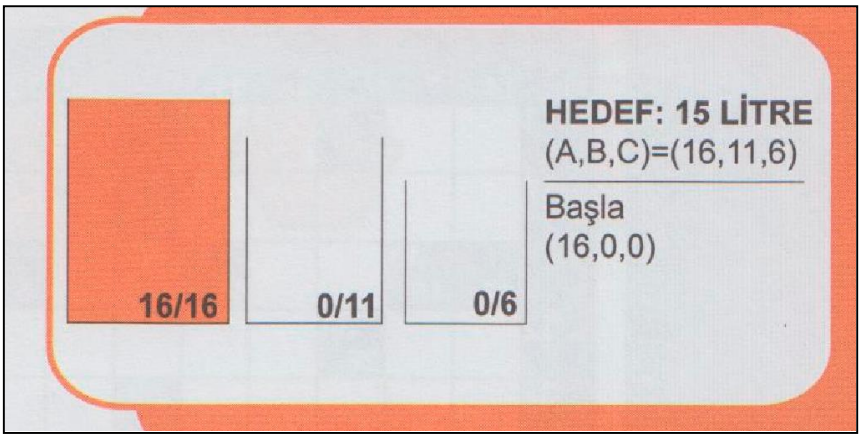
D.1.1 Problem 2: Measuring volume of container by the containers whose volume are different and known

"You have got 3 containers whose volumes are stated below. The first container is full, and the other two containers are empty. How do you get targeted amount of water by using only these containers and performing the number of pouring operations at least?". The mind problem 2 is given in Figure D1 ("Kaplar", 2012).

Problem 1: Volume of 1st container 15L, 2nd container 6L, 3rd container 5L and targeted water 11L



Problem 2: Volume of 1st container 16L, 2nd container 11L, 3rd container 6L and targeted water 15L



Problem 3: Volume of 1st container 17L, 2nd container 9L, 3rd container 4L and targeted water 16L

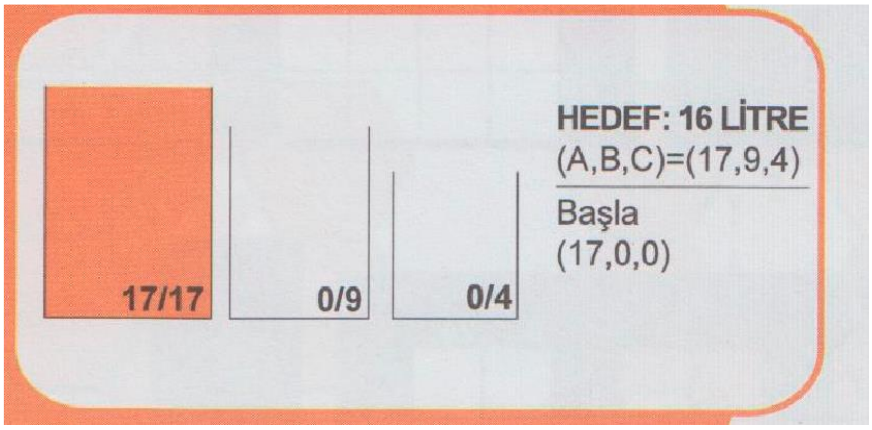


Figure D 1 Problem Situations in Mind Problem 2

D.1.2 Problem 3: Einstein puzzle

There are five houses of different colors next to each other on the same road. In each house lives a man of a different nationality. Every man has his favorite drinks, his favorite sports, and keeps pets of a particular kind.

1. The Englishman lives in the red house and keeps birds.
2. The Swede keeps dogs.
3. The Dane drinks tea.
4. The green house is just to the left of the white one.
5. The owner of the green house drinks coffee.
6. The man who plays football keeps birds.
7. The owner of the yellow house plays baseball
8. The man in the center house drinks milk.
9. The Norwegian lives in the first house and feeds cats.
10. The man who plays volleyball has a neighbor who keeps cats.
11. The man who plays tennis drinks bier.
12. The man who has horse lives next to the the man who plays baseball.
13. The German plays hokey.

14. The Norwegian lives next to the blue house.
15. The man who plays volleyball has a neighbor who drinks water.

The question is who feeds the fish? (“Einstein’s Puzzle”, n.d.).

Students are expected to fill out the table given in Figure D.2

	1st house	**2nd house**	**3rd house**	**4th house**	**5th house**
Nationality					
Color					
Drink					
Sport					
Animal					

Figure D 2 Einstein Puzzle

D.1.3 Problem 4: The color of the hat

Four men are standing in a line as shown below in Figure D.3 and they cannot turn their heads. There is brick wall between A and B that they cannot see through. They know that they each have one hat, and that of four hats two are black and two are white. They cannot see the color of the hat that they wear. In order to be release from the line, they must call out the color of their hat. If they are wrong, no one can leave. They are not allowed to talk to each other, and they have been given ten minutes to figure out their hat colors. After 1 minute: one of them calls out that he figured out his hat color. Which one called out? How can he be 100 % sure of the color of his hat? (“Tuff Stuff Riddles”, n.d.).

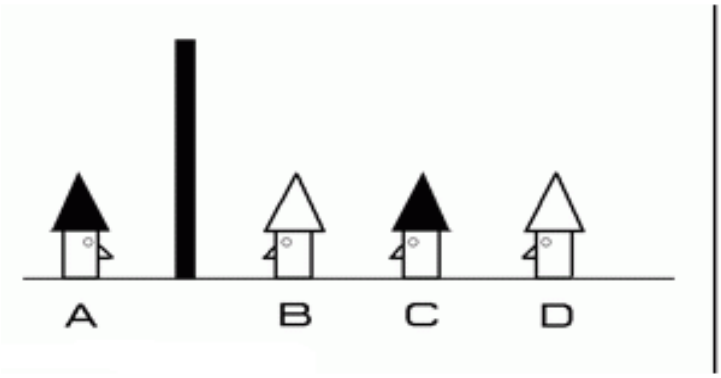


Figure D 3 The color of the hat

D.1.4 Problem 5: Colorful Digits on Clock

Color the digits on the clock in Figure D.4 with three different colors that addition of each colored digits is 17. (Zekâ Oyunları 2, 2014, p. 61)

Figure D 4 Digits on Clock

D.1.5 Problem 6: The liar and the truth teller

There are two guards and two doors. One door goes to heaven, the other door hell. One guard always lies, the other always tells the truth. They know which they are. They know where the two doors go. You do not know which guard is which. You may ask one yes or no question. What do you ask to determine which door goes to heaven? (“Logic Puzzles”, n.d.)

E. Mathematical Problem Solving Test

1) Erdal öğretmen matematik dersinde bir etkinlik yapacaktır. Bunun için elindeki ip parçasını 25 makas darbesiyle eş parçalara ayırır ve parçaları hiç artmayacak şekilde öğrencilerine dağıtır. İp almayan öğrenci kalmadığına göre Erdal öğretmenin bu sınıfta kaç öğrencisi vardır?

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

2) Barış Kırtasiye'de üç çeşit kalem satılmaktadır. Kurşun kalemlerin tanesi 3TL'ye, tükenmez kalemlerin tanesi 5TL'ye ve pilot kalemlerin tanesi 10 TL'ye satılmaktadır. Cebindeki 39TL ile Barış Kırtasiye'ye giden Ceren kalem çeşitlerinin her birinden en az bir tane alarak cebindeki tüm parasıyla kalemler almıştır. Ceren en fazla kaç tane kalem almış olabilir?

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

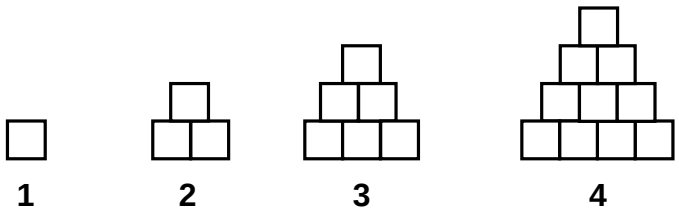
3) Aşağıdaki hikâyeden tüm sayılar çıkartılmıştır. Verilen sayıları boşluklara uygun şekilde yazınız. (Tüm sayıları bir kez kullanmanız gerekmektedir. Sayıların veriliş sırası hikâyedeki sırası ile aynı olmayabilir.)

"Bir kitapçının eline yeni Harry Potter serisinden _____ kitap gelmiştir. Kitapçı, sattığı bu kitapların her birinden _____ TL kâr etmektedir. İlk gün kitapların _____ tanesini, ikinci gün kalan bütün kitapları satmıştır. İkinci gün sattığı kitaplardan _____ TL kâr ettiğine göre, bu kitapçının toplam satıştan elde ettiği kârı bulunuz."

900 300 4,5 100

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

4) Bir mimar aşağıda verilen resimdeki gibi her karenin bir ofisi gösterdiği binaların projesini çizmektedir. Her çizimin altında o binadaki kat sayısı yazmaktadır.



Projeye bakarak aşağıdaki soruları yanıtlayınız.

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

a) Beş katlı binada kaç tane ofis vardır?

b) Yedi katlı binada kaç tane ofis vardır?

5) Okuldan kalan boş vakitlerinizde bir işte çalışmak istiyorsunuz. Bir kitapçı Bilim ve Çocuk (fiyatı 3TL) dergilerini okul çıkışında satmanızı öneriyor ve dergi satışından elde edeceğiniz kazanç ile ilgili 3 farklı seçenek sunuyor:

a) Aylık 230 TL

b) Hafta içi her gün 5 kişiye sattığınızı düşünerek, aylık 200 TL ve her dergi için 1 TL kâr (1ay=4hafta)

c) Hafta içi her gün 5 kişiye sattığınızı düşünerek, aylık 160 TL ve her dergi için 2 TL kâr
(1ay=4hafta)

Size sunulan ödeme seçeneklerinden hangisini seçerdiniz? Nedenini açıklayınız.

6) Ali, Burak ve Emel bir oyun oynamaktadır. Üç ayrı bölümden oluşan bu oyunun sonunda en çok puan toplayan oyunu kazanmaktadır. 1. bölümünde Ali 4 puan ve Burak 6 puan kazanır, Emel hiç puan kazanamaz. İkinci bölümde Emel 3 puan kazanır, Burak 3 puan kaybeder ve Ali hiç puan kazanamaz. Üçüncü bölümde ise Ali 2 puan kaybeder, Burak 5 puan kazanır ve Emel hiç puan kazanamaz. Oyunu kim kazanmıştır?

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

7) 500 öğrenci hafta sonu Eymir Gölü'ne piknik yapmaya gidiyor. Otobüsler 1'den başlayarak numaralandırılıyor, öğrenciler sıraya göre 1. otobüsten başlayarak biniyorlar. Tuncay 249. sırada bekliyor. Bir otobüsün 50 kişilik kapasitesi olduğunu düşünerek aşağıdaki soruları yanıtlayınız.

Her soruda çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

a) Toplam kaç otobüse ihtiyaç vardır?

b) Tuncay kaç numaralı otobüse binmiştir?

c) 70.sıradaki öğrenci kaç numaralı otobüse binmiştir?

8) Bir kutuda bulunan 6 eş görünümlü topun 5 tanesinin ağırlığı birbirine eşit,1 tanesi ise daha ağırdır. Ağır olan topu eşit kollu terazi ile en az kaç kez tartarak ayırabilirsiniz?

Çözüme ulaşmak için kullandığınız stratejinizi ve çözümünüzü açık bir şekilde yazınız.

eşit kollu terazi

F. Rubric for Mathematical Problem Solving Test

1. PROBLEM

0: Yanlış Cevaplar

Örnek: 5 öğrenci vardır. Çünkü 25 sadece 5 eş parçaya bölünür.

1: İşlem Hatası Yapanlar

Örnek: Kurdele çizip 25 makas darbesi çizip parçaları yanlış sayanlar.

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: 25 + 1 = 26 parça

2. PROBLEM

0: Yanlış Cevaplar

1: Sorudaki bazı bilgileri kullanmayanlar veya işlem hatası yapanlar

Örnek: Nasıl "en fazla" kaç kalem alınabileceğini hesaplayamayanlar

2: Uygun Strateji ile Doğru Cevabı Bulanlar:

Örnek: 3TL + 5TL + 10TL = 18TL (3 kalem)

39TL – 18TL = 21 TL (kalan para)

21TL: 3TL = 7 kalem

3 + 7 = 10 kalem

3. PROBLEM

0: Yanlış Cevaplar

Örnek: Hiçbir sayı doğru boşlukta değil.

1: Bazı sayılar doğru boşlukta.

Örnek: Bir kitap satışından 4,5TL kar edilebileceğini düşünme

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: Sırasıyla 300 – 4,5 – 100 – 900

4. PROBLEM

0: Yanlış Cevaplar

1: İşlem Hatası Yapanlar

Örnek: Örüntüyü şekil çizerek ifade ederken şekilleri eksik çizenler

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: a) 15 ofis b) 28 ofis

Örüntüyü fark edip şekil - tablo çizenler ya da sayısal olarak ifade edenler.

5. PROBLEM

0: Yanlış Cevaplar

Örnek: a seçeneğini seçenler (sadece maaşlara bakanlar)

1: Uygun strateji ile Yanlış Cevabı Bulanlar

Örnek: Hafta içi her gün ifadesini her hafta gibi algılayanlar

İşlem hatası yapanlar

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: c seçeneği

Her seçenek için günlük karı ya da aylık kazancı hesaplayanlar

6. PROBLEM

0: Yanlış Cevaplar

Örnek: Ali ya da Emel bulanlar

1: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: Burak

Tablo yaparak verilen bilgileri düzenleyenler

7. PROBLEM

a) Seçeneği

0: Yanlış Cevaplar

1: Uygun strateji ile Yanlış Cevabı Bulanlar

Örnek: İşlem hatası yapanlar

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: 500 : 10 = 10 otobüs

b) <u>Seçeneği</u>

0: Yanlış Cevaplar

1: Uygun strateji ile Yanlış Cevabı Bulanlar

Örnek: Bölme işlemindeki kalan öğrenciler için 1 otobüs eklememe

İşlem hatası yapanlar

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: 5 otobüs

(4 otobüs tam dolu, kalan 49 öğrenci için de 1 otobüs ve toplam 4 + 1 = 5)

c) <u>Seçeneği</u>

0: Yanlış Cevaplar

1: Uygun strateji ile Yanlış Cevabı Bulanlar

Örnek: İşlem hatası yapanlar

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: 2 otobüs

(1 otobüs tam dolu, kalan 20 öğrenci için de 1 otobüs ve toplam 1 + 1 = 2)

8. <u>PROBLEM</u>

0: Yanlış Cevaplar

Örnek: 6 kez tartarım

1: Uygun Strateji ile Yanlış Cevabı Bulanlar

Örnek: 3 kez ya da 5 kez

2: Uygun Strateji ile Doğru Cevabı Bulanlar

Örnek: 2 kez

G. Puzzles and Games Course Evolution Forms (PGCEF)

ZEKÂ OYUNLARI DERSİ DEĞERLENDİRME FORMU

1) Zekâ Oyunları dersinde yaptığınız etkinlikler hakkında neler söylemek istersin?

2) Bu etkinlikler sana göre kolay mı zor mu? Hangi yönlerden kolay ya da zor olduğunu açıklar mısın?

3) Bu etkinliklerin sana faydalı olduğunu düşünüyor musun? Cevabın evetse hangi açılardan sana faydalı olduğunu açıklar mısın?

4) Etkinlikleri yaparken kendine özgü stratejiler geliştirdin mi? Geliştirdiysen ne gibi stratejiler geliştirdin?

5) Zekâ Oyunları dersinde öğrendiğin oyunlar günlük yaşamında değişikliklere sebep oldu mu? Olduysa ne gibi değişiklikler?

6) Zekâ Oyunları dersini aldıktan sonra farklı bakış açıları geliştirdiğini düşünüyor musun? Cevabın evetse örnek vererek açıklar mısın?

7) Bu dersi almaya başladıktan sonra, matematik dersinde problem çözerken eskiye göre daha farklı çözüm yolları kullandığını düşünüyor musun? Cevabın evetse örnek vererek açıklar mısın?

8) Bunların dışında Zekâ Oyunları dersi ile ilgili söylemek istediklerin nelerdir?

H. Interview Protocol

1. BÖLÜM

1) 1. soruda sınıfta kaç öğrenci olduğunu bulmak için nasıl bir strateji düşündün?

2) 2. soruda Ceren'in en fazla kaç kalem almış olabileceğini bulmak için nasıl bir strateji düşündün?

3) 3. sorudaki boşlukları doldurmak için nasıl bir strateji düşündün?

4) 4. soruda binalarda kaç tane ofis olduğunu bulmak için nasıl bir strateji düşündün?

5) 5. soruda hangi seçeneğin daha kazançlı olduğuna nasıl karar verdin?

6) 6. soruda oyunun kimin kazandığını bulmak için nasıl bir strateji düşündün?

7) 7. soruda kaç otobüse ihtiyaç olduğunu ve Tuncay'ın kaç numaralı otobüse binmesi gerektiğini bulmak için nasıl bir strateji düşündün?

8) 8. soruda çözüme ulaşırken zorlandığın noktalar neler oldu? Bu zorlukları aşmak için nasıl bir strateji uyguladın?

2. BÖLÜM

1) Zekâ Oyunları dersinde yaptığınız etkinlikler hakkında neler söylemek istersin?

2) Bu etkinlikler sana göre kolay mı zor mu? Hangi yönlerden kolay ya da zor olduğunu açıklar mısın?

3) Bu etkinliklerin sana faydalı olduğunu düşünüyor musun? Cevabın evetse hangi açılardan sana faydalı olduğunu açıklar mısın?

4) Etkinlikleri yaparken kendine özgü stratejiler geliştirdin mi? Geliştirdiysen ne gibi stratejiler geliştirdin?

5) Zekâ Oyunları dersinde öğrendiğin oyunlar günlük yaşamında değişikliklere sebep oldu mu? Olduysa ne gibi değişiklikler?

6) Zekâ Oyunları dersini aldıktan sonra farklı bakış açıları geliştirdiğini düşünüyor musun? Cevabın evetse örnek vererek açıklar mısın?

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8) Bunların dışında Zekâ Oyunları dersi ile ilgili söylemek istediklerin nelerdir?

I. 1st period of 2014-2015 Academic Year 6th grade Mind Game Course Plan

Week	Activity	Game Type
1st	**1st lesson: Introduction to Mind Games**	introduction
	2nd lesson: Tree Tent	reasoning and operational games
2nd	**1st lesson: Pretest (MPT)**	**Problem Solving and Reasoning Test**
	2nd lesson: Digital Operations	reasoning and operational games
3rd	**1st lesson: Sudoku**	reasoning and operational games
	2nd lesson: Sudoku	reasoning and operational games
4th	**Religious Holiday**	
5th	**1st lesson: Battleships**	reasoning and operational games
	2nd lesson: Battleships	reasoning and operational games
6th	**1st lesson: Slitherlink**	reasoning and operational games
	2nd lesson: Problems	reasoning and operational games
7th	**National Holiday**	
8th	**1st lesson: Sudoku**	reasoning and operational games
	2nd lesson: Mangala	strategy games
9th	**1st lesson: Einstein Puzzle**	problems
	2nd lesson: Quixo	strategy games
10th	**1st lesson: Kendoku**	reasoning and operational games
	2nd lesson:Mangala	strategy games
11th	**1st lesson: Turkish Checkers**	strategy games

	2nd lesson: Turkish Checkers	strategy games
12th	**1st lesson: Problems**	problems
	2nd lesson: Quarto	strategy games
13th	**1st lesson: Kendoku**	reasoning and operational games
	2nd lesson: Quoridor	strategy games
14th	**1st lesson: Master Mind**	strategy games
	2nd lesson: Problems	problems
15th	**1st lesson: ABC Connection Puzzle**	reasoning and operational games
	2nd lesson: Mangala	strategy games
16th	**1st lesson: ABC Connection Puzzle**	reasoning and operational games
	2nd lesson: Master Mind	strategy games
17th	**1st lesson: Problems**	problems
	2nd lesson: Quarto	strategy games
18th	**1st lesson: Posttest (MPT)**	**Problem Solving and Reasoning Test**
	2nd lesson: Memory Cards Game	memory games
19th	**1st lesson: Magic Pyramids**	reasoning and operational games
	2nd lesson: Tangram	geometric-mechanic games

J. Permission Obtained From METU Applied Ethics Research Center

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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Gönderen : Prof. Dr. Canan Özgen
IAK Başkanı

İlgi : Etik Onayı

Danışmanlığını yapmış olduğunuz İlköğretim Fen ve Matematik Eğitimi Bölümü öğrencisi Mukaddes Seçil Kurbal'ın "Zekâ Oyunları Dersinin 6.Sınıf Öğrencilerinin Akıl Yürütme ve Problem Çözme Becerilerine Olan Etkisinin İncelenmesi" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

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L. Turkish Summary

6. SINIF ZEKÂ OYUNLARI DERSİ ÖĞRENCİLERİNİN PROBLEM ÇÖZME STRATEJİLERİNİN VE AKIL YÜRÜTME BECERİLERİNİN İNCELENMESİ

GİRİŞ

Son zamanlarda günlük hayatımızda matematiği kullanma ve anlama ihtiyacı önem kazanmıştır (Milli Eğitim Bakanlığı, (MEB), 2009). Değişen dünyada matematiği anlayan ve kullanabilen bireylerin gelecekleri için önemli fırsatlar geliştirebilecekleri öngörülmektedir (National Council of Teachers of Mathematics, (NCTM), 2000). Matematik öğretiminin amaçlarından biri de öğrencilerin problem çözme ve akıl yürütme becerilerini geliştirmektir (NCTM, 2000). NCTM standartlarına göre öğrencilerden farklı problem çözme stratejilerini bilmesi ve uygulaması ve çözüm stratejilerinin altında yatan akıl yürütme biçimlerini açıklayabilmesi beklenmektedir (NCTM, 2000).

Literatürde *problem* kavramı farklı şekillerde tanımlanmıştır. *Problem*, problem çözenin ilgisini çeken, aklını zorlayan ve problemin sonucunu bulmaya yönlendiren bir durum olarak belirtilmiştir (Orton & Wain, 1994). Ayrıca, Krulik ve Rudnick (1985) *problem* kavramını başlangıçta sonucu bilinmeyen bir durum olarak tanımlamıştır. Tanımlardan anlaşıldığı üzere, bir durumun problem olabilmesi için problem çözen kişinin problemin çözümünü önceden bilmemesi ve bu durumun problem çözen kişide bir zorluk yaratması gerekmektedir.

Matematiksel problemler rutin ve rutin olmayan problemler olmak üzere iki grupta toplanmıştır (Arslan & Altun, 2007). Rutin problemler sadece bilinen formülleri ve methodları uygulamayı gerektirirken (Bayazit, 2013) rutin olmayan problemler farklı problem çözme stratejileri kullanmayı gerektiren ve problem çözen kişiyi farklı yöntemler kullanmaya zorlayan problemler olarak ifade edilmiştir (Inoune, 2005). Rutin olmayan problemlerin bir örneği de gerçek hayat

problemleridir (Verschaffel, De Corte & Vierstraete, 1999). Gerçek hayat problemi çözen öğrencilerin, üst seviyede anlama ve kavrama becerilerini kullanırken problemde verilen bilgileri uygun problem çözme stratejileri kullanarak modellemeleri ve sonucu bulduktan sonra yorumlamaları gerekmektedir (Chacko, 2004). Ayrıca öğrencilerin gerçek hayat problemi çözmeleri, onların gerçek hayat durumlarını matematik kullanarak çözmelerini sağlar (Brown, 2001; NCTM, 1991).

Bunun yanı sıra, öğrencilerin matematik derslerinde karşılaştıkları problemlerin çoğu sözel problemlerdir (Aladağ & Artut, 2012). Sözel problemler, herhangi bir matematiksel alıştırmanın matematiksel bir ifade yerine bir metin içerisinde ifade edildiği problemlerdir (Verschaffer, Greer & De Corte, 2000). Sözel problem çözmenin öğrencilerin iletişim, sorgulama, gerekçelendirme ve akıl yürütme becerilerini geliştirdiği ifade edilmiştir (MEB, 2013 & NCTM, 2000).

Akıl yürütme sonuçların doğruluğu ile ilgili kanıtların, inanışların ve düşüncelerin organize edilme süreci olarak tanımlanmıştır (Leighton, 2003). Bu yüzden, matematiği anlamanın akıl yürütme olmadan eksik kalacağı ifade edilmiştir (Ball & Bass, 2013). Bu sebeple, matematik eğitimcilerinin öğrencilerin matematikte bilgi ve kavrama seviyelerinin üst seviyelere çıkabilmesi için akıl yürütme ve gerekçelendirme becerilerini desteklemesi gerekmektedir (Yackel & Hanna, 2003). Başka bir bakış açısıyla, akıl yürütme becerisinin gelişmesinin matematiği anlamlı öğrenmede önemli bir payı olduğu söylenebilir.

Yapılan literatür taramasında problem çözme ve akıl yürütme becerisinin bazı açılardan bağlantılı olduğu ortaya çıkmıştır. Chang (2002) öğrencilerin problem çözme ve akıl yürütme becerileri arasında önemli bir ilişki olduğunu iddia etmiştir. Chang (2010) yaptığı çalışmada hem özel alan bilgisinin hem de akıl yürütme becerisinin öğrencilerin problem çözme becerisinde önemli bir rolü olduğunu ortaya çıkarmıştır. Bu sebeple, Cheves and Parks (1984), öğretmenlerin problem çözme sürecinde problem çözümün mantığının ve altında yatan akıl yürütme stratejilerinin altını çizmesi gerektiğini belirtmişlerdir.

Öğrencilerin akıl yürütme becerilerini nasıl geliştireceği ile ilgili yapılan bir çalışmada, akıl yürütme becerisinin erken yaşlarda öğretilebileceği ve bu becerinin

yaş ilerledikçe gelişebileceği iddia edilmiştir (Lester, 1975). Ancak, bazı araştırmacılar akıl yürütme becerisinin erken yaşlarda oyun oynarak geliştirilebileceğini ifade etmişlerdir (Kiili, 2007; McFarlane, Sparrowhawk & Heald, 2002).

Son zamanlarda, sınıfta oyun kullanımı birçok araştırmacı, eğitimci ve öğretmenin ilgisini çekmektedir. Literaturde birçok oyun çeşidi olduğu görülmüştür. Örneğin "aksiyon", "macera", "savaş", "rol yapma", "simulasyon" ve "zekâ oyunları" ortaya çıkan oyunlardan bazılarıdır (Kirriemuir & McFarlane, 2004, s.7). Zekâ oyunları "düşünme ve akıl yürütme gücü gerektiren ve herhangi bir ders kazanımından bağımsız olan oyunlar" olarak tanımlanmıştır (Bottino, Ott, & Tavella, 2013, s.62). Ayrıca, zekâ oyunları oynamanın öğrencilerin akıl yürütme ve mantıksal düşünme becerilerini geliştirdiği düşünülmektedir (Kiili, 2007; McFarlane, Sparrowhawk & Heald, 2002; Rohde & Thompson, 2007).

Zekâ Oyunları dersi Milli Eğitim Bakanlığı tarafından 2012-2013 eğitim öğretim yılında seçmeli ders olarak ortaokullarda okutulmaya başlamıştır. Dersin müfredatı altı üniteden oluşmaktadır: Akıl yürütme ve işlem oyunları, hafıza oyunları, geometrik mekanik oyunlar, kelime oyunları, strateji oyunları ve zekâ soruları. Zekâ oyunları dersi kapsamında öğrencilerin farklı problem çözme becerileri kazanmaları, farklı bakış açıları geliştirmeleri ve akıl yürütme ve mantıksal düşünme becerilerini güçlendirmeleri beklenmektedir. Derste oynatılan oyunlar ve dersin kazanımları göz önüne alındığında Zekâ Oyunları dersinin öğrencilere sağlayacağı katkılar bakımından çok fazla incelenmediği ortaya çıkmıştır.

Araştırma Soruları

Bu çalışmanın amacı 6. sınıf Zekâ Oyunları dersi alan öğrencilerin problem çözme ve akıl yürütme becerilerinin incelenmesidir. Bu amaç doğrultusunda, öğrencilerin Zekâ Oyunları dersinin etkililiği hakkındaki görüşleri de incelenecektir. Bu kapsamda aşağıdaki araştırma soruları ceveplanacaktır:

1. Zekâ Oyunları dersi 6. sınıf öğrencilerinin problem çözme ve akıl yürütme becerilerini ne derecede etkilemektedir?

1.1 Zekâ Oyunları dersinin öncesinde ve sonrasında öğrencilerin Matematiksel Problem Çözme Testi'nden elde ettikleri puanlar arasında istatistiksel olarak anlamlı bir fark var mıdır?

1.2 Öğrenciler Zekâ Oyunları dersinin sonunda hangi problem çözme stratejilerini ve altında yatan akıl yürütme becerini geliştirmişlerdir?

2. Öğrencilerin Zekâ Oyunları dersinin etkililiği hakkındaki görüşleri nelerdir?

LİTERATÜR TARAMASI

Problem çözme matematik öğretiminin her aşamasında önemli bir role sahiptir (Posamentier, Smith & Stepelman, 2006). Schoenfeld (2007), problem çözme sürecini farklı problem çözme stratejileriyle çözülebilen problemlerle uğraşmak olarak tanımlamıştır. Buna ek olarak, öğrencilerin matematiksel problemleri çözerken uygun problem çözme stratejilerini seçebilmelerinin önemli olduğu vurgulanmıştır (NCTM, 2000). Bu açıdan bazı araştırmacılar bazı özel alıştırmaların öğrencilerin problem çözme stratejilerine ve performanslarına olan etkisini incelemiştir (Altun, 1995; Erdoğan, 2015; Lester, Garofalo & Kroll, 1989). Bunun yanı sıra, gerçek hayat problemlerinin ve rutin ve rutin olmayan problemlerin bazı özelliklerinin problem çözme stratejilerine olan etkisi de çalışılmıştır (Bayazit, 2013; Erdoğan, 2015; Nunokawa, 2004; Yazgan & Bintaş, 2005).

Akıl yürütme matematik öğretiminin önemli amaçlarından biridir (Yankelewitz, 2009). Yapılan literatür çalışmasında, akıl yürütme becerisinin bazı çeşitleri olduğu ortaya çıkmıştır. Bu çalışmada da ortaya çıkan akıl yürütme çeşitleri *uyarlanır akıl yürütme, cebirsel akıl yürütme* ve *temsili akıl yürütme*dir. *Uyarlanır akıl yürütme*, "kavramlar ve durumlar arasındaki ilişki ile ilgili mantıksal düşünebilme ve bu ilişkiyi matematiksel olarak gerekçelendirme ve kanıtlama kapasitesi" olarak tanımlanmıştır (National Research Council, (NRC), 2001, s.170). *Cebirsel akıl yürütme* ise cebirsel düşünebilme ya da anlamlı sembol sistemleri

kullararak sayılar ve işlemler ile ilgili deneyimleri genelleme yetisi olarak ifade edilmiştir (Van de Walle, Karp & Bay-Williams, 2011). Ayrıca, *temsili akıl yürütme* ise diagram, grafik, harita ya da tablo kullanarak matematiksel özellikleri ve ilişkileri görsel olarak ifade edebilme yeteneği olarak tanımlanmıştır (Long, DeTemple & Millman, 2009).

Literatür taramasında, bazı araştırmacıların akıl yürütme çeşitlerinin bazı matematiksel becerilere olan etkilerini inceledikleri ortaya çıkmıştır (Erdem, 2015; Francisco & Maher, 2005; Maher, 2002; Maher & Martino, 1996; Markovits & Brunet, 2012). Ayrıca araştırmacılar akıl yürütme ve problem çözme becerilerinin arasındaki güçlü ilişkiyi ortaya çıkaran çalışmalar da yapmışlardır (Chang, 2010 & Küpçü, 2008).

Literatürde zekâ oyunlarının problem çözme ve akıl yürütme becerilerine olan etkisi ile ilgili yeteri kadar çalışma olmadığı gözlemlenmiştir. Ancak bazı özel zekâ oyunlarının problem çözme ve akıl yürütme becerilerine olan etkisi incelenmiştir (Applebaum & Freiman, 2014; Best, 1990; Larsen & Garn, 1988; Laughlin, Lange & Adamopoulus, 1982; Shriki, 2009). Son olarak, Devecioğlu ve Karadağ (2014), Zekâ Oyunları dersi ile ilgili öğrenci, öğretmen ve idareci görüşlerini ortaya çıkaran bir çalışma yapmıştır. Çalışmanın sonunda Zekâ Oyunları dersi alan öğrencilerin problemi belirleme, farklı bakış açışları geliştirme ve farklı çözüm yolları bulma gibi yeterlilikler edindiği anlaşılmıştır. Ayrıca öğrencilerin bu ders sayesinde analiz, sentez, neden-sonuç ilişkisi gibi farklı beceriler edinirken aynı zamanda sosyal ilişkilerinde de gelişim gösterdikleri sonucuna varılmıştır. Bu açıdan öğrenci ve öğretmenler Zekâ Oyunları dersinin öğrencilere farklı beceriler kazandırarak, verilen bilgiyi kullanma, pratik düşünmeyi sağlama gibi özellikler kazandırdığı ifade edilmiştir.

YÖNTEM

Bu çalışmada nitel ve nicel araştırma yöntemleri kullanılmıştır. Çalışmanın yapıldığı okulun kuralları gereği çalışmada kontrol grubu oluşturalamamıştır.

Katılımcılar ve Bağlam

Çalışmanın örneklemi kolayda örneklem yöntemiyle belirlenmiştir. Çalışmaya Ankara'nın Gölbaşı ilçesinde özel bir ortaokulda okuyan 40 6. sınıf Zekâ Oyunları dersi öğrencileri katılmıştır. Bu öğrenciler iki Zekâ Oyunları sınıfında toplanmıştır. Öğrenciler Zekâ Oyunları dersini gönüllü olarak dönemin başında seçmişlerdir. Araştırmacı bu sınıflardan birinin öğretmeni olarak çalışmada yer almıştır. Çalışmanın gerçekleştiği okul Ankara'nın Gölbaşı ilçesinde bulunan özel bir ortaokuldur.

Zekâ Oyunları dersi 2012-2013 eğitim öğretim yılından itibaren seçmeli ders olarak ortaokul müfredatına eklenmiştir. Dersin içeriği, basamaklı öğretim kuramı temel alınarak hazırlanmıştır. Derste hazırlanan etkinliklerin kolaydan zora oyunlar içermesini gerektiren bu kuram sayesinde sınıfta bulunan her seviyedeki öğrencinin derse katılımı hedeflenmiştir (MEB, 2013). Zekâ Oyunları dersinin müfredatı altı üniteden oluşmaktadır; akıl yürütme ve işlem oyunları, sözel oyunlar, hafıza oyunları, geometrik-mekanik oyunlar, strateji oyunları ve zekâ soruları. Çalışmanın yapıldığı 2014-2015 eğitim öğretim yılının 1. döneminde akıl yürütme ve işlem oyunları ve strateji oyunları oynatılmış ve bu oyunların yanı sıra zekâ soruları çözülmüştür. İkinci dönemde ise kalan üniteleri içeren oyunlar oynatılmış ve 1. dönemde oynatılan oyunlar tekrar edilmiştir.

Veri Toplama Araçları

Çalışmada üç tane veri toplama aracı vardır. Literatürden uyarlanan sekiz tane açık uçlu gerçek yaşam problemi içeren Matematiksel Problem Çözme Testi (MPT) hazırlanmıştır. Öğrencilerin Zekâ Oyunları dersinin etkililiği hakkındaki görüşlerini almak için sekiz tane açık uçlu soru içeren Zekâ Oyunları Dersi Değerlendirme Formları oluşturulmuştur. Ayrıca iki bölümden oluşan görüşme soruları hazırlanmıştır. Görüşmenin ilk bölümününde öğrencilerin seçtikleri problem çözme stratejileri ve altında yatan akıl yürütme becerileri ile ilgili derinlemesine bilgi edinmeyi sağlayacak sorular bulunmaktadır. Bunun yanı sıra görüşmenin ikinci bölümündeki sorular ise değerlendirme formunda bulunan sekiz

soru ile aynıdır. Bunun amacı, öğrencilerin ders hakkındaki görüşleri ile ilgili daha detaylı veri elde etmektir.

Verilerin Toplama Süreci

2013-2014 eğitim öğretim yılının 2. döneminde Matematiksel Problem Çözme Testi'nin pilot uygulaması 61 6. sınıf Zekâ Oyunları dersi öğrencileriyle yapılmıştır. Yapılan pilot çalışmaya göre MPT için bütünsel puanlama rubriği oluşturulmuştur. Çalışmanın verileri 2014-2015 eğitim öğretim yılının 1. döneminde toplanmıştır. Öntest ve sontest olarak kullanılan MPT dönemin başında ve sonunda uygulanmıştır. Sontest uygulamasından sonra Zekâ Oyunları Dersi Değerlendirme Formları öğrencilere uygulanmış ve ilgili öğrencilerle görüşmeler yapılmıştır.

Araştırmacı MPT öntest ve sontest sonuçlarını karşılaştırmış ve önteste göre sontestte gelişim gösteren yedi öğrenci ile görüşmeler yapmıştır. Görüşmelerin amacı öğrencilerin seçtikleri problem çözme stratejileri ve altında yatan akıl yürütme becerileri ile ilgili derinlemesine bilgi edinmektir. Bunun yanı sıra görüşmelerin sonunda öğrencilere değerlendirme formlarında bulunan sekiz soru tekrar yöneltilmiştir.

Veri Analizi

Dönemin başında ve sonunda öntest ve sontest olarak uygulanan MPT, oluşturulan bütünsel puanlama rubriğine göre değerlendirilmiştir. Öntest ve sontest sonuçlarını karşılaştırmak için SSPS 20 programı yardımıyla eşleştirilmiş t-test yapılmıştır. Öğrencilerin problem çözme stratejileri ve altında yatan akıl yürütme becerilerinin ortaya çıkarılması için öğrencilerin çözümleri ve görüşme transkripleri derinlemesine incelenmiştir. Ayrıca, öğrencilerin ders hakkındaki görüşlerinin ortaya çıkması için yapılan görüşmeler ve değerlendirme formları dikkatle incelenmiş ve elde edilen veriler kategorilere ayrılmıştır.

Varsayımlar ve Sınırlılıklar

Araştırmanın ilk varsayımı öğrencilerin problem çözme stratejilerindeki ve altında yatan akıl yürütme becerilerindeki gelişimlerin Matematik Problem Çözme testi aracılığıyla ölçülebiliceğidir. Ayrıca öğrencilerln testi cevaplarken ve yapılan bireysel görüşmelerde içten, dürüst, açık yürekli ve işbirlikçi oldukları varsayılmıştır.

Çalışmanın katılımcıları kolayda örneklem yönetimiyle seçilmesi sonuçların daha geniş bir popülasyona genellenmesini sınırlandırmaktadır. Ayrıca görüşmeler için seçilen öğrencilerin amaca yönelik seçilmesinden dolayı görüşmelerden elde edilen veriler bu katılımcılarla sınırlı olabilir. Buna ek olarak çalışmada kontrol grubunun olmaması çalışmanın sonuçlarının genellenmesini sınırlamaktadır.

BULGULAR

Öntest ve Sontest Sonuçlarının Analizi

Öğrencilerin öntest ve sontest puanlarıyla ilgili betimleyici istatistikler Tablo 1'de verilmiştir. Tablo 1'de görüldüğü üzere öğrencilerin öntestteki ortalaması *M=11,60* iken sontestteki ortalaması *M=15,65*'tir. Öğrencilerin sontestteki ortalamalarının öğrencilerin öntestteki ortalamalarına göre daha yüksek olduğu görülmektedir. Bu sonucun sebebi olarak 6. sınıf Zekâ Oyunları dersi öğrencilerinin bir dönem boyunca akıl yürütme ve işlem oyunlarını ve strateji oyunlarını oynamalarının ve zekâ sorularını çözmelerinin etkili olduğu söylenebilir.

Tablo 1 Öntest ve Sontest ile ilgili Betimleyici İstatistikler

	S	Ortalama	Std. Sapma	Std. Ort. Hatası
Öntest	40	11,60	2,649	,419
Sontest	40	15,65	2,304	,364

Not: S= Katılımcı sayısı

Öğrencilerin öntest ve sontestteki çözümleri incelenmiş ve öğrencilerin çözümlerinde bazı problem çözme stratejileri ortaya çıkmıştır: "*Tahmin ve kontrol", "mantıksal çıkarım", "problemi basitleştirme", "şekil çizme","sistematik liste yapma"*, ve *"bağıntı arama"*. Ancak öğrencilerin öntest ve sonttesteki çözümleri karşılaştırıldığında, öğrencilerin önteste kıyasla *tahmin ve kontrol, mantıksal çıkarım* ve *şekil çizme* stratejilerinde gelişme gösterdikleri görülmüştür.

Aynı şekilde, öğrencilerin öntest ve sontestteki çözümleri incelenmiş ve öğrencilerin seçtikleri problem çözme stratejilerinin altında yatan bazı akıl yürütme becerileri ortaya çıkmıştır: *Uyarlanır akıl yürütme, cebirsel akıl yürütme* ve *temsili akıl yürütme***.** Ancak öğrencilerin öntest ve sontestteki çözümleri karşılaştırıldğında öğrencilerin önteste kıyasla *uyarlanır akıl yürütme* ve *temsili akıl yürütme* becerilerinde gelişme gösterdikleri anlaşılmıştır.

Zekâ Oyunları Dersi Değerlendirme Formlarının ve Görüşmelerinin Analizi

Öğrencilerin doldurdukları değerlendirme formları ve öğrencilerle yapılan görüşmeler ayrıntılı olarak incelenmiş ve elde edilen veriler iki ana kategori altında toplanmıştır: öğrencilerin zekâ oyunları dersi hakkındaki görüşleri ve öğrencilerin zekâ oyunları dersinin katkıları hakkındaki görüşleri.

Öğrencilerin Zekâ Oyunları Dersi Hakkındaki Görüşleri

- **Zekâ Oyunları Dersi ile ilgili Genel Görüşleri**

Öğrencilerin çoğunluğu dersle ilgili olumlu görüşlerini belirtmişlerdir. Derste genel olarak eğlenceli oyunlar ve zekâ soruları çözdüklerini dile getirmişlerdir. Ancak bazı öğrenciler akıl yürütme ve işlem oyunlarının ve zekâ sorularının sıkıcı, strateji oyunlarının eğlenceli olduğunu belirtmişlerdir.

- **Aktivitelerin Zorluk Seviyeleri ile ilgili Görüşleri**

Öğrenciler akıl yürütme ve işlem oyunlarının ve zekâ sorularının zor olduğunu düşünürken strateji oyunlarının kolay olduğu ile ilgili görüşlerini dile

getirmişlerdir. Bunun yanı sıra bazı öğrenciler zorluk seviyesinin öğrencinin kendi seviyesine bağlı olduğunu gözlemlemişlerdir.

- **Aktivitelerin Yararlı Yönleri ile ilgili Görüşleri**

Çoğu öğrenci Zekâ Oyunları dersinin yararlı olduğunu düşünmektedir. Örneğin, ders süresince yeni stratejiler ve farklı bakış açıları geliştirdiklerini, zamanı iyi kullanmayı, ipucu yakalamayı ve empati kurmayı öğrendiklerini belirtmişlerdir.

Öğrencilerin Zekâ Oyunları Dersinin Katkıları ile ilgili Görüşleri

- **Öğrencilerin Kendine Özgü Stratejiler Geliştirmesine Katkısı**

Öğrenciler çoğunlukla Sudoku, Mastermind, Mancala, Quarto ve Quixo gibi oyunları oynarken kendilerine özgü stratejiler geliştirdiklerini ve bunun yanı sıra bu oyunları oynarken arkadaşlarının ya da rakiplerinin stratejilerini de öğrendiklerini belirtmişlerdir.

- **Öğrencilerin Günlük Yaşamlarına Katkısı**

Öğrenciler öğrendikleri oyunlarından bazılarını satın aldıklarını ve boş zamanlarında bu oyunları oynayarak aileleriyle verimli zaman geçirdiklerini ifade etmişlerdir. Ayrıca, bazı öğrenciler üç ayda bir yayınlanan Zekâ Oyunları dergisine abone olduklarını dile getirmişlerdir.

- **Öğrencilerin Farklı Bakış Açıları Geliştirmesine Katkısı**

Derste çözülen zekâ sorularının öğrencilerin farklı bakış açıları geliştirmesine katkısı olduğu anlaşılmıştır. Bunun yanı sıra rakiple oynanan strateji oyunlarını oynarken, öğrencilerin rakiplerin stratejilerini keşfettikleri ortaya çıkmıştır. Son olarak her dersin sonunda yapılan fikir paylaşımı seanslarının öğrencilerin farklı bakışları geliştirmelerini sağladığı görülmüştür.

- **Öğrencilerin Matematik Dersinde Problem Çözme Becerilerine Katkısı**

Öğrencilerin çoğu Zekâ Oyunları dersinin matematik dersindeki problem çözme becerilerine katkısı olmadığını belirtmişlerdir. Ancak bazı öğrenciler kendoku oynayarak daha iyi dört işlem yapabildiklerini, Sudoku oynarak olası ve olası olmayan cevapları daha iyi belirleyebildiklerini ve zekâ sorularını çözerek şekil çizme ve verileri organize becerilerini geliştirdiklerini söylemişlerdir.

TARTIŞMA

Öğrencilerin öntestteki ortalamalarına göre posttestteki ortalamalarının daha yüksek olmasının birçok sebebi olabilir. Öncellikle bu sonuç, öğrencilerin Zekâ Oyunları dersinde oynadıkları akıl yürütme ve işlem oyunlarının ve strateji oyunlarının ve çözdükleri zekâ sorularının öğrencilerin problem çözme ve akıl yürütme becerilerine olumlu bir katkısı olduğunu göstermektedir.

Strateji oyunları matematik dersinde çözülen problemlere benzemektedir (Corbalán, 1998). Şöyleki Polya'nın problem çözme basamakları strateji oyunlarını oynama basamaklarıyla benzerlikler göstermektedir. Ayrıca, başarı öğrenciler "farklı kavramları uygun içerikler" içerisinde fırsata dönüştürebilirler (Tyson, Venville, Harrison & Treagust, 1997, s.402). Bu yüzden Zekâ Oyunları dersinde strateji oyunları oynayan öğrenciler geliştirdikleri problem çözme becerilerini karşılaştıkları problemleri çözerken kullanmış olabilirler.

Ayrıca, strateji oyunları rekabet ortamı yarattığı için öğrencilerin matematiksel düşünme ve akıl yürütme becerilerini geliştirmelerine yardımcı olabilir (Shriki, 2009). Bu yüzden, strateji oyunları oynayan öğrenciler, rakiplerinin stratejilerinin üstesinden gelebilmek için kendilerini zorlarlar ve bu durum onlarda problematik bir durum yaratır. Bu durumun üstesinden gelmek isteyen öğrenciler problem çözme stratejileri ve akıl yürütme becerilerini geliştirerek oyunu kazanmaya çalışırlar.

Bunun yanı sıra, öğrencilerdeki bu değişimin sebebi matematik dersinde çözdükleri problemler sayesinde olabilir (Öztuncay, 2005). Benzer bir bakış açısıyla, öğrencilerin tecrübeleri ve matematikle geçirdikleri süre arttıkça geçen

süreç içinde oynadıkları oyunlar ve çözdükleri zekâ sorularının da yardımıyla öğrenciler problem çözme ve akıl yürütme becerilerini geliştirmiş olabilirler.

Ayrıca öğrenciler çoğunlukla *tahmin ve kontrol, mantıksal çıkarım* ve *şekil çizme* stratejilerinde ve *uyarlanır akıl yürütme* ve *temsili akıl yürütme* becerilerinde gelişim göstermişlerdir. Öğrencilerin özellikle bu problem çözme stratejilerinde ve akıl yürütme becerinde gelişim göstermelerinde Zekâ Oyunları dersinde oynadıkları akıl yürütme ve işlem oyunlarının ve strateji oyunlarının ve çözdükleri zekâ sorunlarının etkisi olabilir. Çünkü akıl yürütme ve işlem oyunları, Sudoku, Kendoku, Çadır, Amiral Battı, ABC Bağlama, ipuçlarını yorumlayarak mantıksal çıkarımlar yapıp sonuca ulaşmayı gerektiren oyunlardır. Benzer şekilde, strateji oyunları, Mastermind, Mangala, Koridor, Turk Daması, Quixo, Quarto, rakibin stratejisini tahmin etmeyi gerektiren ve mantıksal çıkarımların yanı sıra strateji geliştirmeyi gerektiren oyunlardır. Hem akıl yürütme ve işlem oyunlarının hem de strateji oyunlarının özelliklerine bakıldığında oyunların karakterlerinin öğrencilerin problem çözme ve akıl yürütme becerilerine katkıda bulunabileceği iddia edilebilir.

Bunların yanı sıra, öğrenciler zekâ soruları çözdükleri derslerde öğretmenler tarafından farklı bakış açıları geliştirmeleri konusunda yönlendirilmişlerdir. Ayrıca, bütün zekâ soruları şekil çizme ya da verileri düzenleme stratejileriyle tahtada öğrencilerin katılımlarıyla çözülmüştür. Bu açıdan da zekâ soruları çözmenin öğrencilerin problem çözme ve akıl yürütme becerilerine etkisi olduğu söylenebilir.

Son olarak, öğrencilerin çoğunun Zekâ Oyunları dersi ile ilgili olumlu görüşlere sahip oldukları gözlemlenmiştir. Bu dersin seçmeli bir ders olması ve dersin çoğunlukla oyun oynama temelli olması öğrencilerin bu şekilde düşünmesine sebep olmuş olabilir. Ayrıca, öğrenciler genellikle akıl yürütme ve işlem oyunlarının ve zekâ sorularının sıkıcı ve zor olduğunu belirtirken strateji oyunlarının kolay ve eğlenceli olduğunu vurgulamışlardır. Bunun sebebi ise akıl yürütme ve işlem oyunlarının tek kişilik oyunlar olması ve zekâ sorularının ilk bakışta çözülememesi olabilir. Strateji oyunları ise rakipli oyunlardır ve bu yaş seviyesindeki çocuklar çoğunlukla rekabet ortamlarında bulunmaktan keyif almaktadırlar.

Gelecek Çalışmalar için Öneriler

Bu çalışmada kontrol grubu kullanılmamıştır. Bu yüzden bu çalışmanın daha genellenebilir sonuçlarının ortaya çıkması açısından sonraki çalışmalarda kontrol grubu kullanılabilir. Ayrıca, bu çalışmada araştırmacı aynı zamanda dersin öğretmendir. Bu durum çalışmanın sonuçları ile ilgili bazı kısıtlamalar getirmektedir. Bu sebeple sonraki çalışmalarda araştırmacı ve dersin öğretmenin farklı kişiler olması sağlanabilir. Bunlara ek olarak, bu çalışma 6.sınıf Zekâ Oyunları dersi alan özel okul öğrencileriyle yapılmıştır. Çalışmanın daha genellenebilir olması açısından sonraki çalışmalar devlet okullarında okuyan farklı sınıf seviyelerindeki 5.sınıf, 7.sınıf ve 8.sınıf öğrencileriyle yapılabilir.

Zekâ Oyunları dersinin öğrencilerin problem çözme ve akıl yürütme becerilerine olan katkısı göz önüne alındığında bu dersin hem ilkokullarda hem de liselerde de seçmeli ders olarak koyulmasının yararlı olabileceğini söylenebilir. Bunun yanı sıra Zekâ Oyunları dersi zorunlu ders kapsamında ders proğramlarına eklenebilir.

Milli Eğitim Bakanlığı Zekâ Oyunları dersi müfredatı ile ilgili seminerler ve atölye çalışmaları düzenleyerek Zekâ Oyunları dersi öğretmenlerinin kendilerini geliştirmelerine olanak sağlayabilir. Bu açıdan, Türk Beyin Takımı'nın Zekâ Oyunları dersi için düzenlediği öğretmen eğitimlerinin oldukça faydalı olabileceği söylenebilir.

Akıl yürütme ve işlem oyunları ve strateji oyunları matematik dersinin bir parçası olacak şekilde ders planları düzenlenebilir. Bu tür oyunlar öğrencilerin matematiğe olan ilgisini arttırabilir.

Son olarak üniversitelerdeki öğretmen eğitim ile ilgili proğramlarda zekâ oyunları ile ilgili dersler konarak öğretmen adaylarının bu oyunlar ve zekâ soruları ile ilgili gelişmeleri sağlanabilir.

M. Tez Fotokopisi İzin Formu

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : .....
Adı : .....
Bölümü : .....

TEZİN ADI (İngilizce) : .....
.....
.....
.....
.....

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

Yazarın imzası ..... Tarih .....