International Journal of Mathematics Teaching and Interdisciplinary Practices (IJMTIP)
https://www.ijmtip.com/
Volume 1, Issue 2, July 2026, pp. 83–103

Research Article

Investigating Sixth-Grade Students' Reasoning Strategies, Difficulties, and Coping Strategies During the Mastermind (Code-Breaking) Game

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Abstract

This study aimed to examine the reasoning strategies used by sixth-grade students during the Mastermind (Code-Breaking) game process, the difficulties they encountered, and the strategies they used to cope with these difficulties. The study was conducted as a qualitative case study with 12 sixth-grade students attending a public school in Ankara, Türkiye. The activity was structured around the Mastermind game, which was implemented at two levels of difficulty using three-bead and four-bead code structures. Data were collected through a pre-game student information form, post-game reflection forms, audio-recorded student dialogues, and researcher observation notes. The data were analyzed through content analysis, and students' reasoning processes were interpreted using Lithner's framework of imitative and creative mathematically founded reasoning. The findings showed that students used strategies such as guessing, elimination, planning, using feedback clues, referring to previous guesses, and comparison. At the more complex game level, students experienced difficulties such as managing many possibilities, following color-position relationships, and making decisions. The results suggest that Mastermind provides a reusable and engaging learning context that makes students' reasoning, problem-solving, and strategy development processes visible. The study recommends using leveled intelligence games in mathematics classrooms and encouraging students to explain their strategies after gameplay.

Keywords: Mastermind, intelligence games, mathematical reasoning, problem solving, strategy development, sixth-grade students.

Submitted: 31.05.2026 **Accepted**: 27.07.2026 **Published:** 31.07.2026

How To Cite: Taşlıalan, M. N., & Saygı, E. (2026). Investigating sixth-grade students' reasoning strategies, difficulties, and coping strategies during the Mastermind (code-breaking) game. *International Journal of Mathematics Teaching and Interdisciplinary Practices*, *1*(2), 83–103.

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INTRODUCTION

Contemporary mathematics education aims not only to enable students to memorize predetermined algorithms and rules, but also to support them in analyzing mathematical situations, discovering patterns, making logical inferences, and justifying their conclusions with valid reasons (Tunç & Bolat, 2023; Yöndemli & Taş, 2018). In this context, reasoning, which refers to the process through which students justify their ideas by seeking answers to "why" and "how" questions when they encounter problems, is regarded as one of the fundamental components of mathematical competence (Brodie, 2010; Umay, 2003). Reasoning is defined as the process of generating new knowledge based on existing information by using the specific tools of mathematics, such as definitions and symbols, as well as thinking techniques such as deduction and induction (Çiftçi & Akgün, 2021; Ministry of National Education [MoNE], 2013). This process is not limited to reaching the answer to a problem; it also involves forming assumptions, testing these assumptions, and justifying the conclusions reached through a logical line of thought (Çiftçi & Akgün, 2021; Umay, 2003).

In recent years, intelligence games have become innovative and effective tools frequently used in educational settings to foster the reasoning skills targeted in mathematics instruction (Demirel, 2015). Intelligence games are activities designed to help students recognize and develop their cognitive potential, produce different and original strategies when faced with problems, make quick and accurate decisions, and develop a systematic way of thinking (MoNE, 2013). Studies in the literature show that intelligence games have positive effects on students' problem-solving skills, reasoning abilities, and academic achievement (Bottino et al., 2009; Namlı, 2016). In addition, these games play a critical role in reducing students' negative preconceptions about mathematics and in helping them develop positive attitudes toward the lesson (Aslan, 2022).

Intelligence games are classified into six main learning areas according to their underlying forms of thinking and structural characteristics: Reasoning and Operation Games, Verbal Games, Geometric-Mechanical Games, Memory Games, Strategy Games, and Intelligence Questions (MoNE, 2013; Zeybek & Saygı, 2018). Strategy games, which constitute one of these learning areas, require players to consider not only their own moves but also the possible moves of their opponents, to make decisions during the game process, and to base these decisions on a particular strategy (MoNE, 2013). In the Intelligence Games Course Curriculum, games such as Tic-Tac-Toe, chess, Go, Reversi, Mangala, checkers, number guessing, and Battleship are presented as examples of strategy games, and these games are associated with reasoning, problem solving, and communication skills (MoNE, 2013).

The Mastermind (Code-Breaking) game examined in this study can be considered a strategy game related to the logic of the number guessing game included in the curriculum. Due to its structure, Mastermind requires students to use memory, evaluate possibilities, analyze the given clues, and establish relationships between previous and new moves (Ayar et al., 2023; Goodrich, 2009). The Intelligence Games Course Curriculum emphasizes that such games improve students' ability to list possibilities, make eliminations, and determine the best move.

Similar to the number-guessing game, in Mastermind one player creates a hidden code, while the other player attempts to identify this code based on their guesses and the clues they receive. In this respect, Mastermind requires students not only to make guesses, but also to evaluate clues, eliminate incorrect options, establish relationships between previous and new moves, and generate more effective guesses based on the remaining possibilities. Therefore, the game provides an appropriate context for observing students' reasoning and problem-solving processes (MoNE, 2013; Goodrich, 2009).

The structure of Mastermind can also be associated with the leveled instruction and differentiation approach emphasized in the Intelligence Games Course Curriculum. In the curriculum, the leveled instruction approach is based on the understanding that students may differ in terms of their prior knowledge, learning styles, and thinking systems, and that they should be provided with learning opportunities that progress from simple to complex, from easy to difficult, and from basic knowledge and skills to higher-order thinking skills (MoNE, 2013). Within this scope, beginner-level games are associated with understanding rules and acquiring basic skills; intermediate-level games are associated with making logical inferences and using basic strategies; and advanced-level games are associated with higher-order skills such as analysis, developing original strategies, and evaluation (MoNE, 2013). In this study, implementing the Mastermind game in two different forms, namely three-bead and four-bead versions, is consistent with this leveled approach. The three-bead game can be considered closer to a basic level because it includes fewer beads and more limited possibilities, allowing students to more easily recognize the basic logic of the game, its rules, and the way clues are used. The four-bead game, on the other hand, can be considered a more complex implementation because the increase in the number of beads also increases the number of color-position relationships, possibilities, and clues that need to be followed, thereby requiring more analysis, comparison, elimination, and strategy development. For this reason, the three-bead and four-bead Mastermind implementations were used in this study to comparatively examine the reasoning strategies students used at different difficulty levels, the cognitive difficulties they encountered, and the ways they coped with these difficulties.

The literature indicates that students may have difficulty developing appropriate strategies and structuring their reasoning processes when they encounter non-routine problems (Artut & Tarım, 2009; Elia et al., 2009). Games such as Mastermind, which require in-depth analytical thinking, allow students to test their cognitive flexibility in an environment where they have the freedom to make mistakes (Somuncu, 2022). However, qualitative studies focusing on students' reasoning difficulties, cognitive challenges, and the original strategies they develop to overcome these challenges during such processes remain limited. As emphasized by Yılmaz and Tekerek (2024), understanding participants' strategic choices and coping strategies is important for identifying gaps in their mathematical thinking capacities. Therefore, examining the reasoning strategies used by sixth-grade students while playing Mastermind, as well as the difficulties they experience and the strategies they use to cope with these difficulties, is expected to contribute to the literature. Accordingly, this study sought answers to the following research questions:

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- RQ1. What are sixth-grade students' general views about the Mastermind game?
- RQ2. What reasoning strategies do sixth-grade students use in the Mastermind game?
- RQ3. What kinds of difficulties do sixth-grade students encounter during the Mastermind game?
- RQ4. What coping strategies do sixth-grade students use to overcome the difficulties they encounter during the Mastermind game?
- RQ5. How do sixth-grade students' perceived difficulties and strategy use differ between the three-bead and four-bead Mastermind games?

THEORETICAL FRAMEWORK

The interpretation of students' reasoning processes in this study was informed by Lithner's (2008) framework of creative and imitative reasoning. Lithner (2008) defines reasoning as the line of thought adopted to produce assertions and reach conclusions during task-solving processes. Within this framework, reasoning is not evaluated only in terms of whether the final answer is correct. Rather, it is examined through how students understand a problematic situation, select a strategy, implement that strategy, and justify the conclusions they reach.

Lithner (2008) distinguishes between imitative reasoning and creative mathematically founded reasoning. Imitative reasoning is generally characterized by recalling previously encountered answers or procedures, relying on surface features of a task, or using strategies without meaningful justification. Creative mathematically founded reasoning, on the other hand, involves constructing or reconstructing a reasoning sequence that is new to the learner, supporting this sequence with plausible arguments, and grounding these arguments in the intrinsic mathematical properties of the task.

In the context of this study, the intrinsic properties of the Mastermind game were considered to include colors, bead positions, feedback clues, previous guesses, and the reduction of possibilities. Students' attempts to find the hidden code were interpreted as encountering a problematic situation; determining a new move based on colors, positions, and clues was interpreted as strategy selection; trying the selected guess on the game board was interpreted as strategy implementation; and evaluating correct and incorrect colors or positions based on feedback was interpreted as reaching a conclusion and regulating the next move. More specifically, students' actions were interpreted by examining whether and how their reasoning was grounded in the intrinsic properties of the game. For example, selecting colors without referring to previous feedback was regarded as a surface-level or minimally justified strategy. In contrast, retaining colors that students inferred to be correct, changing their positions in response to feedback, comparing successive guesses, and eliminating colors or positions that were inconsistent with earlier clues were interpreted as more systematic and task-based forms of reasoning. Such actions were considered to approach creative mathematically founded reasoning when students constructed a strategy that was new to them, supported it with a plausible explanation, and grounded that explanation in the color-position constraints, feedback structure, and progressive reduction of possible codes. Accordingly, the Mastermind game provided a suitable context for examining whether students' reasoning was primarily based on

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surface-level or random explanations or supported by more systematic, justified, and task-based strategies.

DESIGN AND IMPLEMENTATION OF THE ACTIVITY

The Mastermind activity was designed to support sixth-grade students' reasoning, problem-solving, decision-making, elimination, comparison, and strategy development skills. The Mastermind game material used in the implementation was prepared by the researcher in accordance with the structure of the game. The material was designed to be reusable and suitable for different levels of difficulty, allowing students to follow their guesses and the feedback clues they received during the activity. The colored beads, feedback tokens, and game board were organized in a way that enabled students to visually follow color-position relationships. The researcher-prepared game material is presented in Figure 1.

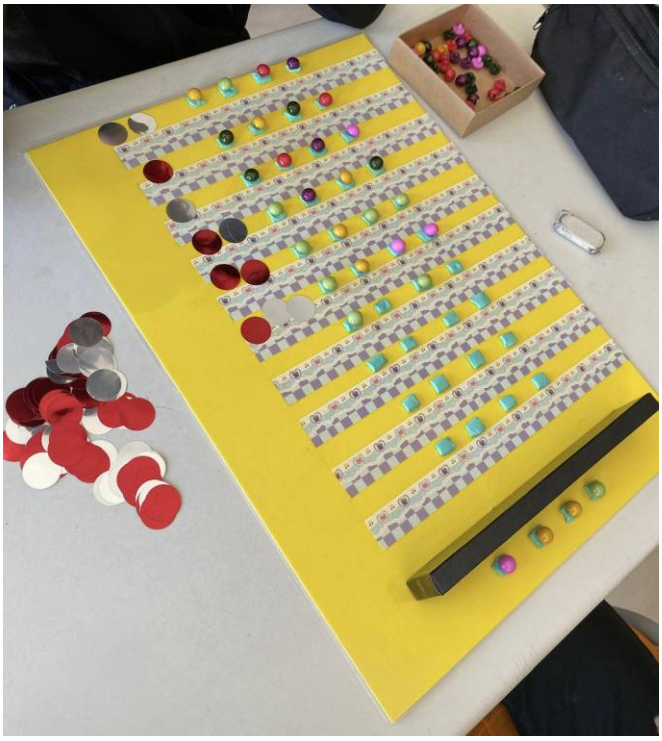

Figure 1. *Researcher-prepared reusable Mastermind game material.*

The implementation was conducted over a two-week period and consisted of six gameplay sessions, each lasting approximately 45 minutes. Before the six gameplay sessions began, the researcher introduced the aim and rules of the game, explained the use of the game materials, the roles of code-maker and code-breaker, and the feedback system, and demonstrated a sample round. Students were also given time to become familiar with the game material. Once the rules and gameplay were understood, students selected their own partners, typically choosing close friends, and remained with the same partner throughout the implementation. Two sessions were devoted to the three-bead version, followed by four sessions devoted to the four-bead version.

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In each round, one student initially acted as the code-maker and created a hidden code composed of colored beads, while the other acted as the code-breaker and attempted to identify the code by making guesses and using the feedback clues received after each attempt. After the round was completed, the roles were reversed so that both students experienced the roles of code-maker and code-breaker. The winner was determined according to which student identified the opponent's code in fewer attempts. During the code-breaking process, students were expected to consider information about correct colors and positions, review their previous moves, eliminate incorrect colors or positions, evaluate feedback clues, and construct new guesses based on the remaining possibilities. This paired implementation process is illustrated in Figure 2.

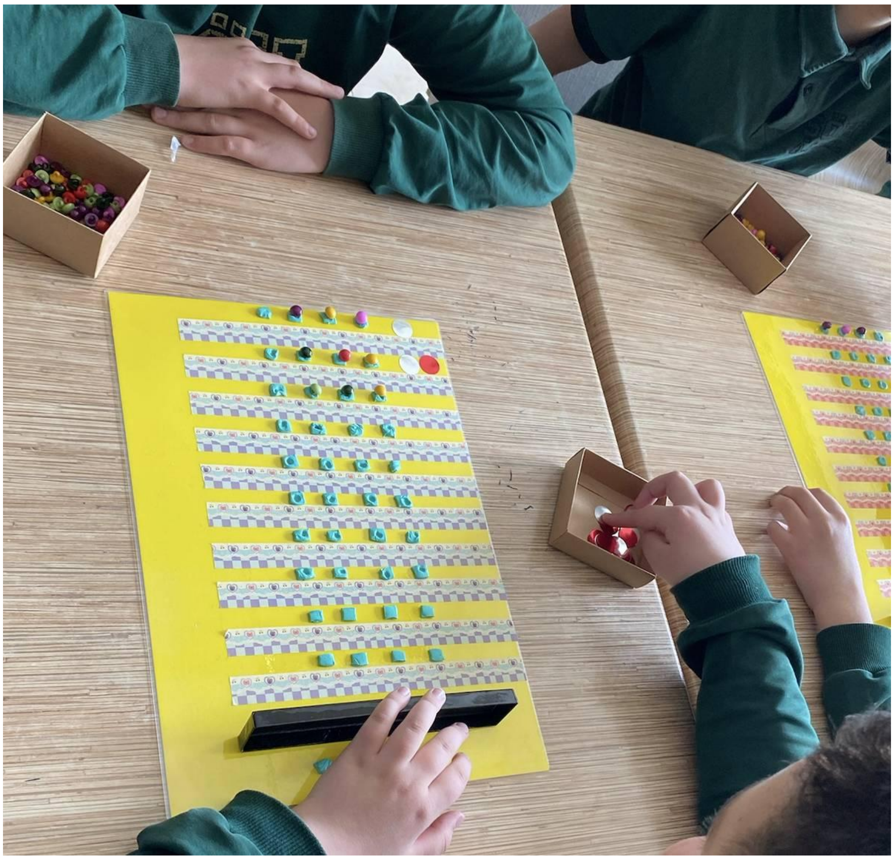

Figure 2. *Students playing the Mastermind game in pairs during the implementation.*

The activity was conducted in the school's intelligence games workshop, where students worked in small groups in a comfortable and interactive learning environment. A view of the implementation setting is presented in Figure 3.

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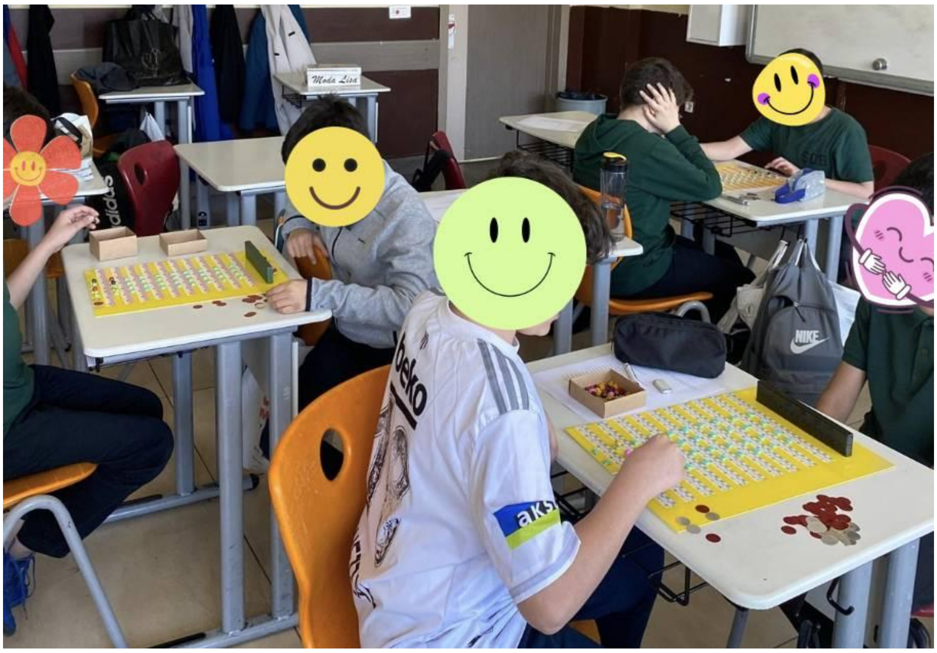

Figure 3. *The implementation setting in the school's intelligence games workshop.*

The activity was implemented at two levels of difficulty. In the three-bead version of the game, the number of possible sequences and color-position relationships was relatively limited. Therefore, this version was considered suitable for helping students notice the basic logic of the game, understand how clues are used, and practice elimination strategies. In the four-bead version, the increase in the number of beads also increased the number of possible combinations, color-position relationships, and feedback clues that students needed to monitor. For this reason, the four-bead version was expected to require more intensive reasoning, comparison, elimination, and strategy development. This expectation was based on the need to coordinate a larger number of possible arrangements, color-position relationships, and feedback clues across successive guesses. Compared with the three-bead version, students were required to retain and compare more information, eliminate a wider range of alternatives, and make more deliberate decisions when constructing subsequent moves.

Participants and Context

The participants were 12 sixth-grade students attending a public school in Ankara, Türkiye. They were selected through convenience sampling and participated in the study voluntarily. According to the mathematics teacher, the students represented varied levels of mathematics achievement based on their course grades and classroom performance. The teacher also reported that the class generally had a harmonious atmosphere and that the participating students interacted actively with their peers. During the implementation, the researcher similarly observed that the students communicated positively and worked cooperatively with their partners. All participants were male; however, gender was not used as a selection criterion, since the study focused on students' reasoning strategies, difficulties, and coping strategies during the Mastermind game process.

Before the implementation, all students stated that they liked playing intelligence games and that they played such games in their daily lives. They also reported an interest in strategy games. According to the information obtained before the activity, the students had previously played some strategy games such as Reversi, Mangala, chess, and Battleship; however, none of them had previously played Mastermind or the number-guessing game.

The activity was carried out in the school's intelligence games workshop. This setting provided a calm and comfortable environment for paired gameplay, peer interaction, observation, and audio recording. During the implementation, students worked in pairs and took the roles of code-maker and code-breaker.

Data Collection and Analysis

The research was conducted using a case study design. A case study is a qualitative research approach that allows a case to be examined in depth within its own context (Creswell, 2003).

Data were collected through a pre-game student information form, post-game reflection forms, audio recordings of student dialogues, and researcher observation notes. The data collection tools were designed to reveal students' prior experiences with Mastermind, the reasoning strategies they used during the game process, the difficulties they encountered, and the ways they coped with these difficulties.

The pre-game student information form was used to determine students' prior knowledge of Mastermind and their tendencies toward strategy games. The form included questions about whether students had played Mastermind before, whether they liked playing strategy games, how they usually behaved when they encountered a problem, and how they typically proceeded while playing games.

The post-game reflection forms were used to reveal students' experiences with the three-bead and four-bead Mastermind implementations. The forms included both multiple-choice and open-ended questions. The strategy options in the multiple-choice questions were developed by considering the structure of the Mastermind game and the ways of thinking that students might use during gameplay, such as guessing, elimination, comparison, evaluating feedback clues, and using previous guesses. The forms and the strategy options were reviewed by an expert in mathematics education in terms of clarity, relevance to the research questions, and suitability for sixth-grade students. The multiple-choice questions aimed to identify students' perceived difficulty levels and the strategies they believed they used, whereas the open-ended questions allowed students to explain their thinking processes in their own words. Students' perceived strategy use was initially identified through the options they selected and their open-ended explanations. These self-reports were not considered in isolation; they were examined

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together with the audio-recorded student dialogues and researcher observation notes to obtain a more holistic understanding of students' strategy use. During the activity, students' peer dialogues were audio-recorded, and the researcher took non-directive observation notes throughout the process.

The data were analyzed through content analysis. Content analysis involves identifying meaningful units in the data and labeling these units according to the phenomena they represent (Gillham, 2000). In the analysis process, all data sources were first read together, and students' ways of thinking, difficulties, and coping strategies during the Mastermind game were examined. To protect the identities of the participants, student responses were coded as S1, S2, S3, and so forth.

The broad themes of reasoning strategies, cognitive difficulties, and coping strategies were initially guided by the structure of the Mastermind game. As the reflection forms, audio-recorded dialogues, and observation notes were examined, these themes and their related codes were further refined based on recurring patterns in the data. Under the theme of reasoning strategies, the codes included guessing, trial-and-error, elimination, evaluating feedback clues, using previous guesses, comparison, logical inference, and planned/systematic progress. Under the theme of cognitive difficulties, the codes included encountering many options, initial uncertainty, confusing colors and positions, indecision, difficulty following previous moves, and difficulty in the final move. Under the theme of coping strategies, the codes included reviewing previous guesses, reconsidering clues, eliminating incorrect colors or positions, trying a different guess, attempting to proceed more systematically, and pausing to think before continuing.

Following the content analysis, the findings under the reasoning strategies theme were further interpreted through Lithner's (2008) framework described in the theoretical framework section. Thus, the framework was used as an interpretive lens to examine the quality and justification of students' reasoning rather than as the sole basis for generating the initial codes. In this process, student responses were examined in terms of whether they reflected indicators of imitative/superficial reasoning or indicators close to creative mathematically founded reasoning. Audio-recorded dialogues were used to support the findings obtained from the student forms. Expressions such as "there are two correct here," "I changed its position," "I found three of them," and "this color will be here" were considered as supporting data showing that students interpreted clues, established color-position relationships, and constructed new guesses based on previous moves. To support the trustworthiness of the analysis, the data were coded independently by the researcher and a field expert, and the evaluations continued until consistency was achieved.

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FINDINGS AND DISCUSSION

RQ1. Students' Prior Readiness and General Views About the Game

The findings obtained from the pre-game student information form showed that none of the students had prior experience with the Mastermind game. All students (100%, n = 12) stated that they had not played Mastermind before. Similarly, all students (100%, n = 12) reported that they liked playing strategy games. This finding indicates that although the students encountered Mastermind for the first time during the implementation, they already had a positive tendency toward strategy-based games.

Students' responses regarding how they usually behave when they encounter a problem showed that they tended to use different problem-solving approaches before the game process. More than half of the students (58.3%, n = 7) stated that they used trial and error, while 50% (n = 6) reported that they first thought carefully. In addition, 33.3% (n = 4) stated that they tried to solve the problem immediately, 25% (n = 3) indicated that they first tried to remember similar examples, 16.7% (n = 2) stated that they asked for help, and 8.3% (n = 1) reported that they gave up when they had difficulty. Some students also explained their approaches with statements such as "I first determine my moves," "I do not give up until I reach a solution," and "I try different solution methods." These responses suggest that students already had tendencies toward trying, thinking, planning, and searching for alternative solutions before engaging with the Mastermind game.

After the implementation, students' general views about Mastermind were mostly positive. A total of 91.7% (n = 11) of the students stated that they liked the game, whereas 8.3% (n = 1) stated that they did not. Students' reasons for liking the game included playing in groups, competition, the need for strategy, making guesses, and having fun. For example, S4 described the game by stating, "While making guesses, it also develops my thinking, and it is very fun." This statement shows that the student perceived the game not only as an enjoyable activity but also as a context that supported thinking. However, some students also expressed feelings such as tension, anger, or embarrassment depending on the difficulty of the game or the experience of losing. This suggests that the game created both an engaging and cognitively demanding learning environment.

RQ2. Reasoning Strategies Used by Students in the Mastermind Game

When students' responses regarding the ways of thinking they used during the game process were examined, the most frequently reported strategies were guessing, elimination, and planning. Students reported using guessing (75%, n = 9), elimination (75%, n = 9), and planning (75%, n = 9). These were followed by trial and error (58.3%, n = 7), using previous guesses (58.3%, n = 7), evaluating feedback clues (50%, n = 6), making logical inferences (50%, n = 6), systematic thinking (41.7%, n = 5), and comparison (33.3%, n = 4). These findings indicate that students did not rely only on random guessing during the game. Rather, they supported their guesses through elimination, planning, interpreting feedback clues, and using previous moves.

Students' open-ended responses were further examined according to Lithner's (2008) framework of creative and imitative reasoning. Based on the dominant indicators in students' written explanations, two groups were identified. Students who based their guesses on the intrinsic properties of the game, such as colors, bead positions, feedback clues, previous moves, and reducing possibilities, were interpreted as showing indicators of creative mathematically founded reasoning. In contrast, students who explained their guesses mainly through randomness, luck, knowing the opponent, or unjustified intuitive claims were interpreted as showing indicators of imitative/superficial reasoning.

Indicators of Imitative/Superficial Reasoning

Indicators of imitative/superficial reasoning were dominant in the responses of 25% of the students (n = 3). These students tended to explain their decisions through randomness, luck, or knowing the opponent rather than through the color-position relationships, feedback clues, or previous guesses that form the internal structure of the game. For instance, S8 stated, "I guessed randomly and eliminated colors," and also explained, "By guessing randomly; for example, my friend guessed randomly that I used purple." These statements show that the student's explanation of the guessing process was largely based on random attempts. Similarly, S10's statements, such as "I analyzed my opponent," "knowing the opponent," and "I knew my opponent would do something like this," indicate that the strategy choice was based more on predicting the opponent's behavior than on the clue and possibility structure of the game. S1's statement, "My friend made a big mistake and laughed a lot, so I made a guess from that," also suggests that the guess was based on the other player's behavior rather than on systematic in-game evidence.

These statements indicate that although these students made guesses during the game, they did not clearly justify their guesses through the mathematical or strategic structure of the game. From Lithner's (2008) perspective, such explanations can be interpreted as reasoning indicators that are based on surface features, have limited justification, and establish weak connections with the intrinsic structure of the task. This does not mean that these students proceeded with no strategy at all; however, in their written explanations, the reasons supporting their strategies were mostly constructed through randomness, luck, or opponent behavior.

Indicators of Creative Mathematically Founded Reasoning

Indicators of creative mathematically founded reasoning were identified in the responses of 75% of the students (n = 9). Students in this group based their guesses on information obtained from previous moves, feedback clues, color-position relationships, elimination, and reducing possibilities. For example, S2 stated, "According to the clues and my guesses," S3 stated, "Each time, I became sure of one color," S5 stated, "I compared what I found," S6 stated, "I eliminated colors," S9 stated, "I looked at my previous answers," and S11 stated, "I generally used the colors from my previous guesses." These statements show that students constructed their guesses based on data obtained from previous moves rather than treating each attempt as an independent guess.

Some student statements also revealed that they did not merely make guesses, but revised their guesses according to in-game feedback. S4 stated, "When I find a red token, I try to find what it is, and meanwhile I find the others." This statement indicates that the student tried to organize the remaining possibilities based on a feedback clue. Similarly, S11 stated, "Using the colors from my previous guesses, I evaluated whether another bead could come to the next position." This response shows that the student used information from previous moves to construct a new move. These statements can be associated with the criteria of plausible justification and reasoning grounded in the intrinsic properties of the task emphasized by Lithner (2008). S7's statement, "At first, I guessed randomly. Then I used elimination," is noteworthy because it shows that students' reasoning processes could change during the game. The response indicates that the student initially used a superficial or random guess, but then moved toward an elimination strategy based on feedback clues. Therefore, S7's response was interpreted as an indicator of transition from random guessing to more systematic and justified reasoning.

Overall, the findings for RQ2 suggest that most students used reasoning strategies that were grounded in the internal structure of the Mastermind game. While 25% of the students (n = 3) showed dominant indicators of imitative/superficial reasoning, 75% (n = 9) showed indicators of creative mathematically founded reasoning. This result suggests that Mastermind can make different qualities of students' reasoning visible, ranging from random or surface-level explanations to more systematic, justified, and task-based reasoning. During the game process, students used previous guesses, feedback clues, and elimination strategies to revise their subsequent attempts. An example of students' sequential guesses and use of feedback clues is presented in Figure 4.

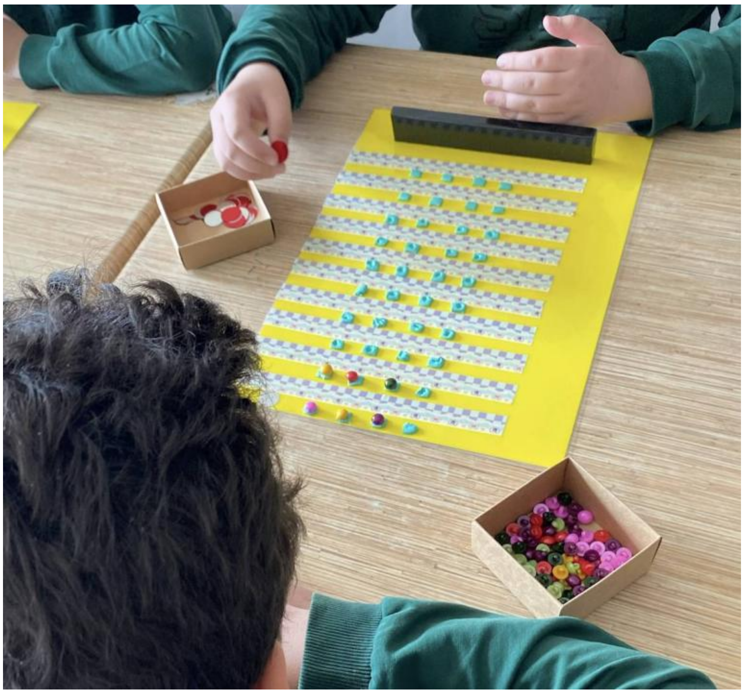

Figure 4. *An example of students' sequential guesses and use of feedback clues.*

RQ3. Cognitive Difficulties Experienced by Students

When students' perceived difficulty of the four-bead Mastermind game was examined, the game was generally found to be challenging. A total of 33.3% of the students (n = 4) evaluated the game as "challenging," 25% (n = 3) as "moderately challenging," 16.7% (n = 2) as "very difficult," 16.7% (n = 2) as "easy," and 8.3% (n = 1) as "slightly challenging." The highest percentage was gathered under the "challenging" option, showing that students had difficulty especially in following color-position relationships and possibilities at the four-bead game level.

When students' reasons for difficulty were examined, having too many options, not knowing the correct position, requiring strategy, taking a long time, and the difficulty of following four positions came to the fore. S2 stated, "Because there are many options," S4 stated, "Because you do not know which position is correct and your attempts run out before you can determine it," S5 stated, "Because it required too much strategy," and S11 stated, "Because knowing four positions is challenging." These statements show that students explained the difficulty not only through not being able to win the game, but also through the structural features of the game, such as possibilities, positions, and clue tracking.

According to students' open-ended responses, the situations in which they had the most difficulty during the game were initial uncertainty, indecision, confusing colors and positions, choosing beads, difficulty in the final move, and arranging positions. S12's statement, "At first, nothing was clear, so I had difficulty," points to initial uncertainty. S4's statement, "I had difficulty when I was indecisive," points to difficulty in decision making. S11's statement, "Arranging the positions of the beads," points to the difficulty experienced in establishing color-position relationships.

RQ4. Students' Coping Strategies for Overcoming Difficulties

When the ways students used when they had difficulty were examined, the most frequently used coping strategy was reviewing previous guesses. A total of 83.3% of the students (n = 10) stated that they reviewed their previous guesses when they had difficulty. In addition, 66.7% of the students (n = 8) stated that they eliminated colors or positions they thought were incorrect, 66.7% (n = 8) stated that they paused for a while and then continued, 50% (n = 6) stated that they reconsidered the clues, 50% (n = 6) stated that they tried a different guess, 50% (n = 6) stated that they tried to proceed more systematically, and 16.7% (n = 2) stated that they asked for help. These findings show that students mostly proceeded by re-evaluating the data within the game when faced with difficulty.

Coping strategies also provide important clues about the quality of students' reasoning processes. Behaviors such as reviewing previous guesses, reconsidering clues, and eliminating incorrect colors or positions show that students used the feedback they obtained as a result of their guesses to regulate their subsequent moves. This situation shows that reasoning in the Mastermind game is not limited to making a guess at the beginning; rather, it continues through the reinterpretation of the information obtained after each move.

Audio-recording transcripts also support these findings. Statements in the transcripts such as "there are two correct here," "I changed its position," "I found three of them," and "this color will be here" show that students interpreted clues during the game, established color-position relationships, and created new guesses by using previous moves. These statements are consistent with the strategies of elimination, evaluating clues, and using previous guesses stated in the reflection forms.

RQ5. Comparative Findings Regarding the Three-Bead and Four-Bead Games

When students' perceived difficulty of the three-bead Mastermind game was examined, it was seen that students generally evaluated this game as easier. A total of 33.3% of the students (n = 4) evaluated the three-bead game as "very easy," 33.3% (n = 4) as "easy," 16.7% (n = 2) as "slightly challenging," and 16.7% (n = 2) as "moderately challenging." No student selected the options "challenging" or "very difficult." This finding shows that the three-bead game was perceived by students as a more basic game level.

When the three-bead game and the four-bead game were compared, 91.7% of the students (n = 11) stated that the three-bead game was easier, while 8.3% (n = 1) stated that the two games were similar in difficulty. No student stated that the three-bead game was more difficult or that they were unsure. In students' explanations regarding this comparison, the number of beads, number of options, number of guessing attempts, and possibilities came to the fore. S5 stated, "It was easier because there were fewer beads," S7 stated, "It was easier because there were

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fewer options," S8 stated, "I found it easier because there were many guessing attempts," and S11 stated, "There are many possibilities in the four-bead game; the three-bead game is easier." These explanations show that students noticed that the increase in the number of beads increased the difficulty level of the game.

In the question regarding which game required more thinking, 91.7% of the students (n = 11) selected the four-bead game, while 8.3% (n = 1) selected both games. No student stated that the three-bead game required more thinking. S10's statement, "When the number of beads increases, the possibilities increase; it is necessary to be more careful so as not to waste attempts," is noteworthy because it shows that the student established a relationship between the number of beads and the increase in possibilities. Since this statement includes an explanation based on the structural features of the game, it can be evaluated as an indicator close to creative mathematically founded reasoning.

Regarding whether there was a difference in strategy use between the three-bead and four-bead games, 41.7% of the students (n = 5) stated that they used a different strategy, 33.3% (n = 4) stated that their strategy did not change, and 25% (n = 3) stated that it changed partially. Students' explanations revealed different patterns of change. S2 stated, "After the three-bead game, I understood the four-bead game better," while S6 stated, "In the three-bead game, I understood what I needed to do; in the four-bead game, I reinforced it." S10 added, "I needed to think more in the four-bead game. I checked my previous moves." These responses suggest that some students perceived their strategies as becoming clearer, more consolidated, or more deliberate across the two levels. However, other students reported continuity rather than change. S11 stated, "Their logic was the same; I needed to return to previous moves," while S9 stated, "There was not a very different strategy; only the possibilities increased." Thus, the findings indicate individual variation rather than a uniform progression in students' strategy use.

Overall, the findings show that students used strategies such as guessing, elimination, planning, evaluating clues, and using previous guesses together in the Mastermind game. Although some student statements were based on random or intuitive guesses, a considerable part of the responses was based on the intrinsic features of the game, such as color, position, clues, possibilities, and previous moves. Therefore, students' reasoning was not one-dimensional; rather, it showed a variety ranging from random attempts to partially justified strategies and indicators close to creative mathematically founded reasoning.

CONCLUSION AND RECOMMENDATIONS

In this study, the reasoning strategies used by sixth-grade students during the Mastermind/Code-Breaking game process, the cognitive difficulties they encountered, and the strategies they used to cope with these difficulties were examined. The findings showed that students did not rely only on random guesses in the Mastermind game; rather, they used different ways of thinking together, such as guessing, elimination, planning, using previous guesses, evaluating feedback clues, comparison, and making logical inferences. This result is consistent with studies showing that intelligence games provide an effective context for making students' problem-solving and reasoning processes visible (Bayramin, 2020; Erdoğan et al., 2017; Yöndemli & Taş, 2018).

The fact that guessing, elimination, and planning were among the most frequently used strategies in this study is directly related to the nature of the Mastermind game. During the game process, students had to evaluate the clues they obtained after each guess, eliminate incorrect colors or positions, and regulate their subsequent moves accordingly. This finding is consistent with Bayramin's (2020) study with sixth-grade students, which found that students used different problem-solving strategies while playing intelligence games and most frequently used reasoning strategies. Similarly, Zengin Kılavuz (2024) reported that students began to examine games and think about possible situations during intelligence game activities, while students who proceeded through direct guessing experienced more difficulty. In the present study, statements such as "I eliminated colors," "I looked at my previous answers," "I thought according to the clues," and "I compared what I found" indicate the use of systematic and task-based strategies. More direct evidence of strategy change was provided by S7, who stated, "At first, I guessed randomly. Then I used elimination." This response suggests that at least some students revised their strategies during the implementation.

When the findings of this study are evaluated in terms of Lithner's (2008) framework of creative and imitative reasoning, it is evident that students' reasoning cannot be reduced to a single category. Some students provided surface-level explanations such as "I guessed randomly," "luck," or "I know my opponent," whereas others justified their strategies by referring to clues, elimination, previous guesses, and remaining possibilities. The data therefore reflected a range of reasoning qualities rather than a uniform progression shared by all students. Nevertheless, some responses provided further evidence of change or consolidation in strategy use. S2 explained, "After the three-bead game, I understood the four-bead game better," while S6 stated, "In the three-bead game, I understood what I needed to do; in the four-bead game, I reinforced it." Together with S7's shift from random guessing to elimination discussed above, these responses suggest that some students revised, clarified, or consolidated their strategies during the implementation. According to Lithner (2008), creative mathematically founded reasoning requires the student to develop a new or reconstructed line of thought, support this line of thought with plausible arguments, and ground these arguments in the intrinsic properties of the task. In this study, when the intrinsic properties of the Mastermind game are considered as colors, bead positions, clues, previous guesses, and the reduction of possibilities, students' explanations based on these features can be evaluated as indicators close to creative mathematically founded reasoning. However, the fact that some students explained their strategies through luck or knowing the opponent shows that intelligence games do not automatically reveal mathematical thinking at the same level for every student.

Another result of the study is that students experienced various cognitive difficulties during the Mastermind game. It is noteworthy that students particularly found the four-bead Mastermind game "challenging" (33.3%). The main reason for this difficulty is that as the number of beads increases, the possible combinations and the color-position relationships that need to be followed become more complex. This finding is consistent with Lithner's (2004) studies, which indicate that students may tend more toward imitative reasoning as problems become more complex. The increase in cognitive load in complex tasks may make it more difficult for students to develop strategies (Kalyuga & Plass, 2009). Students especially described situations such as encountering too many options, distinguishing the correct color and position, experiencing initial uncertainty, being indecisive, following previous moves, and having difficulty in the final move as challenging. This finding is similar to the study by Yılmaz and Tekerek (2024), which showed that participants not only used strategies while constructing a square tangram, but also encountered difficulties such as determining the dimensions of the shape, arranging the positions of the pieces, and explaining what they had done.

On the other hand, students' frequent use of reviewing previous guesses (83.3%) and eliminating incorrect options (66.7%) shows that they returned to information obtained from earlier moves and used it to guide their subsequent decisions. This interpretation is supported by S11's explanation that previous colors were used to evaluate whether another bead could occupy the next position and by S10's statement that he checked previous moves in the four-bead game. The audio-recorded expressions "there are two correct here" and "I changed its position" also illustrate how students used feedback to revise their subsequent guesses. Accordingly, these behaviors were interpreted as feedback-based monitoring and revision of strategy use. This pattern is consistent with Kenna (2016), who reported that students reached solutions by learning from their mistakes through systematic approaches. Game environments in which students have the freedom to make mistakes allow them to take risks and try different strategies (Plass et al., 2015). In addition, these results show that intelligence games direct students not only to find the correct answer but also to try alternative approaches and reorganize their strategies when they encounter obstacles. In this respect, the Mastermind game can be considered a learning environment that supports the cognitive, affective, and behavioral engagement dimensions emphasized by Plass et al. (2015) in game-based learning.

The comparative findings regarding the three-bead and four-bead games showed that the increase in the number of beads affected students' perceived difficulty and strategy use. The majority of the students evaluated the three-bead game as easier and the four-bead game as requiring more thinking. Students' explanations such as "there were fewer beads," "there were fewer options," "there are many possibilities in the four-bead game," and "when the number of beads increases, the possibilities increase" show that they were able to relate the difficulty level to the structural features of the game. This finding is consistent with the progression approach in the Intelligence Games Course Curriculum, which emphasizes moving from simple to complex, from easy to difficult, and from basic skills to higher-order thinking skills (MoNE, 2013). In addition, the implementation of the Apartments game by Zeybek and Saygı (2018), in which the game was structured as Level 1, Level 2, and Level 3, shows that a leveled approach in intelligence games can be used to support students' or participants' cognitive development. Similarly, in the present study, the three-bead game made the processes of using clues and making eliminations visible at a basic level, whereas the four-bead game revealed a more intensive cognitive process in terms of managing more complex possibilities and developing strategies.

The fact that the majority of students liked the game and wanted it to be used in mathematics lessons suggests that intelligence games can provide an affectively supportive learning environment. This finding is consistent with Zengin Kılavuz's (2024) study, which reported that students enjoyed the intelligence game process, found the games entertaining, and wanted intelligence games to be used in mathematics lessons. Similarly, Alaca and Özen (2025) stated that mind and intelligence games were effective in reducing students' negative attitudes toward mathematics, decreasing their anxiety, and increasing their motivation. Şanlıdağ and Aykaç (2021) also found that the intelligence games course improved students' attitudes toward mathematical problem solving and their reflective thinking skills related to mathematical problem solving. In this context, the positive student views in the present study suggest that the Mastermind game can support not only students' cognitive skills but also their participation and motivation in the lesson.

The results suggest that the Mastermind game provided a context in which sixth-grade students' reasoning processes and strategy use became visible. Students demonstrated a range of approaches, from trial-and-error and surface-level guesses to strategies based on feedback clues, elimination, previous moves, and comparison. Although the data do not indicate that all students followed the same developmental path, some students' reflections suggest that the game's feedback mechanism supported the revision, clarification, or consolidation of their strategies. As a result, intelligence games can be considered not only as tools for entertainment but also as instructional materials that provide opportunities for students to engage with non-routine problems and make their reasoning processes visible in mathematics education.

Based on these results, it is recommended that the Mastermind game be used in mathematics lessons especially to support reasoning, problem solving, evaluating possibilities, elimination, and strategy development skills. Teachers can design activities appropriate to students' readiness levels by adapting the game with different numbers of beads. In addition, after the game, students can be encouraged to explain the strategies they used either orally or in writing so that their reasoning processes become more visible. Future studies may examine the effects of the Mastermind game on students' mathematical reasoning, problem solving, and strategy development skills with larger groups of students, at different grade levels, and through longer-term implementations. In addition, students' moves during the game process can be recorded in detail, allowing for a deeper analysis of how reasoning strategies are related to in-game behaviors.

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Ethical Approval

The study was conducted in compliance with ethical research principles.

Author Contributions

Melike Nur Taşlıalan designed and implemented the activity, collected and analyzed the data. Elif Saygı supervised the research process and contributed to the conceptual and methodological refinement of the study through critical review, feedback, and editing.

Funding

Not applicable.

Conflict of Interest

None declared.