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Book Review

Matchstick mathematics: On Josip Slisko's *Fostering cognitive mathematics skills with matchstick puzzles*

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ABSTRACT

This review article examines the ideas and analyses put forth by Josip Slisko in his 2026 book on matchstick puzzles, which provide a basis for projecting them onto domains of study such as math cognition with implications for math education. The book is a truly significant one bridging these two domains, showing how an apparently simple puzzle form enfolds deep mathematical ideas and principles that, when fleshed out, put on display what fundamental mathematics is all about. Above all else, Slisko's book has specific important implications for math education, which will be highlighted in this review article.

Keywords: matchstick puzzles, matchstick mathematics, math cognition, math pedagogy, creativity, multiple solutions

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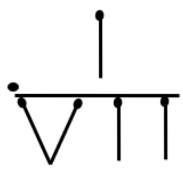
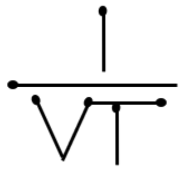
INTRODUCTION

In a comprehensive treatment of their origins and evolution, Hovanec (1978, p. 10) states that puzzles have a strong appeal universally because they "simultaneously conceal the answers yet cry out to be solved." Indeed, a puzzle is a game of creative entanglement between solvers and puzzle content, requiring a substantial use of imaginative thinking, based on figuring out the puzzle's concealed pattern. Perhaps no other puzzle in recreational mathematics brings this out more, in a nutshell, than the matchstick puzzle, where a set number of matches are arranged to form shapes, figures, or equations. The goal is to rearrange, remove, or add a specific number of matches to achieve a new, valid, or intended, structure. Consider, as a case in point, the following classic matchstick puzzle, which initially presents us with an arrangement of six lines laid out as follows, representing the fraction 1/7 in Roman numerals (I/VII):



The puzzle asks us to move a single matchstick so as to change the value of the fraction to one. At first consideration, a solution might seem intractable. Only by envisioning (that is, mentally picturing) possible arrangements of the lines can the solution be found in the layout of symbols used commonly to represent numerical values. A solution, when it comes, typically involves insight or creative thinking. The "V" figure with one of the two upright lines next to it in the denominator can be combined to represent a square root sign. This new arrangement will then stand for I/√I, which is equal to one:



As this simple example shows in its essence, matchstick puzzles involve creative entanglement with several cognitive processes that are at the core of mathematics, such as mapping abstract symbols (matchsticks) onto numerical magnitudes; manipulating the configuration (layout) to visually construct a solution; accessing memory of the mechanics of arithmetic and projecting it onto the puzzle; and others.

Puzzles of this type are unique in their own way, blending formal arithmetical knowledge with spatial reasoning and creative thinking, laying bear what symbolic representation is essentially all about. Moreover, many such puzzles encourage exploring multiple solutions, found through manipulation, mirror reflection, or by reinterpreting the puzzle creatively. In effect, a single matchstick puzzle can have multiple correct solutions depending on how the solver interprets it, envisioning different configurative possibilities. The implications for their use in math education are clearly rather significant, since they have the capacity to turn passive learners into active creators of mathematics, challenging students to use their own abilities.

Given their obvious pedagogical significance, it is somewhat surprising to find that they have rarely caught the attention of cognitive scientists and math educators more broadly—a gap that has now been filled skillfully and comprehensively by Josip Slisko in his 2026 book, *Fostering cognitive mathematics skills with matchstick puzzles*, in which he argues by demonstration and through evidentiary sources that these puzzles are effective tools for fostering critical thinking, spatial-visual intelligence, and mathematical creativity. As the puzzle above brings out, these puzzles encourage conceptual understanding via visualization, manipulation, and restructuring. Puzzles with multiple solutions, moreover, challenge students to think beyond the first, obvious answer, fostering awareness of what in-depth mathematical analysis involves. As Slisko had already shown in previous research (Slisko, 2025; Yuritzi et al., 2024). teaching students the principles behind a matchstick puzzle is far more effective for developing math fluency than just showing them a single solution. Moreover, given the various types of puzzles within this genre, called simply "matchstick mathematics," they can be used to cover different areas of math competence, such as arithmetic (moving or removing matches to make a correct equation), geometry (reconfiguring shapes by moving only a few matches), and topology (transforming one object into another).

Slisko's book is the first comprehensive treatment of matchstick mathematics, showing how solving puzzles activates different faculties by blending creative and formal thinking in tandem. Especially central to his treatment is the fact that these puzzles might have more than one solution—unlike the typical one-puzzle-one-solution approach found in recreational mathematics and educational books. What emerges from reading Slisko's book is that the puzzle format presented by matchstick mathematics allows us to explore the relationships between the different cognitive skills and levels of performance that characterize doing fundamental mathematics. It is therefore of great relevance to cognitive scientists, mathematicians, educators, and puzzle aficionados alike.

The purpose here is to look at the specific implications it bears for cognitive mathematics, as it has been called (Danesi, 2022)—an interdisciplinary field investigating how the brain acquires, understands, and utilizes mathematical knowledge, in view of improving the teaching of mathematics by understanding how associative processes enable mathematical thinking. Slisko's book shows how a specific ludic format (the matchstick puzzle) allows access to the processes that make mathematical thought possible and how these can be projected onto the domain of mathematics pedagogy.

MATCHSTICK MATHEMATICS

Slisko sets the stage for his in-depth analysis of how matchstick puzzles can be utilized systematically in math education with two survey chapters: "Puzzle-based mathematics learning" (Chapter 1), in which he provides a schematic overview of the use of puzzles as a core component of math pedagogy; "Matchstick puzzles: Early history and a critical review of a few recent books" (Chapter 2), in which he outlines the early history of matchstick puzzles, which starts in 1850, culminating with Sophus Tromholt's 1889 book of matchstick games, which can be seen to establish matchstick mathematics within the recreational field. Slisko then devotes two subsequent chapters to Tromholt: "Sophus Tromholt: The man who shaped the world of matchstick puzzles" (Chapter 5) and "Tromholt's matchstick puzzles published by posterior book authors" (Chapter 6). In these chapters, Slisko goes into great depth in showing how subsequent variations to Tromholt's blueprint have diversified the genre, leading in the twentieth century to further development by recreational mathematicians such as Loyd (1925) and Perelman (1934), among others.

The point to be made here is that, before Slisko, there was no historiography of matchstick mathematics, showing how the features of this genre apply broadly to mathematical thinking. First, they cannot be solved with a straightforward or clearly-defined procedure, as many common math problems used in educational contexts are. Finding a solution requires envisioning what can be done with the matchsticks as symbols by manipulating them structurally so as to achieve a different mathematical meaning. Second, as spontaneously as the solution may seem to have cropped up, it is hardly disconnected from previous experience and knowledge. In the puzzle above, only someone who is familiar with square root signs and Roman numerals, and who has reflected on the various notational practices that constitute numerical representation, can envision the solution in the first place. Insight thinking and background experience are thus intrinsically intertwined in the solution process. The result is, thus, not solely fortuitous or based on some special kind of intelligence as traditionally conceived. It comes about through a form of intuitive thinking that is guided by the experience of recurring patterns in mathematical constructs and processes. This is the overall subtext that can be extracted from Slisko's historiography of the genre.

As already suspected by early congeners of matchstick mathematics, the kind of thinking involved in solving matchstick puzzles is critical to the development of math fluency, or the ability to use and apply previously-gained knowledge to different problems, concepts, and contexts. Although some students may be innately talented in mathematics, it is also true that the math abilities and skills of any student can be reinforced through exposure to matchstick puzzles more generally, given that they stimulate awareness of the relation between notation and arithmetic, as well as alluding to the equivalency between numerical systems, and playing on students' curiosity in a specific way.

Matchstick puzzles gained popularity around the 1860s-1880s as newspapers and magazines published them as challenges to readers, likely inspired by the invention of friction matches (c. 1826), becoming a common, inexpensive pastime, with puzzles often printed on the back of matchboxes (Botermans, 2006). As Slisko indicates, it was the German schoolteacher Werner (1865) who is credited with publishing one of the first articles featuring matchstick puzzles as educational, home-schooling activities—indicating that this genre started off with a learning-educational objective in mind, a common thread in the history of recreational mathematics, which famously includes Alcuin's problems designed primarily for students (Danesi, 2025). Given the fact that many of the puzzles can have different solutions, from the outset, it was obvious that they had the capacity to break "pattern bias," where the brain struggles to see new shapes (changing a 3 to a 5) because it focuses on the original structure as retainable in any solution.

In a fundamental way, the puzzles are experiments in basic topological mathematics. Slisko provides examples of how some matchstick puzzles are solved by moving away from plane geometry and into three-dimensional space, challenging the solver to rearrange components in a way that creates new connections, similar to topological transformations. For example, rearranging six matches to form four equilateral triangles requires building a tetrahedron, rather than trying to lay them out flat. Some matchstick problems can actually be analyzed by using planar topological graphs, where the focus is on the connections between vertices (intersections of matches) rather than the lengths or specific angles of the matches. This involves looking at the network structure of the shapes.

COGNITIVE ASPECTS

There are four main types of matchstick puzzles (exemplified and discussed by Slisko in a comprehensive way throughout the book):

(1) rearranging matchsticks to fix incorrect equations,

(2) moving, removing, or adding sticks to change the number of shapes (converting 6 triangles into 5),

(3) rearranging shapes like squares, and

(4) creating specific shapes, such as forming three right angles with given matchsticks.

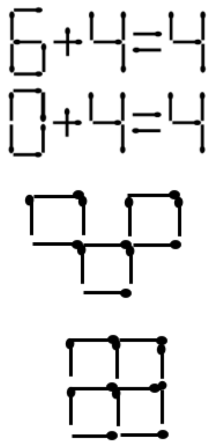
The main cognitive aspects related to these puzzle types are examined by Slisko in two primary chapters: “Matchstick or toothpick puzzles in brain training and different areas of learning “ (Chapter 3) and “Different investigations related to solving matchstick puzzles” (Chapter 4), where he discusses the kinds of research studies carried out with matchstick puzzles with respect to how they are solved and what pedagogical implications they bear.

In Chapter 7, “Restricted and unrestricted formulations of matchstick puzzles,” Slisko critiques the one-puzzle-one-solution approach, given that it stifles the imagination, narrowing the cognitive focus to one solution path, rather than opening it up. This multi-solution aspect of matchstick mathematics mirrors how mathematics is made more broadly, given that the history of the discipline shows how subsequent discoveries in mathematics occur from considering different solutions to the same problem. This has always been a hallmark of mathematical discovery in general, whereby breakthroughs frequently occur from exploring, reconciling, or reinterpreting multiple, distinct solutions to specific problems. Matchstick puzzles serve as a micro-model of this process by forcing solvers to move beyond initial interpretations to search for alternative, often more creative, solutions. For example, the problem of describing the arc length of an ellipse led Euler (1738) to develop elliptic integrals and functions. Before Euler, mathematics focused on solving specific physical and geometric problems that could not be solved using elementary functions. These efforts laid the groundwork for Euler’s later development of the general addition theorem for elliptic integrals.

Significant advancements often occurred when different mathematicians found distinct solutions to the same problem simultaneously, such as Abel, Galois, and Gauss working on the solvability of polynomials, which later helped solidify modern group theory. Just as matchstick puzzles are often reformulated to make them more challenging, the history of math involves redefining or re-proving old theorems using more abstract tools. In sum, matchstick puzzles break down the mental trap of treating problems as fixed, encouraging a re-imagining of the problem space. Ultimately, as with historical mathematical problems, the value of a matchstick puzzle lies not in one single answer, but in the reasoning behind the different solutions that can be discovered.

In Chapter 8, “An unknown history of a popular matchstick puzzle and its changes over time,” Slisko details the unknown history of a famous matchstick puzzle: “Make a polygon from 12 matchsticks with an area of 4 matchstick squares,” first published by Loyd (1925). To solve it, one must move beyond the tendency to fixate on standard rectangles. The most direct solution utilizes the properties of a Pythagorean triple. By arranging the 12 matchsticks into a triangle with side lengths of 3, 4, and 5 matchsticks, you satisfy both the perimeter and area requirements, whose perimeter is 12 and area 6. Loyd’s puzzle specifically asks for an area of 4. To achieve this, the polygon must be non-convex (having dents) or a different irregular shape. To reach an area of 4, one can also arrange the 12 sticks into an L-shaped polygon or a highly indented 3×3 square where corners are pushed inward—that is, the square (which uses 12 sticks but has an area of 9) is folded with the sticks inward at the corners to reduce the interior area until exactly 4 square units remain.

While this is a truly ingenious puzzle, as Slisko argues throughout, *all* matchstick puzzles require a creative form of thinking, to greater or lesser degrees. Consider a few simple examples. In the first one below, the puzzle asks us to move one stick to make the equation correct; and in the second one we are asked to move 3 matchsticks to make 4 equal squares. The puzzles and answers are shown below:



The first puzzle, and all such puzzles in this category, can be seen to constitute a form of cryptarithmetic, which plays on the relation between representation and arithmetical structure through exploration of this relation cognitively. Solvers are required to understand the relation between arithmetic and its representation by symbols. Such puzzles are exercises in “semiotic arithmetic,” showing how mathematics is a system of signs used to represent and solve problems though their manipulation. They induce solvers to construct mathematical processes and principles via a manipulation of symbols. The meaning of the matchstick signs is derived from their position within a “grammar” of mathematical rules—that is, the solver is required to envision the problem on the basis of the mathematical relationships indicated by the various arrangements and locations of the given matchsticks. Pedagogically, this kind of puzzle has a straightforward objective—to get students to envision the structure of arithmetical operations and processes in a concrete, self-based way. The solution requires understanding the reasons why certain symbols are used to “clothe” arithmetical structure. Such puzzles thus instill an accurate and deep understanding of arithmetic and, by extension, how mathematical representation relates to mathematical know-how. The second puzzle above involves geometric reasoning, similar to the kind enlisted in solving tangram puzzles. In both, the object is to assemble or reassemble pieces in ways so as to produce required shapes, figures, or forms.

Overall, these seemingly simple puzzles activate the creative regions of the brain, whereby a solution comes not from memory or problem-solving patternicity alone, but by literally “figuring out” how to move the matchsticks to produce a solution, shifting the process away from solving pre-defined exercises to working on problems that allow multiple approaches, pathways, and solutions, rather than a single correct answer.

In Chapter 9, “Amazing creativity of an anonymous reader,” Slisko recounts an amazing anecdote that shows how such puzzles stimulate creativity in people generally. After buying a fourth edition of Tromholt’s book, *Games with matchsticks* as a second-hand book, he found inscribed in it solutions written by hand by a previous anonymous reader, which allowed him to compare the reader’s solutions with the solutions published by Tromholt and other book authors. For 13 of the puzzles, the reader was able to find Tromholt’s solutions; but the reader found different correct solutions to 12 of the puzzles, showing ingenuity and substantiating Slisko’s overall perspective that the true significance of these puzzles lies in the multiple ways that can be envisioned to solve them. In effect, his fortuitous finding constitutes a case study in the creativity that matchstick puzzles stimulate.

Unlike puzzles with a single answer (like a standard Sudoku), matchstick puzzles require the ability to generate multiple solution paths, shifting between different strategies, and discovering unconventional paths to the solution, as the anonymous reader of Tromholt’s book clearly manifested. The brain is constantly re-evaluating how different shapes might be configured to produce a required solution, which is the core of metacognition—thinking about one’s own thinking. This topic is broached comprehensively by Slisko in Chapter 11, “Visual intelligence in finding additional solutions of matchstick puzzles.” It was Arnheim (1969) who introduced the term “visual thinking” as a powerful form of metacognition that, in the case of matchstick puzzles, involves understanding what one is doing beyond a straightforward learned logical process. One of the first investigations of puzzle-solving in general from a psychological perspective was an 1897 article by Ernest H. Lindley, titled “A study of puzzles with special reference to the psychology of mental adaptation,” in which the importance of the ludic element as a stimulant of abstract mental development is emphasized. This was followed by the 1922 paper by Joyce E. Mather and Linus W. Kline who maintained that puzzles reveal a form of intelligence that invariably involves abstraction. While abstraction allows the mind to detach itself from specific, concrete details to form general concepts, metacognition serves as a foundational mechanism for grounding these abstract concepts—hence the importance of puzzles in the formation of math cognition in learners.

Slisko's cognitive modeling of matchstick puzzles shows how intrinsic they are to the development of math fluency, since they reveal how it unfolds in microcosm, helping identify common cognitive biases, such as the one-puzzle-one-solution bias or the required-squares-must-be-equal bias, where individuals impose unnecessary self-restrictions on possible solutions. Interestingly, the puzzles have been used in computer science as a benchmark to evaluate the ability of artificial intelligence models to perform visual, symbolic, and compositional reasoning tasks, highlighting current limitations in AI compared to human performance (Ji et al. 2025).

PEDAGOGICAL ASPECTS

Perhaps the most significant aspect of Slisko's book, from the perspective of cognitive mathematics, is how it shows why matchstick puzzles are so effective in getting students to grasp fundamental principles of mathematics, thus favoring the acquisition of math fluency via a set of cognitive processes and features, including the following:

1. *A sense of engagement:* They challenge the student to experiment with math concepts directly.
2. *Improvisation:* They provide a unique opportunity for improvisation in problem-solving, allowing students to step outside pre-defined learning paths.
3. *Simulation:* They simulate the creative aspects of mathematics more generally, since they highlight how insight (visualization) thinking forms the core of discovering mathematical ideas.
4. *Openness:* They show how solutions are not always closed, but open-ended, since many of the puzzles can be solved in different ways.
5. *Diversity:* They involve accessing and traversing diverse math domains, from arithmetic to geometry and beyond, discriminating and grasping multiple perspectives and norms within them.

In a related work, Meyer et al. (2014) argue cogently for developing an overall approach to math education that they call, simply, puzzle-based learning. For the authors, puzzles should be selected or designed to motivate students to think about framing and solving unstructured problems. Slisko's treatment provides a concrete example of how this can unfold in terms of a simple, easily constructed puzzle format. Slisko's view of learning is also highly consistent with the model posited by the well-known math educator Dienes (1964, 1973). For Dienes, a direct sensory engagement with learning materials is the crucial first stage in grasping fundamental principles of mathematical structure. Dienes is best known for inventing arithmetic blocks (Dienes blocks), advocating that children learn best through active manipulation, games, and sensory experience, rather than rote memorization. He believed mathematical concepts should be presented in multiple, varied ways so as to help students grasp the cognitive principles involved in doing mathematics.

It is remarkable that many of Dienes' objectives can be achieved through a simple puzzle format (matchstick mathematics), which can then be projected onto larger mathematical domains of learning. A primary challenge in matchstick puzzles is the tendency to impose implicit constraints that are not part of the puzzle's explicit rules, such as assuming that all squares in a problem must remain equal in size or that a two-dimensional problem cannot be solved by thinking in three dimensions. Overcoming these biases, as Slisko argues throughout, is a key component of how math fluency can emerge spontaneously. Solving these puzzles often requires a representational change, where the solver reformulates the problem's goal, considering various solution options. This might involve reinterpreting Roman numerals, changing the perspective of the ways in which shapes are to be combined, or finding alternative ways to achieve the target configuration via symbol manipulation. While a trial-and-error approach is common, Slisko has shown with his own research that helping solvers grasp the underlying principles for a solution (such as the general rules for moving matches in arithmetic problems) is more effective overall for math fluency development, especially via visual-spatial reasoning (envisioning how the matchsticks can be used to form mathematically-meaningful structural patterns), leading to an understanding of the "why" behind mathematical operations.

In Chapter 10, "Stimulating creativity by information about the number possible puzzle solutions: A few small-scale pilot studies," Slisko provides experimental evidence to support his overall cognitive-pedagogical model. He describes his research on how the puzzles stimulate creativity in solvers in terms of the number of possible solutions of a puzzle. Subjects were asked in different wordings to find multiple solutions. In all cases, the participants showed more creativity than the book authors of the puzzles, finding more solutions, some of which were truly novel. Given such findings, in Chapter 12, "Potential utility of matchstick puzzles with erroneous solutions," Slisko presents a pedagogical model for using matchstick puzzles with different types of erroneous solutions, so as to challenge students to engage creatively with the puzzles, thus discovering underlying principles through the error format. Errors are thus springboards for inquiry, incentivizing students to deepen their conceptual understanding, getting them to examine the why and how behind a mistake rather than just identifying it as wrong.

In his *Critique of pure reason* (Kant, 1781), Immanuel Kant argued that mathematical ideas are not merely learned via definitions (like "all straight lines are 180 degrees") but are formed by building figures (like a triangle) in the mind's spatial form of intuition. This precisely characterizes the thinking process involved in solving matchstick puzzles. Kant argued further that the whole process becomes reflective and explicit when we examine the "visible signs" that we use to highlight the structural detail inherent in this type of knowledge. This type of know-how is based on the brain's ability to synthesize scattered bits of information into holistic entities that can then be analyzed reflectively. In line with Kantian ideas, Slisko's book can be seen to promote intuitive mathematics via the use of visible signs, reflecting a core principle of Gestalt psychology—namely that humans do not see separate components in information or in stimuli, unless some situation compels them to do so, but instead to perceive objects or ideas as elements integrated in holistic complex systems of meaning. The three main Gestalt principles that apply to Slisko's overall argument are:

- Recognizing shapes and structures within given situations, such as recognizing a square within a larger, more detailed figure.
- Recognizing symbolic representation as standing for mathematical ideas in abstract ways.
- Using spatial reasoning to imagine manipulating shapes (rotating, rearranging) to solve problems.

Alexander (2012) has identified three dimensions of math cognition that are relevant to the present discussion—"pre-math," "math," and "mathematics." "Pre-math" is innate and intuitive, including a primitive sense of number and space. Some animals other than humans may share the same kind of number sense, as Dehaene (1997) and others have argued. "Math" is what we learn as a set of formal skills, from elementary school to more advanced levels of education. It is what educators and society more generally want everyone to be competent in. "Mathematics" is the discipline itself, with its own professional culture, its research agendas and epistemologies, its own sense of correctness built around rigorous proofs, and so on. The boundaries among the dimensions are not clear-cut, and certainly there are many cross-influences. The goal of math education is, ideally, to transform "pre-math" into "math" knowledge with the use of effective pedagogical devices that should reflect the constitution and origins of "mathematics" itself, as discussed. It is clear, after reading Slisko's book, that matchstick puzzles are such devices, since they mirror how "mathematics" can be constructed and deconstructed (literally).

CONCLUDING REMARKS

To conclude this overview of Slisko's truly significant book for both the study of math cognition and for its implications for math education, it can be said that every once in a while, someone comes forward to make the obvious—*obvious*. Slisko has indeed made it obvious that one does not need a complex model of learning to describe how math is acquired; a simple demonstrative device can expose much more than any intricate theoretical model.

The goal of math pedagogy is, ultimately, to impart math fluency—the ability to transfer procedures acquired in specific contexts to different problems and contexts, recognizing when one procedure is more appropriate to apply than another. To develop such fluency, students need experiences that allow them to grasp these procedures by spontaneously engaging with them creatively on their own, which is the main rationale behind the use of matchstick mathematics in the classroom. Students learn best by experiencing the meaning of new concepts through concrete experiences with creativity, in a manner of speaking. Manipulatives, for instance, have been used commonly to impart the concepts of quantity and numeration, ever since Montessori (1909, 1914) introduced them formally into childhood education in the first decades of the twentieth century. A manipulative is designed to get learners to literally grasp a conceptual distinction, such as *larger* versus *greater* via the manipulation of objects of varying sizes.

Matchstick puzzles fit in, overall, with a fundamental principle of learning—they show how hands-on, self-directed learning serves as a concrete tool to instill mathematical awareness. They align with Montessori principles by encouraging creative trial-and-error, fostering concentration, and providing a self-correcting mechanism where the student can see if a pattern is wrong without teacher intervention. By arranging and moving matchsticks, students develop spatial awareness, understanding how shapes, angles, and positions relate to one another—numerically and geometrically, a connectivity which, since the Pythagoreans, has been a core aspect of "mathematics" as a discipline, to use Alexander's distinction. They break cognitive biases by forcing solvers to seek multiple, often unconventional, solutions. Arranging or rearranging matchsticks in specific patterns helps students connect mathematics to symbolic representation.

Slisko's book corroborates, in its own way, Halmos' (1967, p. vii) famous saying: "The only way to learn mathematics is to do mathematics." Matchstick mathematics is nothing if not *that*—doing mathematics.

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AI statement: No generative AI or AI-based tools were used.

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