EDUCATION MIND

VOL 4, NO 3, 273-283
DOI: 10.58583/EM.4.3.4

Research Article

Open Access

Hidden codes, silent concepts: Spatial language in primary math textbooks from Türkiye and England

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ABSTRACT

This study presents a comparative analysis of spatial language use in first-grade mathematics textbooks from Türkiye and England. It investigates the frequency, contextual depth, and pedagogical function of spatial expressions. A qualitative document analysis method was employed, using state-sanctioned textbooks from the 2023–2024 academic year. The results show that the Turkish textbook contains a higher number of spatial terms; however, these are often used in directive statements (e.g., "complete the shape below") with limited conceptual depth. In contrast, the English textbook includes fewer spatial terms but integrates them into problem-solving tasks, cross-disciplinary activities, and narrative contexts. This approach promotes deeper spatial reasoning and cognitive engagement. The findings suggest that effective use of spatial language depends not only on its frequency but also on how meaningfully it is embedded in instructional content. The study recommends that teacher education programs emphasize the cognitive value of spatial language, and that textbook authors incorporate it in more conceptually rich and interactive ways. Future research should explore spatial language use across different grade levels, international curricula, and real classroom settings to gain further insight into its role in mathematical thinking and learning.

ARTICLE HISTORY

Received 9 June 2025
Accepted 27 September 2025

KEYWORDS

Spatial language
Mathematics textbooks
Comparative education
Primary school

CORRESPONDENCE

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Introduction

Mathematics education is a multidimensional cognitive learning process that goes beyond numbers and operations. It contributes to individuals' understanding of their environment and helps them to make logical inferences and develop problem-solving skills. Language plays a dual role in this process, serving as a teaching tool and the cornerstone of conceptual meaning construction. Linguistic inputs, especially at an early age, shape students' mathematical thinking patterns and deepen learning (Barwell, 2012; Sfard, 2008). At primary school, language plays a decisive role in learning mathematical concepts and constructing mental representations (Morgan, 2010; Sfard, 2008). To comprehend and interpret mathematical concepts, students must be able to access language-based explanations, use terms correctly and understand mathematical language (Barwell, 2012). In this context, spatial language, defined as the set of words that express dimensions, positions, directions and relationships between objects, has a central role in both mathematical meaning construction and spatial cognition development (Levine et al., 2012; Bower et al., 2020). Spatial language effectively helps children to understand geometric concepts, establish visual-spatial relationships and translate mathematical contexts into words (Cannon et al., 2007). Furthermore, spatial language expressions influence the way children describe their surroundings and impact spatial cognition and problem-solving.

Evaluating it in the context of Piaget's (1926, 1928) cognitive development theory reveals that spatial language inputs supported by concrete experiences are of great importance in early childhood, when children's ability to understand abstract concepts is limited. During this period, using spatial expressions correctly and frequently both supports conceptual learning and helps children understand their

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environment (Szechter & Liben, 2004; Wu et al., 2021). Furthermore, research has demonstrated a direct relationship between spatial language and the development of higher-order cognitive skills, such as perspective-taking (Hermer-Vasquez et al., 2001; Shusterman, 2006). While learning and using spatial language in early childhood can be challenging, presenting it to children regularly and meaningfully can directly influence their future academic success (Wu et al., 2021). In particular, the ability to express spatial concepts through language between the ages of 5 and 7 is critical for both conceptual and neurocognitive development. Therefore, spatial language must be introduced to children from an early age and supported by educational materials. Textbooks are among the first systematic linguistic resources that students encounter at this stage. Mathematics textbooks are pedagogical tools that model mathematical thinking patterns and language, not merely content-transmitting materials (Morgan, 2010; O'Halloran, 2015). In this context, the quality and intensity of the spatial language presented in textbooks can directly influence the development of students' spatial intelligence. However, there are limited studies that subject textbooks to content analysis from this perspective, both in Türkiye and in the international literature (Saxe et al., 2001; Özer & Aksu, 2021).

Comparative analyses of education systems provide valuable insights into how various cultural and pedagogical approaches are reflected in teaching materials (OECD, 2019). For example, examining the spatial language usage patterns in primary school mathematics textbooks in countries with different educational approaches, such as Türkiye and England, allows us to analyse not only content differences, but also pedagogical priorities and linguistic orientations. Such comparisons are important for improving the linguistic components of teaching programmes and contributing to material development processes (Weninger, 2020). In Türkiye, research predominantly focuses on the impact of spatial skills on student achievement (Özdemir & Yıldız, 2021; Özer & Aksu, 2021; Mercan & Kandır, 2022), whereas studies analyzing textbook content remain scarce. Similarly, UK studies focus more on teaching strategies and have not sufficiently researched the spatial language environment provided by teaching materials (Weninger, 2020). Nevertheless, research indicates that spatial language input in early childhood is crucial for developing spatial skills (Casasola et al., 2020; Levine et al., 2012). In this context, the type of spatial expressions provided to children in mathematics teaching materials, especially textbooks, is of critical importance. Furthermore, the literature on how spatial language is represented in textbooks in countries with different education systems lacks cross-cultural comparative studies. Further research on this subject is therefore required from both theoretical and practical perspectives.

This study uses a comparative approach to analyse the frequency and distribution of spatial language expressions in primary school first-grade mathematics textbooks used in Türkiye and England. The research sheds light on the extent to which spatial language is presented at this level, revealing the visibility of linguistic elements that support spatial cognition in teaching materials. The study seeks to provide valuable insights into the quality of the linguistic environment presented to students at the early stages of their mathematics education. Thus, it seeks to determine the extent to which teaching materials contribute to the development of spatial cognition in early childhood. This research is framed by the question: 'How frequently and in which categories do spatial language expressions appear in first-grade mathematics textbooks in Türkiye and England?'

In answering this question, the study analysed both quantitative distributions and the visibility of linguistic structures, focusing on subcategories of spatial language such as shape, position, size, movement, and orientation. The study will develop recommendations for organising textbook content, improving material quality, and contributing to teaching practices that support the development of spatial cognition in early childhood.

Method

Research model

This research was designed using the document analysis method, one of the qualitative research approaches. Document analysis is a data collection and analysis method that aims to systematically examine written materials and convert them into meaningful data (Bowen, 2009). The reason for choosing this method is that it allows for the content-based analysis of fixed and structured teaching materials such as textbooks. Within the scope of this study, spatial language expressions in first-grade mathematics textbooks used in Türkiye and the United Kingdom were analysed comparatively.

Data sources

The data for this study were obtained from two primary school mathematics textbooks: one published by the Turkish Ministry of National Education (MoNE) in 2018, and another published by Oxford University Press in 2020, designed for international students in England. A purposive sampling method was employed

in the selection of these textbooks. Both are widely used official sources for early mathematics education and were chosen due to their curricular alignment and widespread use. This sampling was based on the fact that both textbooks cover similar learning domains and introduce foundational spatial skills at the first-grade level.

Data collection process

As a data collection tool, the "Spatial Language Rubric" developed by Dancu et al. (2015) was utilized. This rubric includes subcategories such as shape, location, direction, size, movement, orientation, and comparison. Both textbooks were accessed in PDF format, and all units were scanned systematically in accordance with the rubric. Each instance of spatial language was identified, classified under the appropriate category of the rubric, and recorded numerically.

Data analysis

The collected data were analyzed using descriptive analysis. Descriptive analysis involves systematically summarizing and interpreting data based on pre-determined themes (Yıldırım & Şimşek, 2018). In this study, the data were categorized and interpreted based on the classification of the Spatial Language Rubric developed by Dancu et al. (2015). Accordingly, the content of each textbook was examined under the main categories of spatial language, and the data were presented in tables and supported with explanatory descriptions.

To ensure the reliability of the analysis, two independent coders were involved in the coding process. The coders classified each spatial expression based on the rubric, and inter-coder reliability was calculated using the formula "Agreement / (Agreement + Disagreement)" proposed by Miles and Huberman (1994). The inter-coder reliability was found to be .94 for the textbook from England and .90 for the textbook from Türkiye, yielding an average reliability coefficient of .92. This indicates a high level of reliability in the coding process. Using the Spatial Language Rubric, all the spatial expressions in the textbooks were identified and classified into the subcategories in Table 1.

Table 1. Categories of the Spatial Language Rubric

Category	Definition	Examples
1. Shape	Includes 2D and 3D geometric shapes, their elements, and patterns	triangle, square, cube, sphere, corner, edge, line
2. Location	Indicates the relative position of an object	in front of, behind, next to, between, inside, on top
3. Movement	Refers to motion or movement-related actions	go, come, lift, follow, carry, move
4. Size	Describes attributes such as length, width, height, or volume	big, small, long, short, wide, narrow
5. Orientation	Expresses the direction or alignment of an object	up, down, diagonal, parallel, across
6. Comparison	Involves comparisons, similarities, and differences between objects	same, different, similar, just like, unlike

Note: This categorization is adapted from the rubric developed by Dancu et al. (2015).

Since this study does not involve human participants and is based solely on the analysis of publicly available educational documents, ethical approval was not required. However, all sources used in the study have been transparently cited, and the research process was conducted with academic integrity.

Findings

The findings are presented according to the categories of the Spatial Language Rubric. The data obtained were classified based on the frequency and distribution of spatial language expressions found in the first-grade mathematics textbooks of Turkey and England. The findings are presented under six main categories: shape, location, movement, size, orientation, and comparison. The analysis goes beyond frequency comparisons to include interpretations of the pedagogical function, conceptual contributions, and distribution of expressions across learning domains.

A review of the data shows that the first-grade mathematics textbook from England covers the following topics: numbers and counting, exploring numbers, number pairs, addition, subtraction and difference, number patterns, counting and estimating, multiplication and division, measurement, shapes, time, data handling, and glossary. In contrast, the Turkish textbook covers spatial relations, weight, natural numbers, addition, subtraction, money, fractions, time measurement, geometric solids, patterns, data collection, length, volume, and a glossary.

To enable a direct comparison between the two countries, only the topics with shared or similar titles in both textbooks were selected for analysis. Since the measurement topic in the Turkish textbook is distributed

across several units, the sections on weight, length, volume, and money were grouped together. Similarly, the English textbook topics on numbers and counting, exploring numbers, number pairs, and counting and estimating were combined for consistency. Topics such as multiplication and division in the English textbook and fractions and spatial relations in the Turkish textbook were excluded from comparison due to a lack of equivalency.

Table 2 presents the frequencies of spatial language expressions related to describing the shape of an object (or body) within the common learning areas across the two textbooks. The shape expressions include: 2D shapes (angles, triangle, rectangle, square, pentagon, hexagon, octagon, parallelogram, quadrilateral, rhombus, circle); 3D shapes (sphere, cone, cylinder, pyramid, cube, rectangular prism); Elements of shapes (dimension, edge, side, surface, corner, half, whole, part); Additional terms: shape, form, figure, solid, object, point, line, pattern.

Table 2. Frequency of Shape-Related Spatial Language Use in Textbooks from Türkiye and England

Shape	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	40	6	19	34	8	59	2	20	34	cube, line, shape, square, half, circle
Türkiye	11	12	21	27	34	119	31	0	19	şekil (shape), bütün (whole), and yarım (half) kare (square)

According to Table 2, shape-related expressions appear more frequently in the Turkish textbook, particularly concentrated in the themes of "geometric solids" and "patterns." In contrast, the English textbook includes shape expressions more sparingly and focuses on a limited set of core terms. The high frequency of shape-related language in the Turkish textbook is largely due to its repeated use in directive phrases such as "as seen in the figure," "color the shape," or "complete the figure." These expressions are often used to guide students' attention to the layout of the page rather than to engage them in geometric reasoning. However, such use of spatial language does not directly contribute to the development of cognitive functions like recognizing properties of shapes, classification, or spatial thinking. Therefore, the frequent appearance of the word "shape" in the Turkish textbook should not be interpreted as a sign of stronger spatial understanding; rather, it may reflect a high occurrence of repetitive and surface-level instructions. In contrast, the English textbook, although it contains fewer shape-related expressions overall, presents them within conceptual and activity-based contexts that encourage students to explore geometric features meaningfully. The examples from both textbooks reveal distinct approaches to spatial language. The English textbook integrates shape-related terms across multiple domains such as data, patterns, numbers, and problem-solving, creating a more contextual, activity-oriented, and conceptually coherent structure. This interdisciplinary approach demonstrates that the English textbook does not confine spatial language to geometry alone but embeds it across the mathematics curriculum.

Table 3 presents the frequency of spatial language expressions used to describe the location of an object relative to another, or the relative position of objects, people, or points within a region, across various topics in the textbooks of both countries. These expressions belong to the "position" category of spatial language and include terms such as: direction, right, left, front, back, up, down, position, location, navigation, positioned, center, corner, around, in the middle, next to, between, surrounding, parallel, reversed, surrounding, inside, far, near, distance, displacement, forward, backward, place, map, before, after, end, together, apart, arrangement.

Table 3. Frequency of Position-Related Spatial Language in the Textbooks of Türkiye and England

Position	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	148	27	66	12	28	27	28	38	17	on, in, there, between, from, back
Türkiye	71	70	51	31	106	28	31	5	30	Aşağı (below), arasında (between), alt (under), geri (behind), yer (place)

An examination of Table 3 reveals that position-related spatial expressions are used in high frequency in both countries' textbooks. However, the distribution of these expressions across different learning areas is particularly noteworthy. In the Turkish textbook, these expressions are heavily concentrated in specific topics such as "Measurement" and "Addition," whereas in the English textbook, they are more evenly distributed across nearly all learning domains. This pattern suggests that in the English textbook, spatial language is not confined to particular themes but appears in various contexts, allowing students to encounter it more broadly. This supports implicit instruction, interdisciplinary integration, and systematic reinforcement, all of which contribute to deeper and more lasting learning. In contrast, while the Turkish textbook demonstrates strong thematic concentration, it provides limited integration of spatial language across diverse mathematical topics. This difference offers significant insights into the pedagogical structures of the textbooks with regard to the development of spatial thinking skills.

Although the frequency of position-related expressions appears slightly higher in the Turkish textbook compared to the English one, a significant portion of these expressions are not used for teaching spatial concepts directly. Instead, they are primarily used for within-page navigation. For example, instructions such as "Examine the example below," "Fill in the blank above," or "Solve the problems below" do not promote the understanding of spatial concepts but rather refer to the physical layout of the page. In this context, although the Turkish textbook may contain a higher number of position expressions on a formal level, their semantic and conceptual contribution to spatial thinking skills is rather limited. In contrast, the English textbook presents fewer instances of position-related expressions, but these are often embedded in meaningful spatial relationships between objects (e.g., "between the cubes," "in the basket," "on the top"), making them functionally relevant within the spatial context. This distinction highlights that the effectiveness of spatial language lies not in its quantitative frequency but in its qualitative integration.

Table 4 presents the frequency of movement-related spatial language expressions found in both countries' textbooks across various mathematical topics. These expressions include: route, cross, adjust, path, passage, approach, navigate, lift, travel, run, sit, stay, aim, catch, come, follow, carry, roll, send, shake, hit...

Table 4. Frequency of use of movement expressions as spatial language in different countries

Movement	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	34	4	3	6	6	11	5	9	17	make, put, sit, cross, step, walk
Türkiye	7	24	14	3	9	3	5	0	4	Gel (come), yol (way), kaldır (lift), takip et (follow), yuvarla (roll)

According to Table 4, there is a notable difference between the textbooks of England (total 95) and Türkiye (total 69) in terms of the frequency of movement-related spatial expressions. In the English textbook, these expressions are especially prominent in the topics of "Numbers" and "Glossary," whereas in the Turkish textbook, they are most commonly found in the topics of "Addition" and "Subtraction." This distinction reflects the pedagogical emphasis differences between the two countries. The Turkish textbook tends to guide students more through physical actions, while the English textbook emphasizes instructions that encourage procedural operations.

Movement-related expressions in the English textbook are presented alongside activities that require students to follow paths, change direction, or navigate through a space while solving problems. Through these tasks, students not only gain familiarity with directional concepts but also develop the ability to associate procedural steps with spatial representations, thereby strengthening spatial reasoning in mathematical contexts. Table 5 shows the frequency of spatial language expressions related to describing the size and dimensions of objects, people, and spaces across different topic areas in the textbooks of both countries. These expressions include: big, small, narrow, widen, fat, thin, wide, long, short, slim, thick, skinny, miniature, loose, tight, tiny, capacity, full, empty, deep, shallow.

Table 5. Frequency of Size-Related Spatial Language Use in Textbooks from Türkiye and England

Size	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	11	0	5	2	51	4	2	4	8	measure, tall, short, long, big, small
Türkiye	17	6	7	2	120	13	7	0	18	Uzun (long), boş (empty), ağır (heavy), kısa (short), küçük (small)

According to Table 5, the frequency of dimension-related expressions in the Turkish textbook is found to be almost twice as high as in the English textbook. Notably, these expressions appear most frequently in the "Measurement" and "Glossary" units of the Turkish book. While the Turkish textbook features a broader range of terms such as "long," "big," "small," "empty," and "full," the English textbook typically uses more basic adjectives like "short," "long," and "tall." This suggests that the Turkish textbook addresses quantitative comparisons in a more detailed and comprehensive manner. Dimension-related expressions in the Turkish textbook are mostly used in the form of direct comparisons between opposite adjectives such as "long–short" or "wide–narrow." However, the usage of these expressions is often limited to visual support only, without encouraging students to explain or compare dimensional differences within a meaningful context. In contrast, the English textbook integrates dimension-related expressions into measurement activities, aiming for students to both perform physical measurements and express these measurements verbally. This structure supports conceptual understanding as well as linguistic articulation, ensuring a more cohesive learning experience. Table 6 presents the frequency of spatial expressions related to orientation—i.e., the position of an object relative to a background or direction—in the topic areas of both textbooks. These expressions include: along, angle, around, bend, extend, across, down, horizontal, level, parallel, upright, reverse, slope, stretch, tilt, up, vertical, upside down.

Table 6. Frequency of Orientation-Related Spatial Language Use in Textbooks from Türkiye and England

Orientation	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	2	1	0	1	1	2	1	0	3	face, around, diagonal, along
Türkiye	0	0	0	0	0	0	0	0	2	Ters (opposite) , dik (vertical)

As seen in Table 6, orientation-related expressions are very limited in both textbooks. However, in the English textbook, these expressions (e.g., "around," "along," "diagonally") are used to describe the transformation, redirection, or positioning of a shape. In contrast, the Turkish textbook includes no expressions that are directly associated with orientation. This indicates a notable gap in the Turkish textbook in terms of teaching dynamic spatial concepts such as spatial orientation and directional change. Although limited in number, the English textbook makes an effort to promote these concepts through visualized and activity-based tasks.

Skills such as orientation and perspective awareness are more strongly emphasized in the English textbook. This suggests a greater pedagogical focus on helping students recognize directional and spatial shifts. Table 7 presents the frequency of spatial expressions related to comparison or equivalence across topic areas in the two textbooks. These expressions include: similar, appropriate, separate, difference, different, same, exactly alike, etc.

Table 7. Frequency of Comparison-Related Spatial Language Use in Textbooks from Türkiye and England

Comparison	Numbers	Addition	Subtraction	Number Patterns	Measurement	Shapes	Time	Data Handling	Glossary	Most Frequently Used Words
England	14	23	23	3	4	7	0	19	0	different, same, like, suitable
Türkiye	3	13	6	1	9	8	1	0	4	Farklı (different), aynı (same), benzer, uygun

As shown in Table 7, comparison-related spatial expressions are used more frequently in the English textbook. This suggests that greater emphasis is placed on processes of classification and comparison in the English mathematics curriculum. In the Turkish textbook, expressions of similarity and difference appear mostly in the "Addition" and "Measurement" units.

The English textbook employs comparison-related expressions (e.g., "together," "with," "along with") to describe group activities, collaborative tasks, and joint actions between objects. This type of use contributes to the development of collaborative learning, motor coordination, and communicative language skills in students. In contrast, in the Turkish textbook, comparison expressions are generally embedded within instructional directives, primarily indicating actions to be carried out collectively. As such, they serve more of a guiding function rather than promoting interaction or conceptual understanding.

Generally, the Turkish textbook tends to concentrate spatial language expressions within certain learning domains, which sometimes leads to artificial repetition and may limit students' natural linguistic development. On the other hand, the English textbook presents spatial expressions more widely, implicitly, and contextually, allowing students to be systematically exposed to this language in varied contexts. This design enables the integration of spatial concepts not only within geometry but also across all mathematical processes, thus promoting interdisciplinary thinking. The fact that spatial language appears in topics such as "numbers," "time," and "data handling" reflects an effort to encourage students to reason about spatial ideas in diverse contexts. Such an approach serves as a strong example of interdisciplinary learning and demonstrates that spatial language is not limited to geometric topics but rather integrated into the broader mathematics curriculum. Consequently, the English textbook structures spatial language through systematic exposure, enabling students to develop these skills in a multidimensional and meaningful way.

Discussion

This study comparatively examined the quantitative distribution and pedagogical functionality of spatial language use in first-grade mathematics textbooks from Türkiye and England. The findings revealed that while both countries include spatial language in their textbooks, the ways in which it is used—its context, function, and conceptual depth—differ significantly.

To begin with, spatial language expressions in the English textbook are more evenly distributed and embedded within contextual and implicit learning opportunities. In contrast, the Turkish textbook displays a more concentrated use, focused on specific themes but limited in contextual diversity. This aligns with the findings of Casasola et al. (2020), who emphasized that young children's spatial thinking skills significantly benefit from frequent and varied exposure to spatial language input. Additionally, the high frequency of position and shape expressions in the Turkish textbook often stems from directive phrases such as "as seen in the figure" or "solve the problem below," which limits the functional use of spatial language. This reflects the concerns raised in educational linguistics, which argue that language in educational materials should function not only as a means of transmission but also as a tool for meaning-making (van den Heuvel-Panhuizen, 2020; Pramling & Samuelsson, 2011).

Although the Turkish textbook demonstrates a higher frequency of spatial language expressions, this quantitative density does not necessarily translate into enhanced spatial reasoning. Many of the expressions occur in directive statements such as "complete the figure" or "fill in the blank," which serve page navigation rather than conceptual engagement. Research suggests that spatial learning is not fostered by repetition alone, but by embedding terms in meaningful and varied contexts that stimulate active reasoning (Verdine, Golinkoff, Hirsh-Pasek, & Newcombe, 2014; Casasola et al., 2020). This indicates that the critical factor is not how often students encounter spatial expressions, but the extent to which those encounters invite them to make comparisons, describe relationships, and solve problems through spatial thinking.

The English textbook, despite containing fewer spatial expressions overall, provides richer opportunities for implicit learning. By situating spatial terms within problem-solving activities, cross-disciplinary tasks, and narrative structures, students are repeatedly exposed to spatial reasoning in natural ways. This implicit integration promotes transfer across mathematical domains such as number, measurement, and data, aligning with Bishop's (1980) argument that spatial concepts should not be restricted to geometry alone. Such exposure supports long-term retention and interdisciplinary reasoning, offering a stronger cognitive foundation than mechanical repetition.

The limited contextual diversity observed in the Turkish textbook raises pedagogical and policy concerns. Overemphasis on procedural directives risks narrowing students' opportunities to articulate, compare, and construct spatial relations, which are critical for higher-order mathematical reasoning. As van den Heuvel-Panhuizen (2020) emphasizes, textbooks should serve not only as repositories of exercises but also as vehicles for conceptual meaning-making. Therefore, future curriculum reforms and textbook designs should prioritize embedding spatial language in varied, meaningful contexts that foster both linguistic development and spatial reasoning. This adjustment would align textbook practices more closely with international approaches that support inquiry-based and student-centered learning.

The differences in spatial language use also reflect the cultural pedagogical codes of the two education systems. In more structured, teacher-centered models (e.g., Türkiye), directive expressions are more commonly used, whereas learner-centered systems (e.g., England) tend to employ open-ended, contextual, and intuitive language. This distinction resonates with Vygotsky's (1978) theory on the mediating role of language in cognitive development, suggesting that the quality of linguistic input significantly shapes students' mathematical reasoning processes. The integration of spatial language across all learning domains in the English textbook enhances interdisciplinary learning opportunities and supports students' linguistic, conceptual, and mathematical development in a more integrated manner. This supports Bishop's (1980) argument that spatial concepts should not be confined solely to geometry. In this context, how teachers use textbooks becomes crucial. It is not only about visual or auditory presentation but also about how spatial concepts are pedagogically structured. This has important implications for curriculum implementers (Verdine et al., 2014). Moreover, the curricular context should also be considered when interpreting the findings. In the Turkish mathematics curriculum (MoNE, 2018), spatial concepts are explicitly included under domains such as spatial relations, measurement, and geometry. In contrast, the National Curriculum in England (DfE, 2014) integrates spatial reasoning primarily under geometry and position and direction, often linking it with problem-solving and cross-disciplinary learning. These curricular emphases provide a framework that helps explain the observed differences in textbook design and the pedagogical opportunities afforded to students.

Conclusion and recommendations

This research sheds light on the role of linguistic structures in developing students' spatial thinking skills by comparing the use of spatial language in Turkish and English first-grade mathematics textbooks from both quantitative and qualitative perspectives. The results show that although the Turkish textbook contains a higher number of spatial expressions, many of these are primarily used in page layout directives and lack conceptual depth. In contrast, the English textbook, despite having fewer spatial expressions overall, presents them within meaningful contexts and integrates them across multiple learning domains, enabling students to encounter these concepts as part of their natural language development.

This suggests that spatial language should not be treated as a geometry-specific skill alone but as a fundamental thinking tool that can be integrated into various mathematical processes. Accordingly, education policies should be shaped with the understanding that spatial language facilitates interdisciplinary learning and supports deeper cognitive engagement. Textbook authors should aim to present spatial expressions in more functional and meaningful contexts, allowing students not just to hear these terms but to internalize and use them actively.

In teacher education programs, it is important to provide more training on how to pedagogically introduce spatial concepts and support the development of spatial language. Teachers must become aware of the role of spatial language in learning and consciously integrate it into classroom discourse. Future research should examine different age groups, grade levels, or cultural contexts through comparative studies. In particular, the effects of spatial language on conceptual development and mathematics achievement should be explored in more depth through experimental methods. Moreover, analyzing textbooks used in other countries using similar methods could help build a broader, internationally comparative perspective on spatial language in mathematics education.

Limitations

This study is limited to the analysis of one official textbook from each country at the first-grade level. Therefore, the findings cannot be generalized to all textbooks or grade levels. In addition, the Spatial Language Rubric, although systematically adapted, originates from a different disciplinary context, which may restrict the scope of interpretation. Furthermore, the analysis focused only on written content and visual materials within textbooks, without considering how teachers and students engage with these resources in classroom practice. Future studies should include multiple grade levels, a wider range of textbooks, and classroom-based observations to provide a more comprehensive understanding of spatial language use in mathematics education.

Declarations

Ethics statements

This research involved the analysis of publicly available educational materials (primary school mathematics textbooks). Therefore, no formal ethical approval was required.

Informed consent

Not applicable.

Availability of data and materials

All data analyzed during this study are available from the corresponding author upon reasonable request.

Competing interests

All data analyzed during this study are available from the corresponding author upon reasonable request.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

Emel Çilingir Altıner conceptualized the study, conducted the analysis, interpreted the findings, and wrote the manuscript.

Artificial Intelligence

Artificial intelligence was used in the preparation of this article for language editing and translation. The specific tool used was ChatGPT by OpenAI and DeepL.

Acknowledgments

The author would like to thank colleagues who provided feedback during the earlier stages of the study and the reviewers for their constructive comments.

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