VOLUME 1
ISSUE 4
OCTOBER–DECEMBER
2026

NOMINEE
2026 INTERNATIONAL PUBLISHERS ASSOCIATION (IPA)
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THE EXIGENCY MAGAZINE

Print ISSN: 3116-3769
Electronic ISSN: 3116-3777

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INJELPS

International Journal of Education, Learning, and Pedagogical Sciences

A Quarterly Peer-Reviewed International Research Journal

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International Journal of Education, Learning, and Pedagogical Sciences (INJELPS)
Published by ETCOR, Publisher of the Best Homiletics Book "Preaching with My Scars", 20th Cardinal Sin Catholic Book Awards

International Journal of Education, Learning, and Pedagogical Sciences (INJELPS)
P - ISSN 3116-3769; E - ISSN 3116-3777
National Book Development Board (NBDB) Registration as Book Publisher (Print & Digital): 6312
PRC-CPD Accredited Provider: PTR-2025-749

The effect of spatial language exposure on spatial visualization performance among undergraduate students

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Received: 06 September 2026 **Revised**: 08 September 2026; 08 October 2026; 25 October 2026

Accepted: 27 October 2026 **Available Online**: 28 October 2026

Volume 1 (2026), Issue 4, P-ISSN – 3116-3769; E-ISSN - 3116-3777

https://doi.org/10.63498/injelps120

Abstract

Aim: Spatial visualization is important in learning activities that require the mental representation and transformation of visual information. However, limited evidence is available on whether brief linguistic input can directly influence spatial visualization performance among young adults. This study examined whether exposure to spatially dense language, compared with abstract language, was associated with differences in spatial visualization performance among undergraduate students. The study also considered the relevance of spatial language to instructional activities involving spatially complex content.

Methodology: The study employed a posttest-only, between-subjects experimental design involving 38 undergraduate psychology students. Participants were exposed to either spatially dense language containing explicit positional and directional terms or abstract language containing fewer spatial expressions. Spatial visualization performance was measured using the Revised Mental Rotations Test, Form A (MRT-A). Descriptive statistics were used to summarize performance, while the Mann–Whitney *U* test was used to determine whether the two groups differed significantly at the .05 level.

Results: Participants exposed to spatially dense language obtained a higher mean MRT-A score than those exposed to abstract language, although both groups performed within the lower portion of the possible score range. The difference was not statistically significant, $U = 122$, $p = .091$. Thus, brief exposure to spatially dense language did not produce a statistically significant difference in immediate mental rotation performance among undergraduate students.

Conclusion: The study did not establish a statistically significant difference in immediate spatial visualization performance between the two language exposure conditions. Whether exposure duration, task requirements, or prior spatial experience influence this relationship remains a question for future investigation. In educational settings, spatially explicit language may support the communication of position, direction, and orientation, but it should not be treated as a stand-alone intervention for improving mental rotation performance. Instructional language may be more appropriately integrated with visual representations, demonstrations, and guided spatial activities.

Keywords: *spatial language exposure, spatial visualization performance, mental rotation, spatial cognition, instructional language*

INTRODUCTION

Spatial visualization is a cognitive ability that enables individuals to mentally represent, manipulate, and transform objects and their spatial relationships. It plays an important role in learning situations where students must interpret diagrams, understand visual models, recognize patterns, and process information beyond what is directly presented. Spatial ability has been identified as a major domain of human intellectual functioning, alongside verbal and numerical abilities, although it has historically received comparatively less attention in formal education (Ishikawa & Newcombe, 2021). Harris (2023) further emphasized that spatial reasoning extends beyond isolated cognitive test performance and warrants greater consideration within educational contexts, particularly in relation to mathematical learning. Its relevance extends across academic disciplines, particularly science, technology, engineering, and mathematics (STEM), where learners regularly encounter geometric structures, scientific illustrations, graphs, and other

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visually complex materials. Taylor et al. (2023) further highlighted how visualizations connect spatial thinking with STEM learning by helping students understand disciplinary concepts through spatial representations. As contemporary educational practices continue to incorporate visual and interactive learning materials, understanding the factors involved in spatial processing remains an important consideration in teaching and learning.

International research has explored different approaches to developing spatial abilities through instructional strategies, curriculum integration, and learning experiences that engage students in spatial reasoning. These approaches include targeted spatial training, spatially enriched curricula, integrated STEM activities, and informal spatial learning opportunities (Zhu et al., 2023). The importance of providing students with opportunities to practice spatial thinking has also been emphasized in geoscience education, where spatial reasoning is integral to understanding disciplinary concepts (McLaughlin & Bailey, 2023). Together, these studies reflect growing educational attention to spatial cognition as an ability that can be developed through appropriate learning experiences rather than viewed solely as a fixed individual characteristic. This direction has implications for instructional design, teacher preparation, curriculum development, and educational assessment, particularly in subjects that require students to interpret and manipulate spatial information. While visual representations, technological tools, and hands-on activities have received considerable attention, language remains another component of instruction that warrants closer investigation.

Spatial language refers to expressions that communicate the location, orientation, distance, direction, movement, and relationships of objects. In classroom instruction, these expressions are commonly used to explain diagrams, anatomical structures, geometric figures, and the arrangement of visual elements. Their function may extend beyond verbal description, as linguistic input can provide information that learners use when organizing spatial relationships mentally. Wu et al. (2022), in their scoping review, identified substantial evidence linking early spatial language development with spatial skills and cognition. Relationships between spatial language, spatial performance, and mathematical abilities have likewise been reported among school-age children (Gilligan-Lee et al., 2021). Further evidence concerning the relationship between spatial language and mental transformation was presented by Turan et al. (2021), whose investigation focused on preschoolers. Although these findings support the relevance of language to spatial cognition, much of the available evidence concerns developmental populations. Relationships established during childhood or through accumulated linguistic experiences cannot automatically be interpreted as evidence that brief exposure to spatially explicit language produces an immediate difference in mental rotation performance among university students.

In the Philippines, spatial cognition has also been investigated through educational approaches that allow learners to engage with visual and physical representations. For instance, Montalbo (2021) examined augmented reality teaching and learning materials in chemistry among students at Batangas State University and reported improvements in spatial visualization and related spatial skills following exposure to three-dimensional representations of chemical concepts. Improvements in spatial reasoning were also reported in a more recent Philippine study involving an educational intervention using physical manipulatives among Grade 7 learners (Bansil & Yabut, 2025). Although these investigations involved different educational levels and instructional approaches, they demonstrate the relevance of spatial cognition to Philippine educational research. They also reflect an interest in technological, visual, and hands-on methods of supporting spatial understanding. However, these approaches primarily involve direct engagement with spatial representations, while comparatively less attention has been given to linguistic exposure as a possible factor in subsequent spatial performance. Examining this area within Philippine higher education provides an opportunity to contribute locally situated evidence to the broader international discussion concerning language, spatial cognition, and learning.

At the institutional level, FEU Diliman provided a setting for examining this concern among undergraduate psychology students. Psychology education involves learning from scientific illustrations, anatomical representations, graphs, and other materials that may require students to understand spatial relationships. Language is also integral to how such information is communicated, particularly when instructors explain positions, directions, orientations, and relationships between visual elements. Nevertheless, the use of spatial expressions in instructional materials does not necessarily establish whether exposure to these expressions influences subsequent spatial visualization performance. This presents a relevant educational question concerning whether brief exposure to spatially explicit language, without direct visual or physical training, is associated with measurable differences in performance on a spatial task. Investigating this relationship among undergraduate students may help extend existing evidence beyond the developmental populations and instructional approaches that have received greater attention in previous research.

Three research gaps provided the basis for the present investigation. The first concerned the study population. Much of the existing research connecting spatial language with spatial cognition has focused on children whose linguistic and spatial abilities are still developing, leaving comparatively less evidence concerning undergraduate students. The

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second involved the nature and duration of exposure. Previous investigations have frequently examined developmental relationships or accumulated linguistic experiences, whereas less is known about performance following brief, controlled exposure to spatially dense language immediately before a standardized mental rotation task. The third concerned the educational context. Philippine studies have examined spatial learning through augmented reality, physical manipulatives, and direct visual experiences, but linguistic input has received comparatively less attention as a possible factor in spatial performance. Previous research has therefore established meaningful relationships between language and spatial cognition, alongside the educational relevance of visual and physical approaches to spatial learning. However, these findings do not sufficiently establish whether brief linguistic exposure is associated with immediate differences in mental rotation performance among undergraduate students. Addressing these gaps is important because the contribution of spatial language to subsequent performance should be investigated empirically rather than assumed from developmental findings or research involving other forms of instructional input.

To address these gaps, the present study examined spatial visualization performance among undergraduate psychology students at FEU Diliman following exposure to either spatially dense or abstract language. A posttest-only, between-subjects experimental design was employed to compare two language exposure conditions: spatially dense passages containing explicit positional and directional expressions and abstract passages containing minimal spatial references. Participants subsequently completed the Revised Mental Rotations Test, Form A (MRT-A), to measure their mental rotation performance. Specifically, the study sought to describe spatial visualization performance under each language condition and determine whether a statistically significant difference existed between the two groups. Unlike previous investigations centered on developmental language experiences or instructional approaches involving direct visual and physical manipulation, the present study examined brief linguistic exposure as the experimental input preceding a standardized spatial task. Its contribution to educational psychology and learning sciences lies in extending the investigation of spatial language to a Philippine undergraduate population while providing empirical evidence relevant to the immediate relationship between linguistic input and spatial performance. The findings may inform evidence-based instructional design by contributing to an understanding of the role of spatially explicit language in learning activities and its potential integration with visual representations, demonstrations, and sustained spatial learning experiences, without assuming that brief linguistic exposure alone necessarily improves spatial visualization ability.

Review of Related Literature and Studies

Spatial visualization involves the mental representation and transformation of spatial information, whereas mental rotation specifically requires individuals to imagine changes in an object's orientation while preserving its structural characteristics. Although closely related, spatial thinking encompasses several cognitive abilities that differ in their processes and demands. Performance on mental rotation tasks also varies across individuals, including adolescents and young adults. Rahe and Quaiser-Pohl (2023) examined actual and perceived mental rotation performance in relation to individual characteristics such as gender and mathematics anxiety, highlighting the relevance of individual differences when interpreting spatial performance. The nature of the assessment itself must also be considered. Thayaseelan et al. (2024) addressed the validation of an instrument measuring spatial thinking, reflecting the importance of distinguishing among the abilities represented by spatial assessment measures. Mental rotation requires individuals to encode, transform, and compare spatial representations, processes that involve considerable cognitive demands. These demands may differ according to the characteristics of the figures being manipulated mentally (Bauer et al., 2022). Consequently, performance on a mental rotation test should be understood within the cognitive and testing conditions under which it was measured, rather than treated as a comprehensive indication of an individual's overall spatial ability.

Beyond its cognitive foundations, spatial thinking has important implications for educational practice. Taylor et al. (2023) explained that visualizations connect spatial thinking with learning in science, technology, engineering, and mathematics (STEM), as spatial representations help organize and communicate disciplinary information. This relationship is particularly relevant when learners must interpret complex diagrams, recognize structural relationships, or translate between visual representations and conceptual understanding. The educational value of spatial ability has also encouraged investigations into how spatial skills can be developed through instruction. Zhu et al. (2023) reviewed approaches to fostering spatial ability in authentic STEM learning environments, including targeted spatial training, spatially enriched curricula, integrated STEM practices, and informal spatial learning experiences. Their review demonstrated that spatial development can be considered within the design of educational activities rather than addressed exclusively through separate cognitive exercises. Similarly, a systematic review of geoscience education emphasized the need to provide learners with greater opportunities to practice spatial thinking (McLaughlin & Bailey,

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PRC-CPD Accredited Provider: PTR-2025-749

2023). These findings suggest that instructional planning should consider not only the spatial demands of educational materials but also the experiences through which students engage with spatial information.

The relationship between spatial thinking and educational practice also has implications for teacher preparation and instructional design. Learning materials involving anatomical illustrations, scientific models, diagrams, or geometric representations require educators to communicate information in ways that support students' understanding of spatial relationships. Visual representations provide access to spatial structures, but the accompanying explanations may influence how learners interpret the relationships being presented. From this perspective, spatial language warrants consideration as part of instructional communication. Teachers may use precise positional and directional expressions when explaining the arrangement, orientation, or movement of objects, while visual materials and demonstrations provide corresponding representations of these relationships. The existing educational literature supports the value of spatially enriched learning experiences (Zhu et al., 2023), but this does not establish that brief linguistic exposure alone produces measurable improvements in spatial performance. Distinguishing the contribution of language from that of direct visual or physical engagement is therefore relevant when considering how spatial information should be presented in instructional materials.

Within the Philippine educational context, spatial cognition has been examined through interventions involving technological and hands-on learning experiences. Montalbo (2021) investigated augmented reality materials in chemistry among students at Batangas State University and reported improvements in spatial visualization and related spatial skills following exposure to three-dimensional representations of chemical concepts. In another Philippine investigation, Bansil and Yabut (2025) examined the use of physical manipulatives among Grade 7 learners and reported improvements in spatial reasoning through activities involving the visualization and manipulation of spatial structures. Although these studies employed different approaches, both demonstrate how spatial learning can be addressed through instructional experiences that allow students to interact with representations of spatial information. Augmented reality provides technology-supported access to spatial structures, whereas physical manipulatives allow learners to engage directly with objects and their relationships. These approaches reflect the relevance of visual, technological, and experiential methods in Philippine educational research. However, their findings cannot be directly extended to linguistic exposure because the instructional inputs and cognitive experiences involved are different. This distinction leaves room to examine language as another possible factor in spatial performance, particularly among undergraduate learners.

Spatial language communicates relationships involving position, direction, orientation, distance, and movement through linguistic expressions. Unlike physical manipulatives or three-dimensional visual representations, it presents spatial information through words that individuals must interpret and mentally organize. International studies have identified relationships between spatial language and several aspects of spatial cognition, although the strength and nature of these relationships may vary according to developmental stage and task characteristics. In a scoping review, Wu et al. (2022) identified substantial evidence connecting early spatial language development with spatial skills and cognition. Relationships between spatial language skills, spatial performance, and mathematical ability have also been observed among school-age children (Gilligan-Lee et al., 2021). Meanwhile, Turan et al. (2021) examined spatial language and mental transformation among preschoolers, providing further evidence of the relationship between linguistic and nonlinguistic spatial processes. These investigations establish a basis for considering language as a potentially relevant component of spatial cognition. Nevertheless, much of the available evidence concerns children and developmental relationships. Such findings do not necessarily demonstrate that brief exposure to spatially dense language immediately before a mental rotation task will produce a comparable difference in performance among undergraduate students.

The distinction between developmental associations and immediate experimental exposure is particularly important when interpreting the potential educational contribution of spatial language. Familiarity with spatial expressions acquired through repeated experiences differs from encountering a set of spatially explicit passages during a single experimental session. Although both involve linguistic information, they represent different exposure conditions and should not be assumed to produce equivalent cognitive outcomes. In instructional practice, this distinction raises a question about whether the inclusion of spatial terminology in learning materials is sufficient to influence subsequent spatial performance or whether its contribution may depend on additional visual, demonstrative, and experiential learning opportunities. Existing studies support the relevance of spatial language to spatial cognition (Wu et al., 2022), while educational research has examined approaches involving spatial representations and structured learning experiences (Taylor et al., 2023; Zhu et al., 2023). However, these bodies of evidence address different aspects of spatial learning and provide a limited basis for determining the immediate contribution of brief linguistic exposure to undergraduate mental rotation performance.

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Educational assessment provides another consideration when examining this relationship. Spatial visualization performance must be interpreted in relation to the abilities measured, the cognitive demands of the task, and the conditions under which participants complete an assessment. Instruments designed to measure spatial thinking do not necessarily assess identical cognitive processes, as spatial thinking encompasses multiple related abilities (Thayaseelan et al., 2024). Mental rotation, in particular, requires the manipulation and comparison of visual representations, with task characteristics contributing to the cognitive demands involved (Bauer et al., 2022). Time constraints may also influence performance on mental rotation assessments (Jeng & Lin, 2021). These considerations are relevant when evaluating the possible relationship between language exposure and subsequent performance because an observed score reflects performance on a particular task under specific testing conditions. Accordingly, the MRT-A provides a measure of mental rotation performance rather than a comprehensive classification of an individual's overall spatial ability. This distinction supports a more appropriate interpretation of findings derived from a brief experimental exposure followed by a standardized spatial task.

Taken together, the reviewed literature establishes the educational importance of spatial cognition while revealing a distinction between the evidence concerning spatial instruction and the evidence concerning spatial language. International educational research has examined visualizations, spatially enriched curricula, and structured opportunities for developing spatial skills, while Philippine studies have demonstrated the relevance of augmented reality and physical manipulatives to spatial learning. Research on spatial language, meanwhile, has identified relationships between linguistic experience and spatial cognition, predominantly among developmental populations. What remains comparatively less established is whether brief exposure to spatially explicit language immediately before a standardized mental rotation task is associated with differences in spatial visualization performance among undergraduate students. The present study addressed this intersection by experimentally comparing spatially dense and abstract language exposure and examining subsequent performance using the MRT-A. By focusing on linguistic input rather than direct visual or physical training, the investigation contributes evidence relevant to educational psychology, instructional communication, and the evaluation of spatial learning strategies. Its educational significance lies in helping establish a more informed basis for considering the role of spatial language in instructional design, without assuming that the presence of spatial terminology alone necessarily improves mental rotation performance.

Theoretical Framework

The study was anchored in Perceptual Symbol Systems Theory developed by Barsalou (1999), which proposes that conceptual processing is grounded in perceptual experience rather than relying exclusively on abstract, amodal representations. According to this theory, experiences generate representations within sensory and motor systems that can be partially reactivated during subsequent cognitive processing. Barsalou described this reactivation as simulation, a process through which individuals mentally represent objects, events, and relationships even when the original perceptual experience is no longer physically present. This perspective provides a theoretical basis for understanding how linguistic information may engage mental representations associated with previous spatial experiences.

In the context of the present study, spatial expressions such as *above, below, beside, left,* and *right* communicate perceptual relationships involving position, direction, and orientation. Processing these expressions may engage representations associated with spatial experiences, potentially making spatial information more accessible during subsequent cognitive activities. From this perspective, exposure to spatially dense language may engage spatial representations differently from exposure to abstract language containing fewer explicit spatial cues. This proposed relationship provided the rationale for identifying spatial language exposure as the independent variable and spatial visualization performance as the dependent variable. It also guided the experimental comparison between participants exposed to spatially dense language and those exposed to abstract language.

The theory further informed the study's analytical approach by providing a conceptual basis for examining whether the two language exposure conditions corresponded to differences in subsequent mental rotation performance. The MRT-A was used to measure the behavioral outcome, while the Mann–Whitney *U* test was employed to determine whether the observed difference between the two independent groups was statistically significant. Although the theory provided a rationale for expecting that spatially explicit language might engage perceptual representations relevant to spatial processing, it did not establish that such engagement would necessarily produce superior performance. The findings were therefore interpreted in relation to the proposed theoretical mechanism without assuming that such an effect would necessarily occur. Moreover, because perceptual simulation was not directly measured, the results were limited to determining whether language exposure was associated with a measurable difference in mental rotation performance under the experimental conditions.

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Within educational psychology, this theoretical perspective also provides a basis for considering how instructional language may contribute to students' processing of spatial information. Spatial expressions are commonly used when explaining diagrams, anatomical structures, models, and other visual materials that require learners to understand positional and directional relationships. However, their theoretical relevance to spatial representation does not automatically establish their effectiveness as an independent instructional intervention. The present study therefore applied Perceptual Symbol Systems Theory to examine the immediate behavioral outcome of brief linguistic exposure while recognizing that spatial learning may also involve visual experiences, task demands, and other cognitive processes.

Conceptual Framework

As shown in Figure 1, spatial language exposure is considered as a factor that may affect spatial visualization performance. The two types of language exposure differ in their linguistic content, with spatially dense language focusing on position, direction, and orientation, while abstract language has less explicit spatial information. The framework illustrates the proposed relationship between the type of language exposure and the participants' ability to mentally process and manipulate spatial information.

Figure 1

Conceptual Framework Illustrating the Effect of Spatial Language Exposure on Spatial Visualization Performance



Statement of the Problem

Spatial visualization is an important component of learning because students regularly encounter diagrams, models, anatomical structures, graphs, and other representations that require them to mentally represent and manipulate spatial information. Spatial language may support this process by making position, direction, orientation, distance, and movement explicit. However, existing research has largely examined spatial language in developmental populations or in the context of longer-term linguistic experience, leaving limited evidence on whether brief exposure to spatially dense language can influence immediate spatial visualization performance among undergraduate students. This issue is relevant to instructional practice because teachers and learning materials frequently use spatially explicit language when explaining relationships among objects, positions, and orientations.

Within the Philippine educational context, recent studies on spatial learning have emphasized visual, technological, and hands-on experiences, including augmented reality and physical manipulatives, while comparatively less attention has been given to linguistic input as a possible factor in spatial performance. The extent to which brief exposure to spatially dense language differs from exposure to abstract language in influencing students' immediate spatial visualization performance therefore remains insufficiently established. Addressing this gap may provide evidence relevant to the design of instructional language and learning activities that involve spatial reasoning and visualization.

Accordingly, this study examined the spatial visualization performance of undergraduate students exposed to spatially dense language and abstract language and determined whether a statistically significant difference existed between the two groups.

General Objective

To examine the effect of spatial language exposure on spatial visualization performance among undergraduate students.

Specific Objectives

1. To describe the spatial visualization performance of undergraduate students according to type of language exposure, specifically spatially dense language and abstract language.
2. To determine whether there is a significant difference in spatial visualization performance between undergraduate students exposed to spatially dense language and those exposed to abstract language.

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Research Questions

1. What is the spatial visualization performance of undergraduate students according to type of language exposure, specifically spatially dense language and abstract language?
2. Is there a significant difference in spatial visualization performance between undergraduate students exposed to spatially dense language and those exposed to abstract language?

Ho: There is no significant difference in spatial visualization performance between undergraduate students exposed to spatially dense language and those exposed to abstract language.

METHODOLOGY

Research Design

The study employed a quantitative, posttest-only, between-subjects experimental design to examine differences in spatial visualization performance following exposure to two language conditions. The independent variable was spatial language exposure, consisting of abstract language (Condition A) and spatially dense language (Condition B), while the dependent variable was spatial visualization performance, measured using the MRT-A. Each participant received only one type of language exposure before completing the posttest. The study involved 38 undergraduate psychology students who participated in two batches of 19. The experimental conditions were distributed using an alternating-column seating arrangement, with the first and third columns designated for abstract language and the second and fourth columns for spatially dense language. Although equal allocation of 19 participants per condition was initially intended, an oversight during the distribution of experimental materials resulted in 20 participants receiving abstract language and 18 receiving spatially dense language.

The posttest-only approach was adopted to assess spatial visualization performance without introducing a pretest that could familiarize participants with mental rotation tasks. The two independent groups were subsequently compared to determine whether their performance differed significantly. As random assignment was not established in the documented allocation procedure, possible pre-existing group differences were recognized as a methodological limitation.

Population and Sampling

The study employed convenience sampling, a non-probability sampling technique, involving 38 undergraduate students enrolled in the Bachelor of Science in Psychology program at FEU Diliman. Participants were recruited from the accessible population of enrolled Psychology students who met the study's eligibility criteria and voluntarily agreed to participate. Eligible participants were between 18 and 25 years of age and were able to read and understand the language exposure materials. The participants were divided into two batches of 19 for experimental administration. The final distribution consisted of 20 participants in the abstract language condition and 18 in the spatially dense language condition. The experiment was conducted at the FEU Diliman Basic Education Library, which provided a quiet setting for administering the language exposure materials and subsequent spatial visualization assessment.

Research Instruments

Two research materials were used in the study: researcher-constructed language exposure passages, which served as the experimental manipulation, and the MRT-A, which served as the outcome measure. The researcher-constructed materials consisted of two sets of situational reading passages representing the experimental conditions: abstract language and spatially dense language. The spatially dense passages incorporated explicit positional and directional expressions, such as *above, below, beside, left,* and *right*, whereas the abstract passages contained minimal spatial references. Both sets were developed with the intention of maintaining comparable contextual content, length, sentence complexity, readability, and general structure, while differing primarily in the density of spatial expressions.

The language exposure materials underwent grammatical checking and content validation by one psychologist prior to administration. The review focused on the clarity and appropriateness of the passages in representing their respective language conditions, particularly the presence of explicit spatial expressions in the spatially dense materials and minimal spatial references in the abstract materials. However, no formal pilot testing or quantitative assessment of passage equivalence was conducted. Consequently, potential differences in readability, comprehension demands, and other linguistic characteristics between the two conditions could not be entirely ruled out. Comprehension questions were included to encourage attentiveness and engagement with the assigned passages but were not scored, as they were not intended to measure spatial visualization performance.

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The second instrument was the MRT-A, an established mental rotation measure developed by Peters et al. (1995), based on the Mental Rotations Test of Vandenberg and Kuse. It consists of 24 items requiring participants to identify figures that correspond to a target figure following mental rotation. Scores range from 0 to 24, with higher scores indicating better mental rotation performance. The instrument was used to assess spatial visualization performance following exposure to the assigned language condition.

Data Collection Procedure

Data collection was conducted in two afternoon batches, each consisting of 19 undergraduate psychology students, at the FEU Diliman Basic Education Library. Participants were seated in four columns with alternating language exposure conditions. The first and third columns were designated for abstract language (Condition A), while the second and fourth columns were designated for spatially dense language (Condition B). Although the initial plan was to allocate 19 participants to each condition, an oversight during the distribution of experimental materials resulted in a final distribution of 20 participants in the abstract language condition and 18 in the spatially dense language condition.

To minimize potential contamination between conditions, participants were seated sufficiently apart and explicitly instructed not to communicate with one another or look at other participants' reading materials during the experiment. Each participant received only the passages corresponding to their assigned condition. The same investigator personally administered both batches and provided identical, neutral instructions without indicating which language condition was expected to produce better performance.

Participants were given 10 minutes to read and complete their assigned language exposure materials, followed by a 10-minute break. They subsequently completed the MRT-A, with four minutes allotted for the first 12 items, a two-minute break, and another four minutes for the remaining 12 items. The same instructions, assessment materials, and time allotments were applied to both language conditions.

A 30-minute interval separated the two batches. The same investigator maintained the venue, alternating seating arrangement, administration sequence, instructions, and testing conditions during the second batch to promote procedural consistency. Although physical spacing and restrictions on communication were implemented to minimize potential contamination, complete isolation between the experimental conditions could not be guaranteed.

Treatment of Data

The collected data were encoded and analyzed using jamovi Statistical Software version 2.7.28. Descriptive statistics, including mean, standard deviation, and median, were used to summarize spatial visualization performance according to language exposure condition. The Shapiro–Wilk test was employed to assess the normality of score distributions. Since one group did not satisfy the normality assumption and the sample size was relatively small, the Mann–Whitney *U* test was used to determine whether a statistically significant difference existed in spatial visualization performance between the abstract and spatially dense language groups. The level of statistical significance was set at $\alpha = .05$.

Ethical Considerations

Permission to conduct the study was obtained from the Senior Director of the Tertiary Department of FEU Diliman prior to data collection. At the time of the study, the institution did not have a formally constituted research ethics board. Institutional authorization was therefore obtained through the appropriate academic authority rather than through formal research ethics committee review. Before participation, students received information regarding the study's purpose, procedures, voluntary nature, and confidentiality provisions. Informed consent was obtained before the experimental activities commenced.

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RESULTS AND DISCUSSION

Table 1

Descriptive Statistics of Spatial Visualization Performance Scores According to Type of Language Exposure

Type of Language Exposure	n	*M*	*SD*
Abstract Language	20	6.45	5.37
Spatially Dense Language	18	7.67	3.80

Note. MRT-A scores ranged from 0 to 24, with higher scores indicating greater spatial visualization performance.

Table 1 presents the descriptive statistics of spatial visualization performance according to type of language exposure. Participants exposed to abstract language received a mean MRT-A score of 6.45 (*SD* = 5.37) out of 24 points. The mean was situated toward the lower portion of the possible score range, indicating that participants in this condition generally obtained relatively few correct responses on the mental rotation task. The standard deviation indicated considerable variability in performance, suggesting that scores within the abstract language condition were relatively dispersed.

Participants with spatially dense language received a mean MRT-A score of 7.67 (*SD* = 3.80) out of 24 possible points. This mean was likewise situated toward the lower portion of the possible score range, indicating relatively limited correct performance on the mental rotation task. The standard deviation of 3.80 reflected variation in individual performance, with scores spread around the group mean. These descriptive findings characterize the observed spatial visualization performance within each language condition under the conditions of the mental rotation task.

The observed performance may be interpreted in light of previous research indicating that mental rotation involves considerable cognitive demands. Bauer et al. (2022) demonstrated that characteristics of the figures being mentally transformed may influence cognitive load during task completion. Testing conditions also warrant consideration, particularly as time constraints may affect mental rotation performance (Jeng & Lin, 2021). In the present study, participants were allotted four minutes to complete each 12-item section of the MRT-A. Although these studies provide relevant context for interpreting the observed scores, cognitive load and the effects of different testing durations were not independently examined. The results therefore describe performance under the administered testing conditions rather than provide a general classification of the participants' overall spatial ability.

Table 2

Mann–Whitney U Test for Spatial Visualization Performance by Type of Language Exposure

Group	n	Median	*U*	*p*
Abstract Language	20	5.00	122	.091
Spatially Dense Language	18	7.50		

Note. The Mann–Whitney *U* test compared the two independent language exposure conditions. The test statistic and *p* value apply to the overall group comparison.

Table 2 presents the results of the Mann–Whitney *U* test conducted to determine whether spatial visualization performance differed significantly between the two language exposure conditions. The abstract language group obtained a median score of 5.00, whereas the spatially dense language group obtained a median score of 7.50. Despite the higher median observed in the spatially dense language condition, the difference was not statistically significant, *U* = 122, *p* = .091. Accordingly, the null hypothesis was not rejected at the .05 significance level.

The descriptive difference between the groups warrants cautious interpretation. The higher median observed in the spatially dense language condition cannot be interpreted as sufficient evidence that spatial language improved mental rotation performance. Rather, the analysis did not establish a statistically significant difference between the two conditions under the procedures employed. This finding also does not demonstrate that both conditions were equivalent or that spatial language has no relationship with spatial cognition.

The findings may be considered alongside existing research on spatial language and cognitive development. Wu et al. (2022) identified substantial evidence connecting early spatial language development with spatial skills and cognition. Similar relationships between spatial language and spatial performance have been reported among children (Gilligan-Lee et al., 2021). However, much of this evidence concerns developmental relationships and linguistic experiences accumulated over time rather than brief exposure immediately preceding a spatial assessment. The present findings therefore do not necessarily contradict the broader literature. Instead, they indicate that developmental

International Journal of Education, Learning, and Pedagogical Sciences (INJELPS)
P - ISSN 3116-3769; E - ISSN 3116-3777
National Book Development Board (NBDB) Registration as Book Publisher (Print & Digital): 6312
PRC-CPD Accredited Provider: PTR-2025-749

associations may not translate into a statistically detectable difference following a single brief exposure among undergraduate students.

From an educational perspective, the findings provide a basis for examining how spatial language is incorporated into instructional practice. Teachers frequently use positional and directional expressions when explaining diagrams, models, anatomical structures, and other materials involving spatial relationships. Although such language may assist in communicating these relationships, the present findings do not establish that brief spatial-language exposure is effective as a stand-alone method for improving immediate mental rotation performance. Instructional materials may therefore integrate precise spatial terminology with visual representations, demonstrations, and guided learning activities. This direction is consistent with educational research addressing visualizations and spatially enriched learning experiences (Taylor et al., 2023; Zhu et al., 2023).

The findings also have implications for teacher education, curriculum development, and educational assessment. Teacher preparation programs may consider how spatial vocabulary can be coordinated with visual and experiential instructional approaches, while curriculum developers may evaluate how linguistic and visual representations are integrated into spatially demanding lessons. However, these implications remain tentative. The relatively small sample from a single institution, nonrandom allocation, brief exposure period, and limited validation of the researcher-constructed passages restrict the extent to which the observed results can be generalized or attributed specifically to spatial-language density. Performance on the MRT-A must likewise be interpreted within the particular task requirements and time constraints of the assessment.

Conclusions

The study found that brief exposure to spatially dense language did not produce a statistically significant difference in spatial visualization performance among undergraduate students under the conditions examined. Although the spatial-language group obtained a higher median score than the abstract-language group, the Mann–Whitney U test indicated that the difference was not statistically significant, $U = 122$, $p = .091$. Thus, the findings do not provide sufficient evidence to conclude that a single brief exposure to spatially dense language improves immediate mental-rotation performance.

The findings provide a cautious application of Perceptual Symbol Systems Theory to the present context. Spatial language may provide perceptual information concerning position, direction, and orientation, but the present study did not demonstrate that brief exposure to such language translated into improved mental-rotation performance. The findings therefore suggest that the relationship between linguistic input and spatial performance may be more complex than an immediate direct effect and may depend on factors such as exposure duration, prior spatial experience, accompanying representations, and task demands. These factors were not directly tested in the present study and therefore warrant further investigation.

From an educational perspective, spatially explicit language may communicate spatial relationships, but this study did not establish brief language exposure as an effective stand-alone method for improving immediate spatial visualization performance. Teachers and instructional designers may consider integrating precise spatial language with diagrams, models, demonstrations, and guided spatial activities. The study consequently contributes to educational psychology and instructional design by providing evidence that brief exposure to spatially dense language did not yield a statistically significant difference in immediate mental-rotation performance under the conditions examined.

The findings must also be considered within the methodological limitations of the study. The investigation involved a relatively small sample of 38 undergraduate psychology students from a single institution, with participants allocated through an alternating-column seating arrangement rather than established random assignment. Although the researcher-constructed language passages underwent content validation by one psychologist, no formal pilot testing or quantitative assessment of passage equivalence was conducted. Together with the brief exposure period, these limitations restrict the extent to which the observed differences can be attributed specifically to spatial-language density or generalized to other student populations and instructional settings.

Recommendations

1. For teachers, precise positional, directional, and relational language may be incorporated into instruction when students are learning spatial relationships. Such language may be used together with diagrams, models, demonstrations, and guided spatial activities rather than as a stand-alone strategy for improving mental-rotation performance.
2. For curriculum developers, instructional materials may integrate spatially precise language with corresponding visual representations in subjects that require spatial reasoning, visualization, orientation, and manipulation

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PRC-CPD Accredited Provider: PTR-2025-749

of spatial information. The effectiveness of such integrated approaches may be evaluated within specific learning contexts before broader implementation is considered.

3. For teacher education programs, opportunities may be provided for future teachers to develop skills in using spatial terminology together with visual and demonstrative instructional strategies. This may support clearer communication of spatial relationships while maintaining appropriate caution about the effects of brief linguistic exposure alone.
4. For educational programs and school leaders, evidence concerning spatial learning strategies may be considered when supporting instructional-material development and professional learning. However, the present findings do not provide sufficient evidence to recommend institution-wide adoption of spatial-language exposure as an intervention for improving spatial visualization.
5. For future researchers, larger and more diverse samples may be used to examine whether spatial language exposure produces different outcomes across academic disciplines, educational levels, and levels of prior spatial experience.
6. Future experimental studies may examine repeated or extended exposure to spatially dense language to determine whether effects emerge over time rather than following a single brief exposure. Future studies may also control for baseline spatial ability, prior mental-rotation experience, visuospatial training, attentional demands, and familiarity with spatial tasks.
7. Future research may employ additional measures of spatial cognition, including spatial orientation, spatial perception, and other forms of spatial processing, to determine whether linguistic exposure has different effects across distinct spatial abilities.

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International Journal of Education, Learning, and Pedagogical Sciences (INJELPS)
P - ISSN 3116-3769; E - ISSN 3116-3777
National Book Development Board (NBDB) Registration as Book Publisher (Print & Digital): 6312
PRC-CPD Accredited Provider: PTR-2025-749

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