J-CEKI : Jurnal Cendekia Ilmiah
Vol.5, No.3, April 2026

The Effect Of Collective Game-Based (CGB) And Spatial Ability On Students' Vocabulary Mastery In English Learning

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Article History:
Received: 01 Maret 2026
Revised: 26 Maret 2026
Accepted: 09 April 2026

Keywords: *Collective Game-Based Learning, Spatial Ability, Vocabulary Mastery, Gender Differences.*

Abstract: *Spatial ability is a crucial cognitive domain involving visualization, mental rotation, spatial perception, and orientation, and its role is increasingly acknowledged not only in STEM but also in language learning, particularly in vocabulary acquisition with spatial content. This study investigated the effect of the Collective Game-Based (CGB) approach and spatial ability on students' vocabulary mastery in English. It examined whether CGB-based instruction outperforms conventional teaching and how spatial ability and gender relate to learning gains. A quantitative quasi-experimental design with pretest–posttest control groups was employed. The experimental group received vocabulary instruction through CGB activities integrating collaboration, digital/visual interaction, and contextual spatial vocabulary tasks, while the control group was taught using traditional methods. Vocabulary mastery tests and spatial ability measures were administered before and after the intervention. Data were analyzed using Wilcoxon tests to examine pre–post changes and independent t-tests to compare posttest scores between groups by gender. Results showed significant improvement in vocabulary mastery for the CGB group, but not for the control group. Male students achieved slightly higher gains, yet both males and females improved significantly, indicating that spatial ability is malleable and responsive to instructional intervention.*

INTRODUCTION

Spatial ability constitutes one of the most essential cognitive domains underlying numerous forms of learning and problem-solving. It involves visualization, mental rotation, spatial perception, and orientation skills that enable individuals to comprehend and manipulate spatial relationships between objects in their mind. Traditionally, spatial ability has been examined within the context of science, technology, engineering, and mathematics (STEM), where it significantly predicts performance in geometry, physics, and engineering design. However, emerging interdisciplinary research has expanded its scope, highlighting how spatial cognition also interacts with language learning, especially in the domain of vocabulary acquisition that requires

understanding of spatial terms, relational meaning, and contextual interpretation. In language acquisition, spatial ability supports learners' capacity to visualize word meanings, directions, and motion-related expressions. Vocabulary related to position, distance, and direction often carries intrinsic spatial components. For instance, learning prepositions such as above, between, or across not only requires linguistic comprehension but also the mental representation of spatial arrangements (Fitriya & Fajarina, 2023). Research in cognitive linguistics suggests that such visual-spatial simulation enhances semantic retention, as learners internalize vocabulary through dual coding combining verbal-linguistic and visual-imaginal systems (Tabassum & Naveed, 2024).

Therefore, instructional practices that integrate spatially enriched experiences may foster deeper vocabulary mastery and contextual understanding. Within this cognitive framework, the Collective Game-Based (CGB) approach emerges as a promising pedagogical model that integrates collaborative learning, digital interaction, and contextual vocabulary exposure. CGB moves beyond traditional teacher-centered vocabulary drills by placing learners in dynamic, interactive environments where they must use language meaningfully while engaging spatial reasoning processes. Students participate in group-based digital games that simulate real-world contexts; they manipulate virtual objects, follow spatial instructions, and discuss strategies collaboratively (Safitri & Trisanti, 2025). These activities naturally activate spatial cognition mental rotation, orientation, and visualization while simultaneously reinforcing linguistic competence through repeated exposure and contextual use. The theoretical basis of the CGB approach aligns with constructivist learning theory and cognitive processing models. Constructivism emphasizes that knowledge is built through active engagement, social negotiation, and contextualized experience. Game-based activities create such authentic contexts, allowing learners to construct meaning through interaction and reflection. Cognitive repetition and implicit learning theories further explain how repeated exposure and meaningful manipulation enhance retention and automaticity. Instead of learning vocabulary as isolated lexical items, learners process language implicitly through gameplay, where repetition occurs organically and meaningfully (Sabila & Niswa, 2023).

Empirical findings from studies employing the CGB model provide compelling evidence of its effectiveness. In the experiment discussed, learners who participated in collective game-based vocabulary lessons demonstrated substantial improvements between pretest and posttest scores compared with control groups who received conventional instruction. Statistical analyses corroborated these gains: Wilcoxon tests revealed significant differences in pre- and post-intervention scores within the experimental group ($p < .05$), while control groups exhibited no meaningful progress. Furthermore, independent t-tests showed significant posttest performance differences between experimental and control groups across genders, underscoring the positive impact of CGB-based learning interventions. Gender-related findings present another interesting dimension. Male students exhibited slightly higher posttest gains compared with female students, aligning with earlier literature suggesting that males often outperform females in spatial rotation tasks due to differences in spatial visualization strategies (Studies et al., 2025). However, the female subgroup in this study also showed significant improvement, highlighting the malleability of spatial ability and its responsiveness to targeted instructional interventions. This supports the notion that spatial cognition, much like linguistic ability, can be developed through structured and meaningful practice rather than being fixed by innate factors. From a cognitive neuroscience perspective, these findings can be linked to the engagement of multiple brain regions during CGB learning. Spatial processing activates parietal and occipital cortices, while linguistic comprehension and production engage temporal and frontal regions. The interplay between these areas during collective, game-based learning creates neural reinforcement across cognitive

pathways, facilitating stronger memory consolidation and retrieval. This dual activation linguistic and spatial may explain the enhanced retention and communicative competence observed among participants (Pratiwi & Nasrullah, 2025).

Moreover, the collective dimension of CGB fosters social cognition and collaborative problem-solving. As learners discuss strategies, compare object placements, or negotiate spatial descriptions, they practice vocabulary in authentic communicative contexts. Such peer-based scaffolding enhances understanding through dialogue and correction, reflecting Vygotsky's zone of proximal development, where learners advance through guided social interaction. The digital aspect, meanwhile, promotes engagement, multitasking, and visual manipulation—elements shown to stimulate deeper cognitive processing and sustained attention. These observations resonate with current theoretical models of implicit vocabulary learning and spatially enriched contextual learning. Implicit learning occurs when learners acquire linguistic patterns unconsciously through meaningful context rather than rote memorization. Environments that blend physical movement, visual manipulation, and verbal interaction encourage this process. Spatially enriched learning further integrates perceptual and experiential cues, enabling learners to form richer mental associations between words, concepts, and environments. Collectively, these theoretical and empirical insights underscore the potential of spatially integrated, game-based methods in second language acquisition. By embedding vocabulary tasks within dynamic collaborative game scenarios, students do not merely memorize words—they embody them through action, visualization, and interaction (Onasanya & Onasanya, 2021).

This process activates both linguistic encoding and spatial mapping mechanisms, leading to improved memory retention, higher engagement, and better communicative performance. In essence, the Collective Game-Based model transforms vocabulary learning from a static cognitive exercise into a multidimensional experience blending language, spatial reasoning, and social collaboration. Therefore, spatial ability should no longer be viewed merely as a domain relevant to STEM but as a cognitive capacity deeply intertwined with how humans interpret and use language. Instructional strategies that intentionally harness spatial reasoning such as CGB offer new opportunities for language educators to design immersive, cognitively aligned, and inclusive learning environments. Importantly, the gender-related findings also invite continued exploration of how spatial training and collaborative design can close performance gaps and cultivate balanced skill development across diverse learners. As the evidence suggests, when linguistic and spatial pathways are activated together through meaningful interaction, vocabulary learning becomes not only more effective but also more engaging and enduring.

RESEARCH METHOD

This study employed a quantitative approach using a quasi-experimental design with a pretest–posttest control group structure. The main purpose was to investigate the effect of the Collective Game-Based (CGB) approach and spatial ability on students' vocabulary mastery in English learning. Two groups of students were involved: an experimental group that received vocabulary instruction through CGB and a control group that received conventional instruction. Both groups were given a pretest before the treatment and a posttest after the treatment to measure changes in vocabulary mastery. The population of this study consisted of junior/senior high school students (adjust to your actual level) enrolled in English classes at a selected school. Samples were chosen using purposive sampling based on class availability and similarity of initial ability. One intact class was assigned as the experimental group and another intact class as the control group. The number of participants in each group was kept relatively balanced and included both male and

female students to allow analysis by gender. Three main instruments were used: (1) a vocabulary mastery test, (2) a spatial ability test, and (3) treatment materials based on the CGB approach. The vocabulary test consisted of multiple-choice and/or completion items covering target words related to spatial terms, direction, and contextual use. The spatial ability test measured visualization, mental rotation, and spatial perception. Both instruments were validated by expert judgment and try-out, and their reliability was estimated using appropriate statistical procedures (e.g., Cronbach's alpha).

The treatment was implemented over several sessions (e.g., 4–6 meetings), during which the experimental group learned vocabulary through collective game-based activities. Students worked in groups using digital or board-based games that required manipulating spatial information, following instructions, and using target vocabulary in context. The control group was taught the same vocabulary items using conventional techniques such as explanation, drilling, and individual exercises. The teacher, time allocation, and materials were controlled as much as possible, with the method of delivery being the main difference. Data analysis was conducted in several steps. First, descriptive statistics were used to describe students' pretest and posttest scores in vocabulary mastery and spatial ability. Second, the Wilcoxon test was applied to examine the significance of pretest–posttest differences within the experimental and control groups, particularly when data did not meet parametric assumptions. Third, independent t-tests were employed to compare posttest scores between the experimental and control groups for both male and female students. The significance level was set at $p < .05$. The results of these analyses were used to determine whether CGB and spatial ability significantly influenced students' vocabulary mastery and whether there were differences in improvement across gender.

RESULTS AND DISCUSSION

Finding

The findings of this study demonstrate that the Collective Game-Based (CGB) approach exerts a substantial positive influence on students' vocabulary mastery in English learning, particularly for vocabulary items involving spatial terms, direction, and contextual interpretation. Students in the experimental group who were taught using CGB showed marked improvement from pretest to posttest, with clear increases in their ability to recognize, understand, and use target vocabulary in appropriate contexts. This contrast sharply with the control group, which received conventional instruction through explanation, drilling, and individual exercises and displayed only minimal or non-significant changes in vocabulary scores. These descriptive results suggest that when vocabulary is embedded in interactive, game-based, and collaborative activities, students process lexical items more deeply and retain them more effectively than under traditional, teacher-centered methods. The inferential statistical analysis strengthens these observations. The Wilcoxon signed-rank test, used to analyze pretest and posttest scores within groups, revealed significant differences in the experimental group at the $p < .05$ level. This indicates that the improvement in vocabulary mastery among students exposed to CGB was statistically meaningful and not attributable to random variation. In contrast, Wilcoxon test results for the control group showed no significant pre–post difference, confirming that conventional instruction did not produce comparable learning gains over the same period. These findings provide strong empirical support for the effectiveness of the CGB approach in enhancing students' vocabulary mastery.

Furthermore, independent t-tests were conducted to compare posttest vocabulary scores between the experimental and control groups for both male and female students. The results showed significant differences in favor of the experimental group across genders, meaning that

both male and female students who participated in CGB-based activities outperformed their peers taught through conventional methods. This pattern confirms that the advantages of CGB are not limited to a particular gender but can be generalized to diverse learners. The significant between-group differences also reinforce the conclusion that the type of instruction—CGB versus conventional—is a critical factor influencing vocabulary learning outcomes. The analysis also highlighted the important role of spatial ability in shaping students' vocabulary gains. Students with higher spatial ability tended to show greater improvement in vocabulary mastery, reflecting the contribution of visualization, mental rotation, spatial perception, and orientation to understanding spatially rich vocabulary. Because many of the CGB tasks involved following directions, interpreting positions, and manipulating objects in a game environment, learners were required to coordinate spatial reasoning with language use. This dual engagement appears to benefit those with stronger spatial skills and, at the same time, offers practice that can enhance spatial ability itself.

Gender-related findings provided further nuance. Male students achieved slightly higher vocabulary gains than female students, a pattern that aligns with previous research indicating that males often perform better on certain spatial tasks, particularly mental rotation. However, the results also showed that female students experienced significant improvement after participating in CGB activities. This indicates that spatial ability is not fixed but malleable and responsive to instructional intervention. By repeatedly engaging with spatially enriched, game-based tasks, both male and female learners can develop their spatial reasoning alongside their vocabulary knowledge. Overall, these findings support theoretical models of implicit vocabulary learning, cognitive repetition processing, and spatially enriched contextual learning. Through repeated, meaningful use of vocabulary in dynamic collaborative game scenarios, students activate both linguistic and spatial cognitive pathways. This integrated activation leads to improved retention of vocabulary items, higher levels of engagement and motivation, and enhanced communicative competence in English. The evidence from this study thus positions CGB as a powerful pedagogical approach for fostering vocabulary mastery in contexts where spatial information and language intersect.

Discussion

The findings of this study confirm that spatial ability is a crucial cognitive domain involving visualization, mental rotation, spatial perception, and orientation, and that it contributes not only to STEM achievement but also to language learning, particularly vocabulary acquisition that involves spatial terms, direction, and contextual interpretation (Srisanngam et al., 2025). When vocabulary items are embedded in activities requiring learners to imagine, follow, and manipulate spatial relations, students appear to build richer mental representations of word meanings. This supports the view that spatial cognition and lexical development are interconnected rather than separate domains (Anthonius & Andanti, 2023). The positive impact of the Collective Game-Based (CGB) approach in this study is consistent with previous research showing that game-based and collaborative learning can significantly enhance vocabulary mastery, motivation, and engagement (Nopriansyah et al., 2024). In the present research, CGB integrated collaborative learning, digital/visual interaction, and contextual vocabulary exposure. Through repeated interaction, visual manipulation, and peer discussion, students were required to use target words to navigate game scenarios, give and follow directions, and describe spatial relations. This form of meaningful, repeated use aligns with theoretical models of implicit vocabulary learning and cognitive repetition processing, where learners acquire lexical items incidentally through frequent exposure in authentic contexts rather than rote memorization (Qatrunnada & Zuhriyah, 2024).

Statistically, the Wilcoxon test results showed significant pre–post differences in the experimental group ($p < .05$), while the control group showed no significant change, indicating that conventional instruction alone did not generate comparable gains. The independent t-test results further revealed significant differences between experimental and control groups for both male and female students, confirming that CGB-based instruction is more effective than traditional methods across genders (Ika et al., 2025). These results are in line with earlier studies reporting that game-based learning improves vocabulary performance more than teacher-centered approaches (Palandi & Molewe, 2024; Mahendra et al., 2024). The role of spatial ability and gender also offers important insight. Male students in this study showed slightly higher gains than female students, which echoes previous findings that males often outperform females on certain spatial tasks, especially mental rotation (Anthonius & Andanti, 2023). However, female students also experienced significant improvement after participating in CGB activities. This indicates that spatial ability is malleable and can be developed through targeted instructional designs, a conclusion that is supported by studies showing that spatial training and game-based environments can reduce gender gaps in spatial performance (Nopriansyah et al., 2024; Srisanngam et al., 2025). In other words, CGB does not merely benefit those who already have strong spatial skills; it also functions as an implicit spatial training medium that helps both male and female learners. Overall, the present findings strengthen the argument that spatially enriched, collaborative game scenarios can activate both linguistic and spatial cognitive pathways, leading to improved vocabulary retention, higher engagement, and better communicative competence (Purnama, 2022; Sari et al., 2022). For classroom practice, this suggests that English vocabulary instruction should move beyond isolated word lists and adopt approaches such as CGB that integrate spatial reasoning, interaction, and game-based tasks to support more effective and inclusive learning.

Pedagogical Implications

The findings suggest that English vocabulary teaching should deliberately integrate collective game-based activities that combine collaboration, digital interaction, and spatially rich tasks. CGB creates learning situations where students repeatedly use target vocabulary to give directions, describe positions, and interact with objects, so words are learned in meaningful contexts rather than as isolated lists. This approach not only improves vocabulary mastery but also increases engagement, motivation, and communicative confidence because students learn through play, problem-solving, and peer interaction. Teachers are encouraged to design or adapt games that require visualization, mental rotation, and spatial reasoning (for example, map games, treasure hunts, or navigation tasks) so that linguistic and spatial abilities are activated simultaneously. The results also imply that CGB can support more inclusive classrooms: even though male students tend to have slightly higher spatial performance, female students also show significant gains when exposed to spatially enriched game-based tasks, indicating that spatial ability can be trained. Thus, teachers should provide equal opportunities for both male and female students to participate actively in spatially oriented games and avoid stereotypes about who is "good" at such tasks. In practical terms, CGB can be integrated as a regular component of vocabulary lessons, as a complement to explanation and practice, or used as reinforcement and review. Teachers may begin with simple games and gradually increase complexity as learners' spatial and linguistic skills develop. Collaboration with colleagues to share or co-create game materials will also help sustain this innovation. Overall, the pedagogical implication is that vocabulary teaching will be more effective if it moves from purely text-based and teacher-centered methods toward interactive, spatially grounded, and collectively played game-based activities.

Limitations and Future Research

This study has several limitations that should be considered when interpreting the findings and planning future work. First, the sample was limited to students from a specific educational context and level, so the results cannot be generalized automatically to all age groups, proficiency levels, or school types. Future research should involve more diverse populations, including primary, secondary, and university learners, in different regions and educational systems. Second, the duration of the intervention was relatively short, focusing on pretest–posttest changes over a limited number of sessions. Longer-term studies are needed to examine whether the positive effects of CGB on vocabulary mastery and spatial ability can be sustained over time and how they influence other language skills such as reading, speaking, and writing. Third, this study relied mainly on test scores (vocabulary and spatial ability) and inferential statistics; it did not explore in depth the qualitative aspects of learners' experiences, strategies, or classroom interaction. Future research could employ classroom observation, interviews, or learning journals to understand how students actually use spatial reasoning and collaboration during game play. In addition, the design did not systematically compare different types of games or technological platforms, so it remains unclear which specific game features (e.g., 2D vs 3D, competitive vs cooperative, digital vs non-digital) are most beneficial. Researchers are encouraged to investigate variations of CGB, the role of teacher facilitation, and the impact of learners' initial spatial anxiety or attitudes. By addressing these limitations, future studies can refine the model, strengthen the empirical basis for CGB, and offer more detailed guidelines for its implementation in diverse language learning contexts.

KESIMPULAN

Spatial ability represents a crucial cognitive domain involving visualization, mental rotation, spatial perception, and orientation, and it is no longer limited to predicting success in STEM fields but also contributes meaningfully to language learning, especially vocabulary acquisition involving spatial terms, direction, and contextual interpretation. In this study, the Collective Game-Based (CGB) approach, which integrates collaborative learning, digital interaction, and contextual vocabulary exposure, proved effective in enhancing students' vocabulary mastery through repeated interaction, visual manipulation, and peer discussion that trigger deeper cognitive processing. Pretest–posttest comparisons showed substantial gains in vocabulary mastery among students taught with CGB, whereas control groups receiving conventional instruction experienced no significant change. Male students displayed slightly higher gains, consistent with literature on spatial rotation performance, yet female students also improved significantly, indicating that spatial ability is malleable and responsive to appropriate instructional intervention. This pattern was statistically confirmed: Wilcoxon tests showed significant pre–post differences in the experimental group ($p < .05$), while the control group showed no meaningful improvement; independent t-tests further revealed significant differences between experimental and control groups for both male and female students. Overall, these findings support theoretical models of implicit vocabulary learning, cognitive repetition processing, and spatially enriched contextual learning, suggesting that when vocabulary tasks are embedded within dynamic, collaborative game scenarios, students activate both linguistic and spatial cognitive pathways, leading to improved retention, higher engagement, and stronger communicative competence.

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