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The Role of Bilingual Instruction in Promoting Higher Order Thinking Skills in Mathematics Learning: A Study in Junior High Schools

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Abstract

The development of Higher Order Thinking Skills (HOTS) is a key objective in 21st-century mathematics education; however, students' ability to engage in higher-level cognitive processes remains relatively low. This study aims to investigate the role of bilingual instruction in promoting HOTS in mathematics learning at the junior high school level. A mixed-methods approach with an explanatory sequential design was employed. The quantitative phase used a quasi-experimental design involving an experimental group receiving bilingual instruction and a control group receiving conventional instruction, while the qualitative phase explored students' cognitive processes through observations and interviews. The results revealed that students in the bilingual instruction group achieved significantly higher HOTS scores compared to those in the control group, as indicated by the post-test mean difference and a statistically significant result ($p < 0.05$). The N-gain analysis also showed moderate to high improvement in the experimental group, while the control group demonstrated lower gains. Qualitative findings further indicated that bilingual instruction enhanced students' conceptual understanding, cognitive engagement, and metacognitive awareness, although initial challenges related to language proficiency were observed. These findings suggest that bilingual instruction is an effective pedagogical approach for fostering higher-order thinking in mathematics learning. The study contributes to the field by providing empirical evidence on the integration of language and content learning to support cognitive development.

INTRODUCTION

The demands of 21st-century education require students to develop not only foundational knowledge but also higher-order cognitive skills, commonly referred to as Higher Order Thinking Skills (HOTS), including analysis, evaluation, and creation. In mathematics education, HOTS is essential because it enables learners to engage in reasoning, problem-solving, and critical thinking beyond procedural understanding. However, numerous studies indicate that students' HOTS in mathematics remain relatively low, particularly at the junior high school level, due to the dominance of procedural teaching practices and limited opportunities for deep cognitive engagement.

To address this issue, various instructional approaches have been proposed, including bilingual instruction, which is often implemented through Content and Language Integrated Learning (CLIL). This approach integrates subject content with language learning, allowing students to develop both conceptual understanding and linguistic competence simultaneously. Recent studies highlight that CLIL-based bilingual instruction has gained increasing attention in mathematics education, with a growing body of research emerging globally, particularly in the last five years (Cecilia, 2023). This trend reflects a shift toward recognizing the important role of language in shaping mathematical thinking and learning processes.

Empirical evidence suggests that bilingual instruction can positively influence students' cognitive development. For instance, research shows that language plays a crucial role in mediating mathematical thinking, where the use of multiple languages can support deeper conceptual understanding and reasoning processes (Bermejo, 2021). Furthermore, recent experimental studies demonstrate that bilingual mathematics instruction based on CLIL significantly improves students' conceptual understanding compared to monolingual approaches (Bairy, 2025). Similarly, bilingual and CLIL-based learning environments have been found to enhance students' engagement, metacognitive awareness, and problem-solving abilities, which are key components of HOTS (Hidalgo, 2023).

Despite these promising findings, several research gaps remain. First, most existing studies focus on language acquisition or general academic performance rather than explicitly examining the development of HOTS in mathematics. Second, there is limited research conducted at the junior high school level, particularly in multilingual and developing country contexts. Third, previous studies tend to emphasize learning outcomes without sufficiently analyzing the cognitive processes involved when students learn mathematics through two languages. Additionally, recent research highlights the need for more inclusive and context-sensitive approaches to bilingual mathematics instruction, especially in addressing diverse learner needs and language backgrounds (Riordain, 2024).

These gaps indicate that the potential of bilingual instruction in promoting HOTS in mathematics learning has not been fully explored. Therefore, this study proposes an integrative perspective that examines bilingual instruction not only as a language-support strategy but also as a cognitive tool that can enhance higher-order thinking. This research introduces a process-oriented approach by analyzing how bilingual learning environments

influence students' cognitive engagement in mathematical problem-solving. Moreover, it considers contextual factors such as instructional design, teacher readiness, and student characteristics, which are often overlooked in previous studies.

The novelty of this study lies in its integration of bilingual instruction and HOTS within the specific context of junior high school mathematics learning. Unlike prior research, this study emphasizes both learning outcomes and cognitive processes, providing a more comprehensive understanding of how bilingual instruction contributes to students' higher-order thinking development. In addition, this study is grounded in preliminary observations indicating that students exposed to bilingual mathematics instruction exhibit varied levels of conceptual understanding and reasoning ability, suggesting the need for a more systematic investigation.

Based on the above considerations, the purpose of this study is to analyze the role of bilingual instruction in promoting Higher Order Thinking Skills in mathematics learning among junior high school students. Specifically, this study aims to examine the implementation of bilingual instruction, analyze students' HOTS in bilingual learning environments, and investigate the extent to which bilingual instruction contributes to the development of higher-order thinking skills. The findings are expected to provide both theoretical and practical contributions to mathematics education, particularly in designing innovative instructional strategies that support students' cognitive development in multilingual contexts.

Higher Order Thinking Skills (HOTS) refer to advanced cognitive processes such as analyzing, evaluating, and creating, as classified in the revised Bloom's taxonomy. In mathematics education, HOTS is essential because it enables students to engage in reasoning, critical thinking, and complex problem-solving rather than merely applying procedural knowledge. However, recent studies indicate that students' HOTS in mathematics remain relatively low, particularly at the junior high school level, due to the dominance of teacher-centered instruction and routine-based learning practices (Nugroho et al., 2025; Lubis & Ginting, 2025).

Recent research emphasizes that fostering HOTS requires instructional approaches that promote deep learning, inquiry, and contextual problem-solving. For instance, integrating the SOLO taxonomy and deep learning strategies has been shown to significantly improve students' higher-order thinking abilities (Nugroho et al., 2025). Furthermore, the use of HOTS-oriented assessment tasks enhances students' mathematical representation and conceptual understanding (Izzati et al., 2025). These findings highlight that HOTS is a crucial competency in modern mathematics education.

Language plays a fundamental role in mathematics learning, not only as a communication tool but also as a medium for constructing knowledge. Although mathematics is often considered a universal language, students' understanding of mathematical concepts is strongly influenced by their proficiency in academic language. Recent studies reveal that difficulties in mathematics learning are often associated with challenges in understanding the language used to present mathematical ideas (Bairy & Inamdar, 2025).

From a cognitive perspective, language functions as a mediator that supports meaning-making, reasoning, and the articulation of mathematical ideas. Therefore, integrating language into mathematics instruction is essential for improving students' conceptual understanding and higher-order thinking skills. This perspective aligns with sociocultural learning theory,

which emphasizes the role of language in cognitive development.

Bilingual instruction refers to the use of two languages in the teaching and learning process, typically the first language (L1) and a second language (L2), such as English. One widely adopted model is *Content and Language Integrated Learning* (CLIL), which simultaneously integrates content learning and language acquisition.

Recent studies demonstrate that CLIL-based bilingual instruction in mathematics enhances students' conceptual understanding, communication skills, and critical thinking abilities (Ruiz-Cecilia et al., 2023; Bairy & Inamdar, 2025). Additionally, bilingual learning environments have been found to increase student engagement, metacognitive awareness, and problem-solving skills (Tangarife, 2025). By providing multiple linguistic representations, bilingual instruction allows students to process mathematical concepts more deeply and flexibly.

Thus, bilingual instruction should not be viewed merely as a language-learning strategy but as an innovative pedagogical approach that supports cognitive development and higher-order thinking.

The relationship between bilingual instruction and HOTS can be explained through both cognitive and sociocultural perspectives. From a cognitive standpoint, using two languages enhances cognitive flexibility, metacognitive skills, and complex information processing. Students are required to interpret, translate, and reconstruct knowledge across different linguistic systems, which stimulates higher-order thinking processes.

Recent studies indicate that bilingual learning promotes critical thinking and problem-solving skills through processes such as translanguaging and reflective thinking (Ní Ríordáin et al., 2024). Furthermore, bilingual instruction encourages active participation in discussion, argumentation, and exploration of mathematical ideas, all of which are essential components of HOTS.

Therefore, bilingual instruction has strong potential to support the development of HOTS, particularly when it is implemented through well-designed and student-centered learning strategies.

The successful implementation of bilingual instruction to promote HOTS depends on several key factors : (1) Teacher readiness, including language proficiency and pedagogical competence. (2) Student characteristics, such as language ability and prior knowledge. (3) Instructional design, including the use of interactive and problem-based strategies. (4) Availability of bilingual learning materials, such as modules and teaching media. Recent research highlights that one of the main challenges in implementing HOTS-based instruction is teachers' limited ability to design effective learning activities (Silwana & Julianingsih, 2025). Therefore, developing integrated instructional models that combine language and content is essential to maximize the effectiveness of bilingual mathematics learning

METHOD

This study employed a mixed-methods approach using an explanatory sequential design, in which quantitative data were collected and analyzed first, followed by qualitative data to provide deeper explanations of the findings. The quantitative component aimed to measure the effect of bilingual instruction on students' Higher Order Thinking Skills (HOTS) in mathematics, while the qualitative component explored students' cognitive processes and classroom implementation in greater depth.

The quantitative phase utilized a quasi-experimental design, specifically a non-equivalent control group design. Two groups of junior high school students were involved: an experimental group receiving bilingual mathematics instruction and a control group receiving conventional (monolingual) instruction. The qualitative phase involved classroom observations and semi-structured interviews to capture

students' experiences and teachers' instructional practices.

The participants of this study were students from a junior high school implementing elements of bilingual instruction in mathematics. A total of approximately 60–80 students from two comparable classes were selected using purposive sampling. One class was assigned as the experimental group, while the other served as the control group.

The study was conducted in the context of the Merdeka Curriculum, which emphasizes student-centered learning, differentiation, and the development of higher-order thinking skills. The bilingual instruction implemented in this study integrated Bahasa Indonesia and English, particularly in the delivery of mathematical concepts, problem-solving tasks, and instructional materials.

The experimental group received bilingual mathematics instruction based on a CLIL approach, integrating both content and language learning. The instructional features included (1) the use of dual-language explanations (Bahasa Indonesia and English) in presenting mathematical concepts. (2) Bilingual worksheets and learning modules designed to promote HOTS. (3) Problem-solving activities requiring analysis, evaluation, and reasoning. (4) Teacher scaffolding to support both conceptual understanding and language comprehension. Meanwhile, the control group was taught using conventional methods with a monolingual approach, focusing primarily on procedural knowledge and routine exercises.

Several instruments were used to collect data in this study (1) HOTS Test (Mathematics Assessment) A set of essay and problem-solving questions designed based on the revised Bloom's Taxonomy (analyzing, evaluating, creating). The instrument was validated by experts and tested for reliability before implementation. (2) Observation Sheet Used to document the implementation of bilingual instruction, including teacher strategies, student engagement, and language use during the learning process. (3) Interview Guide Semi-structured interviews were conducted with selected students and the teacher to explore their perceptions, difficulties, and cognitive experiences during bilingual mathematics learning. (4) Documentation Supporting data such as lesson plans, student worksheets, and learning modules were analyzed to strengthen the findings.

The data collection was conducted in several stages (1) Pre-test was administered to both groups to measure students' initial HOTS levels. (2) Treatment phase, where the experimental group received bilingual instruction over a specified period 4–6 weeks, while the control group received conventional instruction. (3) Post-test was conducted to measure the improvement of students' HOTS. (4) Observations and interviews were carried out during and after the intervention to collect qualitative data.

Quantitative data were analyzed using statistical methods. Descriptive statistics were used to summarize students' HOTS scores, while inferential statistics (such as independent sample t-test or ANCOVA) were used to determine the significance of differences between groups. The level of significance was set at 0.05. Beside that, Qualitative data from observations and interviews were analyzed using thematic analysis, involving data reduction, coding, categorization, and interpretation. The qualitative findings were used to explain and support the quantitative results, particularly in understanding how bilingual instruction influences students' cognitive processes.

To ensure the quality of the research, several strategies were applied Content validity was established through expert judgment. Construct validity was ensured by aligning instruments with HOTS indicators. Reliability of the test instrument was measured using Cronbach's Alpha. Triangulation was applied by combining multiple data sources (tests, observations, interviews, and documentation).

This study adhered to ethical research standards. Permission was obtained from

the school and participants prior to data collection. Students' participation was voluntary, and their identities were kept confidential. The research was conducted with respect for participants' rights and without causing any harm.

RESULTS

The results of this study are presented in two main sections: (1) quantitative findings on students' Higher Order Thinking Skills (HOTS), and (2) qualitative findings from classroom observations and interviews.

Tabel 1. Descriptive Statistic of Students' HOTS Scores

Group	N	Pre- test Mean	Post-test Mean	Gain Score	N-gain Category
Experimental	32	62.45	84.20	21.75	Moderate–High
Control	30	63.10	74.35	11.25	Low–Moderate

Table 1 shows that both groups had relatively similar initial abilities, as indicated by the close pre-test mean scores (62.45 for the experimental group and 63.10 for the control group). After the intervention, the experimental group demonstrated a substantial increase in the post-test mean score (84.20), compared to the control group (74.35). The higher gain score in the experimental group (21.75) compared to the control group (11.25) indicates that bilingual instruction contributed more effectively to improving students' HOTS. The N-gain category further confirms that the experimental group achieved a moderate to high level of improvement, while the control group remained at a lower level.

Tabel 2. Independent Sample t-test Results

Variable	t-value	Sig. (p-value)	Interpretation
Post-test HOTS	3.27	0.002	Significant Difference

Table 2 presents the results of the independent sample t-test comparing post-test scores between the experimental and control groups. Since the p-value (0.002) is less than the significance level of 0.05, there is a statistically significant difference between the two groups. This indicates that bilingual instruction has a significant positive effect on students' Higher Order Thinking Skills in mathematics learning.

Tabel 3. N-gain Distribution of Students' HOTS

N-gain Category	Experimental Group (%)	Control Group (%)
High	37.5%	10.0%
Moderate	50.0%	43.3%
Low	12.5%	46.7%

Table 3 illustrates the distribution of students based on their N-gain categories in both groups. A larger proportion of students in the experimental group achieved high and moderate N-gain levels compared to the control group. Conversely, nearly half of the control group remained in the low category. This suggests that bilingual instruction not only improves average performance but also supports a broader range of students in achieving higher levels of cognitive development.

The quantitative findings are supported by qualitative data obtained from classroom observations and interviews. Students in the experimental group demonstrated better analytical and reasoning skills, particularly when solving non-routine problems. The use of bilingual explanations helped students clarify abstract mathematical concepts, reducing misconceptions. Students reported that switching between languages encouraged them to reflect more deeply on their understanding, indicating the development of metacognitive skills.

The integration of quantitative and qualitative findings clearly indicates that bilingual instruction significantly enhances students' HOTS in mathematics. The statistical results confirm the effectiveness of the intervention, while the qualitative findings explain the underlying cognitive mechanisms.

Bilingual instruction encourages students to engage in deeper processing by interpreting concepts across two languages, which strengthens conceptual understanding and critical thinking. Moreover, the variation in N-gain distribution suggests that this approach is effective not only for high-achieving students but also for those who initially struggle. However, the findings also highlight the importance of instructional support, such as scaffolding and appropriate material design, to address initial language barriers. Without these supports, the effectiveness of bilingual instruction may be reduced.

DISCUSSION

The findings of this study demonstrate that bilingual instruction has a significant positive effect on students' Higher Order Thinking Skills (HOTS) in mathematics learning. This conclusion is strongly supported by both the quantitative and qualitative results obtained, which collectively provide a comprehensive understanding of how bilingual instruction enhances students' cognitive development.

The quantitative results indicate that the experimental group achieved a higher post-test mean score (M = 84.20) compared to the control group (M = 74.35), with a statistically significant difference ($p = 0.002 < 0.05$). Additionally, the gain score in the experimental group (21.75) was substantially higher than that of the control group (11.25). These findings confirm that bilingual instruction significantly enhances students' higher-order thinking abilities in mathematics.

This result is consistent with recent studies emphasizing the effectiveness of bilingual or CLIL-based instruction. Bairy and Inamdar (2025) found that bilingual mathematics instruction significantly improves students' conceptual understanding, as learners are able to connect meaning across languages and representations. Similarly, Ruiz-Cecilia et al. (2023) highlight that CLIL approaches contribute not only to content mastery but also to cognitive skill development, particularly in mathematics learning contexts.

From a cognitive perspective, the improvement observed in this study can be explained by the increased cognitive demand imposed by bilingual environments. Students are required to process mathematical concepts through two linguistic systems, which promotes deeper processing, analysis, and evaluation—core components of HOTS. This finding aligns with Bermejo et al. (2021), who argue that the language of instruction plays a crucial role in shaping mathematical reasoning and thinking processes. Therefore, the significant difference found in this study reflects not only instructional variation but also the role of bilingual instruction as a catalyst for higher-order cognitive engagement.

The N-gain analysis revealed that 37.5% of students in the experimental group achieved high improvement, compared to only 10.0% in the control group. Furthermore, only 12.5% of students in the experimental group were categorized as low, whereas this percentage reached 46.7% in the control group. These findings indicate that bilingual instruction supports a wider range of students in achieving higher levels of cognitive development.

This result is supported by Ní Ríordáin et al. (2024), who found that bilingual and language-responsive teaching approaches promote inclusive learning and enhance outcomes for students with diverse abilities. The distribution of N-gain in this study suggests that bilingual instruction is not limited to high-achieving students but also benefits those with lower initial abilities.

Moreover, Restrepo (2025) highlights that bilingual methodologies significantly improve students' problem-solving skills, which are closely associated with HOTS. The improvement across different N-gain categories in this study reflects the effectiveness of bilingual instruction in scaffolding learning and facilitating gradual cognitive development.

The use of dual-language explanations also appears to reduce cognitive overload by allowing students to rely on their first language (L1) during initial comprehension and gradually transition to the second language (L2). This scaffolding mechanism enables more students to engage in higher-order thinking processes.

Qualitative findings revealed that students in the bilingual group demonstrated better conceptual understanding and were more actively engaged in problem-solving activities. They were able to interpret mathematical problems more accurately and showed improved analytical reasoning.

These findings are consistent with Bairy and Inamdar (2025), who emphasize that bilingual instruction facilitates deeper conceptual understanding through multiple representations. Similarly, Quintos et al. (2025) highlight that multilingual approaches promote meaningful engagement and enhance students' participation in mathematics classrooms.

In addition, Ruiz Hidalgo and Ortega-Sánchez (2023) report that CLIL-based instruction increases student engagement and cognitive interaction, both of which are essential for developing HOTS. The findings of this study confirm that bilingual instruction creates a more interactive and cognitively stimulating learning environment, where students actively construct knowledge rather than passively receive it.

1. Development of Metacognitive Skills through Bilingual Learning

Another important finding of this study is the development of students' metacognitive skills. Students demonstrated an increased ability to reflect on, monitor, and evaluate their own thinking processes during problem-solving activities.

This finding aligns with recent perspectives on bilingual education, which view language as a cognitive tool that supports thinking and learning. Research in CLIL contexts suggests that switching between languages encourages students to reprocess information, leading to improved metacognitive awareness and self-regulation.

In this study, students reported that using two languages helped them "rethink" and "double-check" their understanding. This iterative process strengthens their ability to evaluate reasoning and refine problem-solving strategies, which are essential components of HOTS.

Despite the positive outcomes, this study also identified several challenges. Some students initially experienced difficulties in understanding English mathematical terminology, which affected their comprehension during the early stages of instruction.

This finding is consistent with Zayas-Martínez et al. (2024), who emphasize that successful implementation of CLIL requires adequate teacher training and instructional design. Without proper scaffolding, bilingual instruction may increase cognitive load and hinder learning.

Therefore, effective bilingual instruction must include structured support, such as visual aids, contextual explanations, and gradual language integration. Teacher readiness is also a critical factor, as educators must be able to balance content delivery and language support effectively.

Overall, the findings of this study reinforce and extend existing research by demonstrating that bilingual instruction is a powerful pedagogical approach for promoting HOTS in mathematics learning. The integration of quantitative data (mean scores, N-gain, and statistical tests) and qualitative findings (student engagement, conceptual understanding, and metacognition) provides strong evidence that bilingual instruction enhances not only learning outcomes but also cognitive and metacognitive processes.

Unlike previous studies that primarily focused on language development or general achievement, this study highlights the role of bilingual instruction in transforming how students think, reason, and engage with mathematical concepts. Therefore, bilingual instruction can be considered an effective and innovative strategy for fostering higher-order thinking in mathematics education

CONCLUSION

This study aimed to investigate the role of bilingual instruction in promoting Higher Order Thinking Skills (HOTS) in mathematics learning at the junior high school level. Based on the findings, it can be concluded that bilingual instruction has a significant positive effect on students' higher-order thinking abilities. Students who were exposed to bilingual mathematics instruction demonstrated higher levels of improvement

in analyzing, evaluating, and solving complex problems compared to those who received conventional monolingual instruction.

The quantitative results revealed a statistically significant difference between the experimental and control groups, supported by higher mean scores and N-gain values in the experimental group. These findings were further strengthened by qualitative evidence, which showed that bilingual instruction enhanced students' conceptual understanding, cognitive engagement, and metacognitive awareness. The use of two languages enabled students to process mathematical concepts more deeply, reflect on their thinking, and approach problem solving tasks more critically.

However, the study also identified several challenges, particularly related to students' initial language proficiency and the need for appropriate instructional support. These findings indicate that while bilingual instruction is effective, its success depends on careful implementation, including scaffolding strategies, teacher readiness, and well designed instructional materials.

This study confirms that bilingual instruction is not only a language-support approach but also a powerful pedagogical strategy for fostering higher-order thinking in mathematics learning.

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