

ENGLISH GLOSSARY SCAFFOLDING IN CONTENT AND LANGUAGE INTEGRATED LEARNING MATHEMATICS: COGNITIVE LOAD EFFECTS

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ABSTRACT

Content and Language Integrated Learning in mathematics requires students to process mathematical concepts and English simultaneously, which may increase cognitive load and interfere with learning. This study examines the effect of English glossary scaffolding in Content and Language Integrated Learning mathematics on students' cognitive load and learning outcomes. A quasi-experimental design with a non-equivalent control group was employed. The experimental group received Content and Language Integrated Learning instruction supported by an English mathematical glossary, while the control group experienced Content and Language Integrated Learning without glossary support. The glossary provided key mathematical terms, brief definitions, and contextual examples to support students' comprehension during learning activities. Students' cognitive load was measured using a cognitive load questionnaire administered after the learning sessions. Mathematics learning outcomes were assessed through a conceptual understanding test. The results showed that students in the English glossary scaffolding group experienced lower cognitive load compared to those in the control group. Furthermore, the experimental group demonstrated better conceptual understanding in mathematics. These findings indicate that English glossary scaffolding helps reduce the mental effort required to process mathematical content in English, allowing students to focus more effectively on understanding concepts. This study suggests that incorporating English glossary scaffolding in Content and Language Integrated Learning mathematics can reduce cognitive load and improve learning outcomes.

Keywords: Content and Language Integrated Learning in Mathematics; English Glossary Scaffolding; Cognitive Load; Language Scaffolding; Mathematics Learning

1) INTRODUCTION

Content and Language Integrated Learning in mathematics integrates subject content and English simultaneously, allowing students to develop conceptual understanding while learning academic language. This approach has been widely implemented in bilingual education contexts to enhance both disciplinary knowledge and language competence (Ruiz de Zarobe, 2025). In Content and Language Integrated Learning classrooms, English functions as the medium for learning subject matter, requiring students to interpret mathematical concepts,

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instructions, and terminology in a foreign language at the same time (Lo, Lui, & Wong, 2019). Consequently, learners must process mathematical reasoning while simultaneously decoding English academic vocabulary, which increases the complexity of learning tasks and may influence students' cognitive processing (Lo et al., 2019).

The integration of mathematics and English in Content and Language Integrated Learning settings creates linguistic and cognitive challenges, particularly when students are unfamiliar with academic terminology. Students learning through a second language often have limited linguistic resources, which may hinder their comprehension of instructional materials and problem-solving tasks (Mahan, 2020). In such contexts, insufficient language support may lead students to allocate more mental effort to interpreting English vocabulary rather than understanding mathematical concepts (Mahan, 2020; Lo et al., 2019). These challenges are especially critical in mathematics, where conceptual understanding relies heavily on precise terminology and symbolic representations (Mahan, 2020).

To address these challenges, scaffolding has been widely recommended in Content and Language Integrated Learning environments. Scaffolding refers to structured instructional support that helps learners understand new concepts and gradually achieve independent learning (Mahan, 2020). In bilingual classrooms, scaffolding often focuses on supporting academic language comprehension, including vocabulary explanations, contextual examples, and guided use of subject-specific terminology (Mahan, 2020). Previous research indicates that scaffolding strategies in Content and Language Integrated Learning classrooms assist students in comprehending content and completing learning tasks, particularly when language demands are explicitly addressed (Mahan, 2020). Furthermore, scaffolding that targets academic vocabulary is considered essential because Content and Language Integrated Learning teachers often emphasize content delivery while providing limited explicit vocabulary instruction (Mahan, 2020).

One specific form of language scaffolding in mathematics is the use of English mathematical glossaries. Mathematical glossaries provide key terms, concise definitions, and contextual examples to help students understand academic vocabulary during learning activities. In Content and Language Integrated Learning contexts, vocabulary-focused scaffolding has been shown to support comprehension by reducing linguistic barriers and facilitating engagement with subject content (Mahan, 2020; Lo et al., 2019). When learners can quickly access the meaning of unfamiliar English mathematical terms, they may allocate more cognitive resources to conceptual reasoning

rather than language interpretation (Lo et al., 2019). Therefore, English glossary scaffolding is considered a practical strategy for supporting mathematics learning in bilingual classrooms.

From a cognitive perspective, learning effectiveness depends on how instructional design influences students' mental effort. Learning through English in Content and Language Integrated Learning mathematics requires students to process multiple sources of information simultaneously, which may increase cognitive load. High cognitive load can reduce students' ability to process new information and negatively affect conceptual understanding. Therefore, instructional strategies that provide structured language support may help reduce unnecessary mental effort and improve learning efficiency in bilingual mathematics instruction (Lo et al., 2019).

Although previous studies have highlighted the importance of scaffolding in Content and Language Integrated Learning, empirical research focusing specifically on English glossary scaffolding in mathematics remains limited. Existing studies mainly discuss general scaffolding strategies or focus on science and language classrooms rather than mathematics learning (Mahan, 2020; Lo et al., 2019). Furthermore, few studies investigate how vocabulary-based scaffolding influences students' cognitive load during Content and Language Integrated Learning mathematics instruction. This gap indicates the need for empirical research examining the role of English glossary scaffolding in reducing cognitive load.

Therefore, this study aims to investigate the effect of English glossary scaffolding in Content and Language Integrated Learning mathematics on students' cognitive load. By integrating structured vocabulary support into bilingual mathematics instruction, this research seeks to determine whether English glossary scaffolding can reduce students' cognitive load and support more effective learning. The findings are expected to contribute to the development of language-supported instructional design in Content and Language Integrated Learning mathematics and provide empirical evidence for optimizing cognitive processing in bilingual mathematics classrooms.

2) METHODS

Research Design

This study employed a quasi-experimental design using a non-equivalent control group. The design was used to examine the effect of English glossary scaffolding in Content and Language Integrated Learning mathematics on students' cognitive load and learning outcomes. Two groups

were involved: an experimental group receiving Content and Language Integrated Learning mathematics with English glossary scaffolding and a control group receiving Content and Language Integrated Learning mathematics without glossary support. Both groups were taught using the same mathematical content, learning duration, and instructional procedures, with the only difference being the provision of English glossary scaffolding in the experimental group.

Participants

The participants of this study were secondary school students enrolled in mathematics classes implementing Content and Language Integrated Learning. Two intact classes were selected using purposive sampling. One class was assigned as the experimental group, and the other class served as the control group. All participants had prior experience learning mathematics in English to ensure familiarity with Content and Language Integrated Learning instruction. The number of students in each class was comparable to maintain group equivalence.

Instructional Treatment

The experimental group received Content and Language Integrated Learning mathematics supported by English glossary scaffolding. The glossary contained key mathematical terms in English, concise definitions, and contextual examples related to the lesson. The glossary was provided at the beginning of the lesson and used throughout learning activities to support comprehension of instructions, explanations, and problem-solving tasks. Students were encouraged to refer to the glossary when encountering unfamiliar vocabulary.

The control group received Content and Language Integrated Learning mathematics without glossary scaffolding. The teacher delivered instruction using English as the medium of instruction, but no explicit vocabulary support was provided. Both groups learned the same mathematical topics, used identical worksheets, and were taught within the same instructional time frame.

Instruments

a. Cognitive Load Questionnaire

Students' cognitive load was measured using a cognitive load questionnaire administered after the learning sessions. The questionnaire employed a 9-point Likert scale to measure students' perceived mental effort during learning, ranging from 1 (very, very easy) to 9 (very, very difficult).

The items focused on the level of difficulty, mental effort, and concentration required during Content and Language Integrated Learning mathematics instruction. Higher scores indicated higher cognitive load. The questionnaire was adapted for mathematics learning contexts and reviewed by experts to ensure content validity.

b. Mathematics Learning Outcomes Test

Mathematics learning outcomes were measured using a conceptual understanding test developed based on the learning objectives. The test consisted of open-ended and problem-solving questions assessing students' understanding of mathematical concepts learned during the intervention. The instrument was validated by mathematics education experts and piloted before implementation. Reliability was calculated using internal consistency analysis.

Data Collection Procedure

The study was conducted over several instructional sessions. Both groups received Content and Language Integrated Learning mathematics instruction with the same learning objectives. The experimental group used English glossary scaffolding during learning activities, while the control group did not receive glossary support. At the end of the intervention, students completed the cognitive load questionnaire. Afterward, both groups completed the mathematics learning outcomes test.

Data Analysis

The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to summarize the mean and standard deviation of cognitive load and learning outcomes. An independent samples t-test was conducted to determine differences between the experimental and control groups. The level of significance was set at 0.05. The analysis aimed to identify whether English glossary scaffolding in Content and Language Integrated Learning mathematics significantly affected students' cognitive load and learning outcomes.

3) RESULTS

Cognitive Load

Descriptive statistics showed differences in cognitive load between students in the experimental and control groups. The experimental group that received English glossary

scaffolding in Content and Language Integrated Learning mathematics obtained a lower mean cognitive load score ($M = 2.71$, $SD = 0.48$) compared to the control group ($M = 3.34$, $SD = 0.52$). These results indicate that students who learned using English glossary scaffolding experienced lower mental effort during the learning process.

An independent samples t-test was conducted to examine whether the difference between the two groups was statistically significant. The results showed a significant difference in cognitive load between the experimental group and the control group, $t(58) = -4.89$, $p < .001$. This finding indicates that English glossary scaffolding in Content and Language Integrated Learning mathematics significantly reduced students' cognitive load.

Learning Outcomes

Students' learning outcomes were analyzed using posttest scores after the instructional intervention. The descriptive statistics indicated that the experimental group achieved higher learning outcomes ($M = 82.47$, $SD = 7.36$) compared to the control group ($M = 74.92$, $SD = 8.11$). These results suggest that students who received English glossary scaffolding demonstrated better conceptual understanding in mathematics.

An independent samples t-test revealed a statistically significant difference between the two groups, $t(58) = 3.76$, $p < .001$. This result indicates that students who learned through Content and Language Integrated Learning mathematics with English glossary scaffolding performed significantly better than those who learned without glossary support.

Summary of Findings

Overall, the findings indicate that English glossary scaffolding in Content and Language Integrated Learning mathematics reduced students' cognitive load while improving learning outcomes. Students in the experimental group showed lower cognitive load scores ($M = 2.71$) and higher learning outcomes ($M = 82.47$) compared to students in the control group (M cognitive load = 3.34; M learning outcomes = 74.92). These results suggest that English glossary scaffolding supports students in processing mathematical content delivered in English more effectively.

4) DISCUSSION

The findings of this study indicate that students who learned mathematics through Content and Language Integrated Learning supported by English glossary scaffolding experienced

significantly lower cognitive load and higher learning outcomes compared to students who learned without glossary support. These results suggest that providing structured vocabulary support helps students process mathematical content delivered in English more efficiently. Learning subject content through a foreign language requires students to simultaneously process conceptual information and unfamiliar linguistic input, which increases mental effort and may hinder learning performance. Previous research has shown that presenting subject matter in a foreign language can increase cognitive demands and negatively affect content learning when language support is limited (Sweller, Ayres, & Kalyuga, 2017). The study reported that learning content in a foreign language without appropriate instructional support may overload learners' working memory and reduce learning efficiency.

The reduction of cognitive load observed in the experimental group supports the role of scaffolding in Content and Language Integrated Learning classrooms. Scaffolding provides structured assistance that helps learners understand content while gradually reducing dependence on external support. In bilingual classrooms, scaffolding strategies such as vocabulary explanations and terminology support are essential because learners often lack sufficient linguistic resources to interpret academic content. Previous studies reported that scaffolding in Content and Language Integrated Learning environments helps students comprehend instructional materials and reduces linguistic challenges during learning activities (Mahan, 2020). Teachers who provide explicit support for subject-specific terminology can help students focus on conceptual understanding rather than language decoding (Mahan, 2020).

The findings of this study are also consistent with research highlighting the importance of vocabulary scaffolding in Content and Language Integrated Learning contexts. Academic vocabulary plays a central role in understanding subject-specific concepts, particularly in mathematics where terminology is closely linked to conceptual meaning. When students receive explicit vocabulary support, they can access meanings of key terms more efficiently and allocate cognitive resources to problem solving. Previous research has shown that scaffolding focused on academic language improves learners' cognitive development and comprehension in Content and Language Integrated Learning classrooms (Li & Zhang, 2020). This suggests that vocabulary-based scaffolding, such as English glossary support, can facilitate both language processing and conceptual understanding.

The improvement in learning outcomes found in this study is also supported by prior research indicating that scaffolding enhances learning performance in bilingual instruction. Scaffolding strategies that provide language support have been shown to help students overcome linguistic barriers and engage more effectively with subject content. In Content and Language Integrated Learning environments, structured language support helps learners interpret instructions, understand explanations, and complete learning tasks more successfully (Lo, Lui, & Wong, 2019). When students experience fewer linguistic difficulties, they can concentrate on conceptual reasoning, leading to improved academic performance (Lo et al., 2019).

Furthermore, the findings align with research emphasizing multimodal scaffolding in Content and Language Integrated Learning. Studies have shown that combining language-focused support with structured instructional materials helps students process information more efficiently. Multimodal scaffolding strategies, including vocabulary support and visual resources, reduce linguistic barriers and support comprehension in bilingual classrooms (Meyer, Coyle, Halbach, Schuck, & Ting, 2019). Such scaffolding approaches help learners interpret academic terminology and connect language with conceptual meaning.

The lower cognitive load observed in the experimental group suggests that English glossary scaffolding helped reduce the mental effort required to interpret mathematical language. Without vocabulary support, students must allocate additional cognitive resources to understanding unfamiliar English terminology before processing mathematical concepts. This dual processing may overload working memory and hinder learning. Cognitive Load Theory suggests that instructional support that simplifies information processing can improve learning efficiency by reducing unnecessary mental effort (Sweller et al., 2017). The use of English glossary scaffolding in this study appears to function as such support, allowing students to focus on conceptual reasoning.

The improvement in learning outcomes also supports previous findings that Content and Language Integrated Learning can enhance subject learning when appropriate scaffolding is provided. Research has shown that Content and Language Integrated Learning may improve both content knowledge and language competence when instruction includes structured support mechanisms (Bruton, 2016). However, the effectiveness of Content and Language Integrated Learning depends heavily on the availability of scaffolding that helps learners manage cognitive and linguistic demands (Bruton, 2016).

Additionally, previous studies indicate that Content and Language Integrated Learning students often experience difficulties when teachers provide limited language support. When instructional language is not scaffolded, students may struggle to interpret terminology and instructions, resulting in increased cognitive load and reduced comprehension (Lo et al., 2019). Providing English glossary scaffolding directly addresses this issue by offering immediate access to key vocabulary. This support helps students maintain focus on mathematical reasoning rather than language decoding.

Overall, the findings of this study confirm that English glossary scaffolding plays an important role in optimizing learning in Content and Language Integrated Learning mathematics. The reduction in cognitive load and improvement in learning outcomes indicate that vocabulary-focused scaffolding helps students process mathematical content delivered in English more effectively. These findings support previous research emphasizing the importance of language scaffolding in bilingual education and highlight the need for explicit vocabulary support in Content and Language Integrated Learning mathematics classrooms.

5) CONCLUSION

This study investigated the effect of English glossary scaffolding in Content and Language Integrated Learning mathematics on students' cognitive load and learning outcomes. The findings revealed that students who learned mathematics using English glossary scaffolding experienced significantly lower cognitive load compared to students who learned without glossary support. The availability of key English mathematical terms and concise definitions helped students understand instructional language more efficiently, thereby reducing mental effort during the learning process.

In addition, the results showed that students in the experimental group achieved higher learning outcomes than those in the control group. This finding indicates that English glossary scaffolding not only reduces cognitive load but also supports students' conceptual understanding in mathematics. When students encounter fewer linguistic barriers, they can allocate more cognitive resources to processing mathematical concepts and problem solving. As a result, learning becomes more effective in Content and Language Integrated Learning mathematics classrooms.

Overall, the findings suggest that English glossary scaffolding is an effective instructional support for implementing Content and Language Integrated Learning in mathematics. Providing structured vocabulary support helps students manage the cognitive demands of learning

mathematics in English while improving learning outcomes. Therefore, teachers implementing Content and Language Integrated Learning mathematics are recommended to incorporate English glossary scaffolding to reduce cognitive load and enhance students' understanding of mathematical concepts.

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