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Original Article

The Effect of the ICARE Model in the Context of Pagaralam Coffee on Students' Mathematical Communication Skills in the Topic of Ratios in Year 7 at MTs Al Ikhlas Tanjung Sakti PUMI

Icha Febrianti[1*], Novi Susanti[2], Reza Lestari[3]

[1-3]Mathematics Education Program, STKIP Muhammadiyah Pagaralam, South Sumatra, Indonesia
Email: [1)] ichafebrianti94@gmail.com, [3)] lestarireza84@gmail.com

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Abstract

Mathematical communication remains one of the most persistently underdeveloped competencies among secondary school students, yet plays a crucial role in developing students' capacity to express and reason mathematical ideas meaningfully. This study examines the efficacy of the ICARE instructional model, embedded within the Pagaralam coffee context, on the mathematical communication competencies of seventh-grade students at MTs Al Ikhlas Tanjung Sakti PUMI. Grounded in constructivist learning theory, the ICARE model (comprising Introduction, Connection, Application, Reflection, and Extension) facilitates meaningful learning through active knowledge construction and contextual engagement. Mathematical communication is understood in accordance with the NCTM framework as the ability to express, represent, and reason mathematical ideas coherently. This study employed a quantitative experimental design with a Pretest-Posttest Control Group approach. Class VII.1, comprising 23 students, served as the experimental group, while Class VII.2, comprising 20 students, served as the control group. Data were collected through mathematical communication assessments and analyzed using an independent two-sample t-test. The results revealed a mean posttest score of 70.39 for the experimental group, with 69% of students attaining a "good" rating, considerably surpassing the mean posttest score of 52.95 and the 52.86% satisfactory rating recorded in the control group. This difference was statistically significant, with a t-value of 3.474 exceeding the critical threshold of 1.683, leading to the rejection of the null hypothesis. These findings confirm that the integration of the ICARE model within the Pagaralam coffee context produced a significant improvement in students' mathematical communication skills in proportional reasoning.

Keywords: ICARE Model, Mathematical Communication, Pagaralam Coffee, Ratio.

1. Introduction

Mathematics constitutes an indispensable discipline that bears considerable consequence in propelling the advancement of science and technology, while concurrently nurturing students' logical, analytical, critical, and creative cognitive faculties (Siregar, 2021). Mathematical communication proficiency denotes the capacity to articulate mathematical ideas or concepts, both orally and in written form, as well as the aptitude to comprehend and assimilate mathematical ideas or concepts conveyed by others in an accurate, analytical, critical, and evaluative manner, with the overarching intent of augmenting conceptual understanding (Riza, 2020; Utami et al., 2023). Meanwhile, Oktavia et al. (2024) define mathematical communication skills as the ability to understand, convey, and express a mathematical idea or concept in the form of concrete objects, writing, or speech. Mathematics

learning is fundamentally aimed at training students' ability to convey and communicate the results of their thinking through symbols, tables, diagrams, or other learning media in order to clarify a given problem (Munandar, 2023).

Despite its recognized importance, mathematical communication remains one of the most underdeveloped competencies among secondary school students. Several studies have documented persistent difficulties in this area. Mutodi and Mosimege (2021) found that students at the junior secondary level struggled to represent mathematical ideas symbolically and verbally, particularly in topics involving proportional reasoning. Similarly, Mikolaj (2019) reported that conventional instructional approaches often fail to create sufficient opportunity for students to practice mathematical expression, resulting in passive learning behaviors. These findings collectively suggest that the challenge is not merely conceptual but also pedagogical, pointing to the need for instructional models that actively engage students in communicating mathematical thinking.

The ICARE model, comprising the stages of Introduction, Connection, Application, Reflection, and Extension has been proposed as one such approach. Rooted in constructivist learning theory, it is designed to facilitate active knowledge construction by linking new material to prior knowledge and real-world contexts (Antari & Pusvitasari, 2022). Prior research has demonstrated the effectiveness of the ICARE model in various educational settings. Makdalena et al. (2026) found that ICARE-based instruction significantly improved students' conceptual understanding in science learning, while Astuti et al. (2019) reported gains in problem-solving skills among junior high school mathematics students. However, studies specifically examining the effect of the ICARE model on mathematical communication skills, particularly within locally contextualized learning environments, remain limited.

This gap is further evident in the Indonesian educational context, where the integration of local cultural and economic contexts into mathematics learning has shown promising results. According to Susanti et al. (2025), students performed significantly better on mathematics tasks when problems were framed within a familiar coffee-production context, suggesting that contextual relevance enhances both engagement and comprehension. Pagaralam, as a prominent coffee-producing region, thus offers an underexplored but potentially productive context for mathematics instruction. Nevertheless, no study to date has examined whether the combination of the ICARE model and the Pagaralam coffee context produces measurable improvements in students' mathematical communication competencies.

Empirical evidence from a preliminary field observation supports this concern. Based on an interview conducted with a mathematics teacher, Mrs. Heni Wekasari, S.Pd., at MTs Al Ikhlas Tanjung Sakti PUMI on 25 November 2025, students' mathematical communication skills were reported to be severely lacking. Students demonstrated a poor grasp of ratio topics, with many unable to perform the multiplication and division operations that underpin proportional reasoning, and most unable to distinguish between equivalent and inverse ratios. These conditions indicate an urgent need for instructional intervention that simultaneously addresses conceptual understanding and communicative competence.

In response to this gap, the present study investigates the effect of the ICARE instructional model, embedded within the Pagaralam coffee context, on the mathematical communication skills of seventh-grade students at MTs Al Ikhlas Tanjung Sakti PUMI, with a specific focus on proportional reasoning. By combining a theoretically grounded instructional model with a contextually relevant learning environment, this study aims to contribute both empirical evidence and practical insight to the ongoing development of mathematics education in Indonesia.

The use of the Pagaralam coffee context in this study is grounded in the broader tradition of ethnomathematics and culturally responsive teaching. d'Ambrosio (1985) argued that mathematical knowledge is inherently embedded in cultural practices and that instruction becomes more meaningful when it draws on learners' everyday experiences. In the Indonesian context, research has consistently shown that students demonstrate stronger engagement and deeper conceptual understanding when mathematical tasks are framed within local agricultural or economic activities familiar to their daily lives (Fatimah & Prabawanto, 2020; Robinson et al., 2018). Pagaralam, as one of South Sumatra's most prominent coffee-producing regions, offers precisely this kind of contextual relevance for students at MTs Al Ikhlas Tanjung Sakti PUMI. Embedding proportional reasoning within coffee-related scenarios, such as harvest ratios or production pricing aligns with contextual learning theory, which holds that knowledge construction is most effective when learners can connect abstract concepts to meaningful real-world situations (Johnson, 2002). The findings of Susanti et al. (2025) thus serve as empirical confirmation of a theoretically established rationale rather than as its sole basis.

2. Literature Review

2.1. Mathematical Communication

Mathematical communication proficiency alludes to the capacity to articulate a mathematical idea or concept, with the overarching intention of deepening one's knowledge and comprehension; such proficiency may be manifested through written or verbal expression, as well as through the aptitude to interpret and assimilate ideas or concepts espoused by others (Lastari et al., 2023). According to Sari et al. (2022), mathematical communication skills are an important component of competence in any discussion of mathematics. Accordingly, mathematical communication proficiency encompasses the capacity to articulate and elucidate mathematical ideas, whether verbally or in written form, by drawing correlations with tangible objects, diagrams, and algebraic expressions, formulating pertinent mathematical inquiries, and reinterpreting a mathematical depiction or passage in one's own vernacular. The measurable indicators of mathematical communication proficiency delineated in this study are as follows: (1) the aptitude to transmute tangible objects into mathematical concepts; (2) the aptitude to convey conclusive reasoning in responses to contextual problems derived from the findings; (3) the aptitude to articulate mathematical reasoning in written form and to render quotidian occurrences through the employment of mathematical notation.

2.2. The ICARE Learning Model

As noted by Kaban et al. (2020), a learning model constitutes a distinctive pattern or compendium of instructional procedures that are instituted and operationalized so that the designated objectives or competencies of anticipated learning outcomes may be attained expeditiously, with heightened efficacy and efficiency. Among the most contemporary instructional models is ICARE. The ICARE learning model represents a conceptual framework that delineates systematic procedures for orchestrating learning experiences, ensuring that the instructional process unfolds in a focused and deliberate manner, and that the prescribed learning objectives are duly accomplished (Rachmayuni et al., 2022). This ICARE model was selected because it has many advantages, according to Nikmah et al. (2025), including enhancing students' Higher Order Thinking Skills (HOTS), communication, and collaboration. Meanwhile, Siahaan et al. (2020) argue that ICARE can improve students'

collaboration and communication skills through discussion and group work activities; however, there are also shortcomings to the ICARE model. One example is in the case of worksheets (LKPD), where effectiveness depends on the quality of the worksheet/module design and the teacher's ability to manage the ICARE stages; if the design is weak, this can lead to reduced effectiveness.

2.3. Student Worksheet

Pradiptha and Wiarta (2021) state that worksheets are learning resources for students designed to support a contextual and challenging learning process, thereby fostering a student-centred learning environment. According to previous researchers, these LKPD teaching materials have many advantages. Istifadah and Saadah (2023) state that LKPDs contain instructions for use, steps for completion, and tasks within the activity sheets that align with the core competencies to be achieved (Lase & Lase, 2020). Meanwhile, according to Choirudin et al. (2021), student worksheets (LKPD) are a tool to assist and facilitate teaching and learning activities, thereby fostering effective interaction between students and teachers.

2.4. Previous Research

Rahmadhani and Wahyuni (2020) found that the ICARE model in this student activity sheet was valid (score of 3.87), practical (implementation rate of 78%, student activity increased to 86%, student response 3.04, teacher response 3.1), and effective (learning achievement rate of 89%). According to Handayani (2021), the ICARE-based worksheets developed were found to be valid and applicable for teaching the topic of determining enthalpy changes in senior high schools/MA. Several studies have shown that the ICARE model is effective in improving students' learning outcomes and mathematical abilities; however, it is still rarely applied to topics involving comparisons within a local context, hence this study was conducted to address this gap.

3. Methods

The data collection technique utilised a mathematical communication skills test. The research instrument was subjected to rigorous scrutiny encompassing validity, reliability, difficulty gradation, and discriminatory potency. Data analysis was executed through normality and homogeneity verification, followed by an independent two-sample t-test. The methodological approach underpinning this inquiry was experimental in nature, wherein the experimental research method entails the deliberate manipulation of variables through controlled experimentation, constituting a quantitative paradigm. A quantitative orientation was adopted given that this study endeavors to ascertain the bearing of the ICARE learning model, situated within the Pagaralam coffee milieu, on students' mathematical communication proficiencies in a measurable and statistically analyzable manner. The design employed was a Pretest-Posttest Control Group Design, through which the researcher sought to discern disparities in students' mathematical communication competencies between the experimental stratum, subjected to the ICARE model, and the control stratum, subjected to conventional pedagogy. The research sample was delineated through purposive sampling, with due consideration of the equivalence of students' preliminary aptitudes and the recommendations of subject teachers. The sample encompassed two classes, namely Class VII.1 as the experimental class and Class VII.2 as the control class.

The research was conducted at MTs Al Ikhlas Tanjung Sakti PUMI during the 2025/2026 academic year. The total population comprised all seventh-grade students at the institution, distributed across three classes. From this population, two classes were selected

as the research sample through purposive sampling, based on the criteria of equivalent prior academic aptitude and in accordance with the recommendation of the subject teacher. Class VII.1, comprising 23 students, was assigned as the experimental group, and Class VII.2, comprising 20 students, served as the control group. The selection of these two classes was further justified by their comparable baseline performance on the pretest, confirming the initial equivalence of both groups prior to the intervention.

Two data elicitation techniques were employed, namely assessments and documentation. An assessment is construed as a compendium of tasks to be accomplished or a succession of inquiries to be addressed by students, with the overarching purpose of gauging their degree of comprehension or command over the requisite subject matter in consonance with a designated instructional programme (Wahyudi, 2024). The test questions must be pilot-tested on students before use. The questions that have been analysed and declared valid are those given as post-test questions to both the experimental and control classes. Meanwhile, documentation is a data collection technique useful for tracing historical or administrative data (Sibinga & Abdella, 2024). This method was used to obtain data on Year 7 students at MTs Al Ikhlas Tanjung Sakti PUMI for the 2025/2026 academic year. This data comprised information on the students, the school environment, and photographs taken during the research, serving as material to clarify the data and ensure greater accuracy in supporting the research process.

Prior to conducting the test, the researcher carried out a pilot test of the instrument in Class VII.3 at MTs Al Ikhlas Tanjung Sakti PUMI. The researcher created 10 questions on direct and inverse proportion, each worth 12 marks; thus, if a student answered all questions correctly, the total score would be 120. This score is subsequently divided by the maximum attainable score of 120 and multiplied by 100, culminating in a definitive score of 100. Upon obtaining the instrument pilot test scores, the researcher discerned which items were deemed suitable for inclusion in the post-test, whereupon the conclusive assessment was administered across both the experimental and control strata. Subsequent to the instrument pilot test, a pre-test was administered to both the experimental and control strata. Following the administration of the pre-test, the researcher disseminated the prescribed subject matter to the experimental stratum through the ICARE instructional model, while the control stratum was subjected to conventional pedagogical methods.

4. Results and Discussion

4.1. Research Results

The assessment outcomes encompass scores garnered from Class VII.1 as the experimental stratum — a cohort wherein instruction was facilitated through the ICARE (Introduction, Connection, Application, Reflection, Extension) pedagogical model, augmented by structured worksheets, comprising 23 students — and Class VII.2 as the control stratum, a cohort wherein instruction was conducted in the absence of the ICARE (Introduction, Connection, Application, Reflection, Extension) pedagogical model, comprising 20 students, at MTs Al Ikhlas Tanjung Sakti PUMI throughout the 2025/2026 academic year.

Table 1. Qualifications for Mathematical Communication Skills

Score	Qualifications
81% – 100%	Very good
61% – 80%	Good
41% – 60%	Fair
21% – 40%	Poor
0 – 20%	Very poor

Source: Rahmah and Hidayati (2024)

Table 2. Post-test results for Class VII.1 (Experimental)

Indicator	The number of students	Percentage for Each Indicator	Description
The ability to relate real-world objects to mathematical concepts.	23	76,5%	Good
The ability to draw conclusions in response to everyday questions based on the results of those questions.	23	58,5%	Fair
The ability to express mathematical ideas in writing and to describe everyday situations using mathematical symbols.	23	72%	Good

From the table 2 above, we can see that the maximum score for the post-test in the experimental class was 100, and the minimum score was 45. Meanwhile, 69% of the students achieved a 'good' rating in their mathematical communication skills. The second indicator (ability to draw conclusions in answers to everyday questions based on the results of the questions) has the lowest percentage, at 58.5%, compared to the other two indicators. This figure indicates that this is the area students find most difficult to understand and their weakest point in solving the given problems.

Table 3. Post-test results for Class VII.2 (Control)

Indicator	The number of students	Percentage for Each Indicator	Description
The ability to relate real-world objects to mathematical concepts.	20	54,8%	Fair
The ability to draw conclusions in response to everyday questions based on the results of those questions.	20	51,3%	Fair
The ability to express mathematical ideas in writing and to describe everyday situations using mathematical symbols.	20	52,5%	Fair

From the table 3 above, we can see that the maximum score for the post-test results of the experimental class was 78.33, and the minimum score was 30. Meanwhile, the percentage of students' mathematical communication skills was 52.86%, classified as 'Satisfactory'. The second indicator (Ability to present conclusions in answers to everyday questions based on the results of the questions) has the lowest percentage, namely 51.3%, compared to the other two indicators. This figure indicates that this is the area students find most difficult to understand and their weakest point in solving the given problems.

Table 4. Normality Test of Final Data
Tests of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Experiment	.147	20	.200*
Control	.105	20	.200*

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The criterion for decision-making was predicated upon a significance threshold of 5% (0.05). The Sig. values ascertained for both the experimental and control strata were 0.200 respectively, surpassing the stipulated threshold of 0.05. This denotes that the post-test data pertaining to both strata conform to a normal distribution and are thus amenable to subsequent analytical scrutiny. Derived from the outcomes of the independent t-test, computed utilizing SPSS version 25, the determination is delineated as follows:

a. If the Sig. value is < 0.05, then H_0 is rejected and H_1 is accepted.
b. If the Sig. value is ≥ 0.05, then H_0 is accepted and H_1 is rejected.

Looking ate the outcomes of the independent t-test, the obtained significance value (two-tailed) fell below the stipulated threshold (α), yielding 0.001 < 0.05; corroboratively, the t-value of 3.474 surpassed the t-table value of 1.683. It may therefore be unequivocally concluded that H_0 is repudiated and H_1 is affirmed, signifying that instruction facilitated through the ICARE (Introduction, Connection, Application, Reflection, Extension) model, embedded within the Pagaralam coffee milieu, exerted a consequential bearing on the mathematical communication proficiencies of students in the domain of ratios among Year 7 learners at MTs Al Ikhlas Tanjung Sakti PUMI.

4.2. Discussion

The results of the study show that the calculation yields a t-value of 3.474; the test criterion for rejecting H_0 is that the t-value must be greater than the t-table value at a significance level of α = 5% and a t-table value of 1.683, H_0 is rejected because t-value = 3.474 > t-table = 1.683, which means that the research hypothesis is accepted. This is attributed to the use of the ICARE learning model with the Pagaralam coffee context, which enhanced the mathematical communication skills of students in the experimental class; students were able to solve essay-type questions more effectively, as evidenced by their answers.

This finding is consistent with Siahaan et al. (2020), who confirmed that ICARE improves students' communication skills through discussion and group work, and with Susanti et al. (2025), who demonstrated that embedding mathematical tasks within a familiar coffee-production context significantly improves student performance. Students were able to integrate real-world objects into mathematical concepts, express everyday occurrences using mathematical symbols, and present conclusions in their answers to everyday questions based on their calculations. Notably, the second indicator which drawing conclusions from everyday questions recorded the lowest percentage in both classes (58.5% experimental; 51.3% control), consistent with Mutodi and Mosimege (2021), who found that junior secondary students persistently struggle with mathematical representation in proportional reasoning. Conversely, students in the control class, who did not use the ICARE learning model with the Pagaralam coffee context, appeared to still struggle to link the concept of ratios to everyday events, had difficulty stating the steps to the solution, and still lacked understanding in drawing conclusions from the questions provided, reflecting Mikolaj's (2019) finding that passive instructional approaches limit the development of mathematical communicative competence.

5. Conclusion

Grounded in the findings of the hypothesis examination employing the Independent Samples t-test, wherein the significance level (two-tailed) of 0.001 fell below the stipulated threshold of 0.05, culminating in the repudiation of H_0 and the affirmation of H_1, it may be unequivocally ascertained that the assimilation of the ICARE model within the Pagaralam coffee context engendered a consequential and discernible bearing on the mathematical

communication proficiencies of Year 7 students at MTs Al Ikhlas Tanjung Sakti PUMI. This indicates that the ICARE model with the Pagaralam coffee context can serve as an effective instructional approach capable of enhancing students' mathematical communication skills, particularly in the topic of ratios. During lessons using the ICARE model with the Pagaralam coffee context, the experimental class achieved a mean posttest score of 70.39, with 69% of students attaining a "good" rating in mathematical communication skills. In contrast, the control class employing conventional teaching methods recorded a mean posttest score of 52.95, with an average mathematical communication skill percentage of 52.86%, classified as satisfactory. It can therefore be concluded that learning using the ICARE model with the Pagaralam coffee context is superior to conventional learning, as students demonstrated greater capacity to understand ratio-related problems, integrate real-world coffee contexts into mathematical reasoning, and articulate conclusions clearly in their written responses.

Based on these findings, several recommendations are put forward. For mathematics teachers, it is advisable to consider the ICARE model as an alternative instructional approach, particularly when teaching topics that require contextual understanding such as ratios and proportional reasoning, as the integration of a familiar local context has demonstrated measurable benefits for student communication skills. For school institutions, it is recommended that professional development opportunities be provided to familiarise teachers with context-based instructional models and their implementation. For future researchers, this study may serve as a reference point for examining the ICARE model across different mathematical topics, year levels, or cultural contexts, and it is further recommended that subsequent studies incorporate larger sample sizes and additional instruments to assess broader dimensions of mathematical competence beyond communication skills alone.

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