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Designing Ratio And Proportion Learning Using Traditional Banyuasin Snack Contexts To Foster Junior High School Students' Reasoning Skills

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Abstract

Students' understanding of ratio and proportion at the junior high school level still faces challenges because learning is often presented abstractly and insufficiently connected to students' real-life experiences. This study aims to describe a learning trajectory for ratio and proportion using the context of traditional Banyuasin snacks and to examine the role of this learning trajectory in supporting the reasoning ability of seventh-grade junior high school students. The research employed design research of the validation studies type, conducted through three phases: the preparation phase, the design experiment phase (pilot experiment and teaching experiment), and the retrospective analysis phase. The research subjects consisted of 26 seventh-grade students of MTs Al-Hidayah Muara Telang. Data were collected through student activity sheets, observations, interviews, video recordings of classroom learning, and field notes. The development process was carried out iteratively through the design of learning activities, implementation, and reflection on the alignment between the Hypothetical Learning Trajectory (HLT) and the Actual Learning Trajectory (ALT). The results indicate that the learning trajectory based on the context of traditional Banyuasin snacks was able to guide students to gradually understand the concept of ratio and proportion through contextual activities, the use of representations, and mathematical discussions. Furthermore, the learning trajectory played a role in supporting students' reasoning ability, particularly in identifying relationships between quantities, constructing arguments, and drawing mathematical conclusions. Thus, the developed learning trajectory contributes to supporting the teaching and learning of ratio and proportion for junior high school students.

Keywords: learning trajectory; ratio and proportion; traditional Banyuasin snacks; mathematical reasoning; design research

INTRODUCTION

Direct proportion is one of the essential topics in junior high school mathematics learning because it is closely related to various daily activities, such as adjusting food recipes, calculating purchasing costs, and estimating travel time based on speed (Rahmasari et al., 2022). Learning this topic enables students to understand linear relationships between quantities that change proportionally, as emphasized in the

Merdeka Curriculum, which highlights the ability to solve contextual problems relevant to students' real-life experiences (Kemdikbud, 2021). To develop an accurate understanding of proportion, students are required to master the concept of ratios, numerical operation skills, and the ability to interpret representations such as tables or graphs (Kurniawati et al., 2025).

However, the teaching of direct proportion in schools still often focuses on the procedural use of formulas without meaningful connections to real-life situations, resulting in students' superficial understanding of the concept (Zahrah, 2024). This condition contributes to students' low mathematical reasoning ability, particularly when they are confronted with problems that require interpreting relationships between quantities in everyday contexts (Dwi Rahayu et al., 2023). Learning practices dominated by lecturing methods and routine exercises without contextual variation further exacerbate students' limited understanding (D. A. Hidayatullah & Zainil, 2025). On the other hand, the current education system demands that students develop higher-order thinking skills, including reasoning, critical, adaptive, and creative thinking, as part of 21st-century competencies (Hidayat, 2021). The Merdeka Curriculum also emphasizes the importance of mathematical reasoning ability in solving contextual problems (Purwanto et al., 2023).

Mathematical reasoning ability involves activities such as identifying patterns, making generalizations, constructing logical arguments, and drawing conclusions from mathematical conditions (Rosyidah et al., 2021). The topic of direct proportion is highly relevant for fostering these reasoning processes because it requires students to understand proportional relationships and apply them to make predictions or rational decisions (Puspita et al., 2023). However, the results of PISA 2022 indicate that Indonesian students' mathematical problem-solving ability remains low (OECD, 2023), and local studies confirm that students' numeracy levels, particularly in proportion topics, are still suboptimal (Kurniawati et al., 2025; Rahayu et al., 2023).

To address these issues, innovative mathematics learning approaches that are contextual, meaningful, and capable of transforming students' negative perceptions of mathematics are needed (Rehman et al., 2025). Many students experience anxiety and reluctance toward mathematics due to monotonous learning practices that emphasize memorization and symbolic manipulation without meaningful understanding (Aprilia & Fitriana, 2022; Indriani et al., 2021). Learning grounded in real-life experiences through everyday contexts can serve as an effective strategy to enhance students' engagement (Malalina et al., 2020).

One potential context is traditional Banyuasin snacks, which are easily encountered in students' daily lives and contain quantitative information that can be mathematically modeled, particularly in relation to direct proportion concepts (Agnesti & Amelia, 2020). The composition of ingredients such as flour, sugar, and coconut milk in the preparation of traditional snacks can be used as a starting point for mathematization activities in learning. In addition to being authentic and closely related to students' experiences, this context can enhance students' motivation and reduce the perception that mathematics is abstract and uninteresting (Fuad & Hapsari, 2020; Hasanah et al., 2021).

Various studies have shown that the use of food-related contexts in learning not only provides more concrete learning experiences but also enhances conceptual understanding and learning motivation (Nurafifah et al., 2021). Fakhrezi et al., (2023) developed a learning trajectory for solid geometry using the context of traditional Central Javanese foods through a PMRI approach, while Hidayatullah et al. (2024) utilized the context of lemang, a traditional Palembang food, to support students' mathematical argumentation ability in fraction topics. Other local contexts have also been proven effective in helping students connect mathematical concepts with concrete

experiences (Abrika et al., 2023). However, to date, no study has specifically addressed the use of traditional Banyuasin snack contexts in teaching ratio and proportion in mathematics learning.

Although a number of studies have examined mathematics learning based on food contexts and local culture, most of these studies focus on topics other than direct proportion or employ contexts from different regions. Moreover, previous studies have not specifically investigated how learning trajectories are designed and utilized to guide students' reasoning processes in ratio and proportion learning through the context of traditional Banyuasin snacks. Therefore, a research gap remains regarding the development of a learning trajectory for ratio and proportion that is grounded in Banyuasin local culture and oriented toward enhancing junior high school students' mathematical reasoning ability.

One approach that can be used to bridge this gap is the development of a learning trajectory, particularly a Hypothetical Learning Trajectory (HLT). A learning trajectory enables the systematic design of learning activities, starting from contextual situations and progressing toward more formal mathematical representations, thereby guiding students' thinking and reasoning processes in a gradual manner. Through a design research approach, the learning trajectory is designed, implemented, and reflectively analyzed to understand how students construct their understanding of ratio and proportion through contextual activities based on traditional Banyuasin snacks.

Based on this rationale, this study aims to describe a learning trajectory for ratio and proportion using the context of traditional Banyuasin snacks and to examine the role of this learning trajectory in supporting the mathematical reasoning ability of seventh-grade junior high school students.

METHODS

This study employed design research using the validation studies approach, aiming to develop a Hypothetical Learning Trajectory (HLT) for teaching ratio concepts through the context of traditional Banyuasin snacks to support junior secondary students' mathematical reasoning. The research was conducted through three main phases: the preparation phase, design experiment, and retrospective analysis (Plomp & Nieveen, 2013). During the preparation phase, an initial analysis was carried out, including an analysis of students' needs related to understanding ratio concepts, curriculum analysis (the 2013 Curriculum and the Merdeka Curriculum), and analysis of students' characteristics based on their learning experiences and interest in culturally based learning. This phase resulted in an initial HLT design consisting of hypothesized learning paths and learning activities grounded in real-world contexts.

The design experiment phase was conducted in two stages: the pilot experiment and the teaching experiment. In the pilot experiment, instructional materials such as lesson plans, student worksheets, and locally contextualized learning media were validated by experts (university lecturers and mathematics teachers) and revised formatively based on their feedback. Subsequently, the teaching experiment was implemented with 26 seventh-grade students at MTs Al-Hidayah Muara Telang, where the classroom teacher acted as the instructor and the researcher served as an observer to examine the practicality and effectiveness of the learning design.

In the retrospective analysis phase, learning data were analyzed qualitatively by comparing the Hypothetical Learning Trajectory (HLT) with students' Actual Learning Trajectory (ALT) to evaluate the alignment of the design. The effectiveness of the

design was examined in terms of validity, practicality, and potential effects on students' understanding. Data were collected through classroom observations, video recordings of lessons, analysis of students' activity sheets, interviews, field notes, and pre-tests and post-tests. All data were analyzed retrospectively to assess the success of the HLT implementation and to refine the instructional design.

The research participants consisted of 26 seventh-grade students at MTs Al-Hidayah Muara Telang in the second semester of the 2025/2026 academic year. The implementation followed the stages of preliminary design, pilot experiment, and teaching experiment, with adjustments made to the school academic calendar and students' conditions.

RESULTS AND DISCUSSION

The Results and discussion should be written in not less than 60% of the entire body of the manuscript

The implementation of the pilot experiment revealed that some students were not yet able to transition from contextual understanding to formal mathematical representations when solving ratio and proportion problems. Based on the retrospective analysis, it was found that the initial Hypothetical Learning Trajectory (HLT) had not fully accommodated students' cognitive needs, particularly during the transition stage from concrete exploration to the use of tabular representations and ratio formulation

As a follow-up, the Hypothetical Learning Trajectory (HLT) was revised, serving as the primary basis for improving the instructional design in this study. The revisions included reorganizing the sequence of learning stages, refining the objectives of each activity, and modifying students' anticipated thinking conjectures to better align with their conceptual characteristics. In addition, scaffolding questions and quantitative representations in the form of Tables 1 were incorporated to facilitate students' mathematical generalization processes.

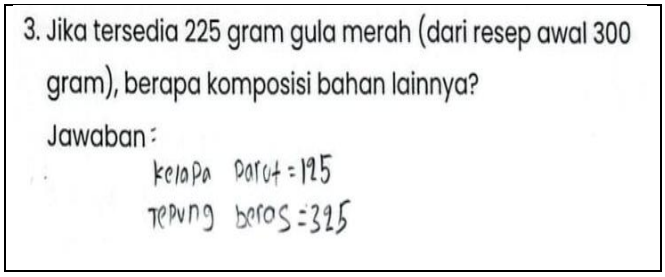
Table 1. Comparison between the Initial HLT and the Revised HLT

HLT Phase	Initial HLT	Revised HLT
Context exploration	Students identify that the quantity of ingredients affects the number of cakes produced.	Scaffolding prompting questions were added to encourage students to explicitly articulate causal relationships.
Quantitative representation	Students divide the ingredients and determine new quantities based on the problem situation.	The teacher guided the use of supportir tables to prevent calculation errors and help students understand that a quantities change proportionally.
Generalization	Students express strategies using ratios (e.g., ½, 2×, etc.).	Maintained, as all students were able to correctly apply direct proportional reasoning.
Formal expression	Students express their strategies orally.	Instructions were added for students to write their strategies in the form of mathematical statements to strengthen the reasoning process.

The revised HLT is presented in detail in Table 1 above, which illustrates a comparison between the initial learning trajectory and the modified version based on the findings of the pilot experiment. These revisions were not merely technical adjustments to the instructional instruments but also served as theoretical refinements of the anticipated development of students' thinking. The revised instructional design was subsequently implemented in the teaching experiment phase to examine its effectiveness in supporting the development of students' mathematical reasoning ability.

The teaching experiment was conducted with 26 seventh-grade students of MTs Al-Hidayah by implementing the revised HLT obtained from the pilot experiment phase. At this stage, learning activities focused on strengthening students' proportional understanding and enhancing their mathematical reasoning ability through the context of traditional Banyuasin snacks. The teacher acted as a facilitator, while the researcher served as an observer to validate students' thinking conjectures.

In the first activity, students were asked to determine changes in the quantities of ingredients used to make kue lumpang when the amount of output changed. In contrast to the pilot experiment, nearly all students were able to adjust the quantities proportionally and no longer relied on additive strategies. The use of supporting tables introduced in the revised HLT proved effective in helping students identify patterns in quantitative relationships. An example of students' work demonstrating this understanding is presented in Figure 1.


3. Jika tersedia 225 gram gula merah (dari resep awal 300 gram), berapa komposisi bahan lainnya?

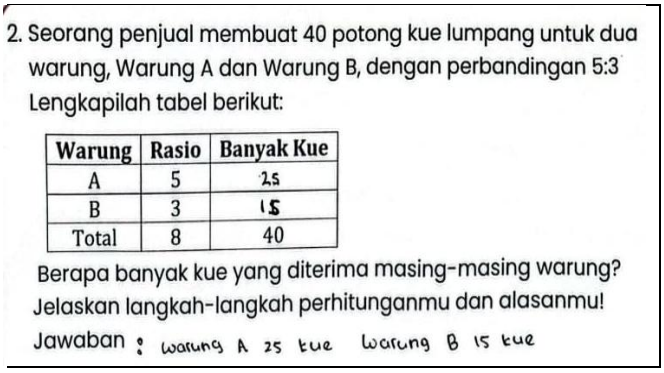
Jawaban:

kelapa parut = 195

tepung beras = 325

Figure 1. Students' responses

In the second activity, students worked with the context of kue rangi to understand a 5:3 ratio, the relationship between time and output, and unit price calculations. Students were able to correctly determine the total number of parts and applied multiplicative strategies to find the value of each part. Students' ability to generalize became more evident, as they stated that changes consistently followed fixed multiplicative patterns in direct proportional relationships. Students' representations in this activity are shown in Figure 2.


2. Seorang penjual membuat 40 potong kue lumpang untuk dua warung, Warung A dan Warung B, dengan perbandingan 5:3 Lengkapilah tabel berikut:

Warung	Rasio	Banyak Kue
A	5	25
B	3	15
Total	8	40

Berapa banyak kue yang diterima masing-masing warung? Jelaskan langkah-langkah perhitunganmu dan alasanmu!

Jawaban : warung A 25 kue warung B 15 kue

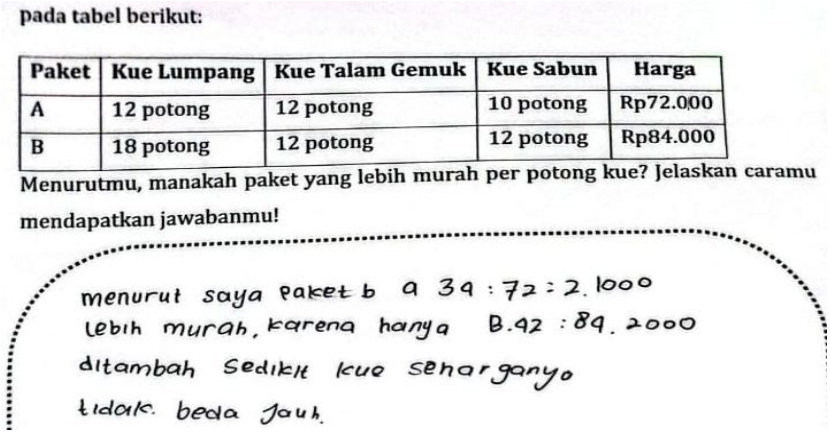
Figure 2. Students' responses

Group discussions during the teaching experiment indicated an improvement in students' mathematical justification abilities. Students did not merely state their answers but also provided logical reasons for the strategies they employed. In several groups, students compared their strategies with those of other groups before drawing final conclusions. This level of engagement reflects the emergence of higher-order reasoning and supports the theory of emergent modeling. Documentation of the discussion process is presented in Figure 3



Figure 3. Documentation of students' discussions

Further improvement in students' reasoning ability was evident in the post-test results. Most students who had previously relied on additive strategies were now able to solve problems using multiplicative reasoning. Students began to employ tables, formal ratios, and direct calculations based on proportional factors. This shift indicates the effectiveness of the revised HLT in fostering model-for mathematical understanding. An example of students' representations in the post-test is shown in Figure 4.



pada tabel berikut:

Paket	Kue Lumpang	Kue Talam Gemuk	Kue Sabun	Harga
A	12 potong	12 potong	10 potong	Rp72.000
B	18 potong	12 potong	12 potong	Rp84.000

Menurutmu, manakah paket yang lebih murah per potong kue? Jelaskan caramu mendapatkan jawabanmu!

menurut saya paket b a 34 : 72 : 2.1000
lebih murah, karena hanya B.42 : 84. 2000
ditambah sedikit kue seharganyo
tidak beda jauh.

Figure 4. Students' post-test representations showing a shiftfrom additive to multiplicative strategies

Overall, the teaching experiment demonstrates that the learning design based on traditional Banyuasin snack contexts and the revised HLT effectively enhanced students' mathematical reasoning ability. Students were able to perform interpretation, quantitative analysis, tabular representation, and formal

generalization more systematically than during the pilot experiment. These findings strengthen the empirical validity of the revised HLT and result in a Local Instructional Theory (LIT) that explains how mathematical reasoning develops through contextual learning grounded in local cultural practices.

This discussion interprets the findings of the teaching experiment by relating them to theories of mathematics learning and previous studies within the design research framework. During the pilot experiment, it was found that some students were not yet able to transition from contextual understanding to formal mathematical representations. The difficulties mainly emerged when students were required to express changes in quantities using tables or ratios, indicating that the initial Hypothetical Learning Trajectory (HLT) had not provided sufficient representational bridges. This finding is consistent with Purwasi et al., (2025), who emphasize the importance of visual scaffolding in learning ratio and proportion.

The revision of the HLT after the pilot experiment resulted in significant improvements. The inclusion of prompting questions, supporting tables, and an emphasis on causal relationships helped students organize information and perceive proportional relationships more clearly. These results align with Sari and Jupri (2021), who argue that scaffolding can guide students gradually from intuitive reasoning toward formal reasoning.

During the teaching experiment, the development of students' reasoning became evident. Nearly all students shifted from additive to multiplicative strategies in activities involving adjustments to the ingredients of kue lumpang. The supporting tables functioned as a model-for representation (Gravemeijer & Cobb, 2006), enabling students to recognize fixed multiplicative patterns and proportional relationships. This improvement is consistent with Lamon (2020), who states that structural representations can reduce misconceptions in ratio and proportion. In subsequent activities, the context of kue rangi supported students in generalizing ratios and solving unit price problems using more stable multiplicative reasoning. These findings support Gómez and Escudero (2021), who highlight the effectiveness of food-related contexts in eliciting proportional reasoning, as well as Putra (2020), who emphasizes that local cultural contexts serve as conceptual anchors in mathematics learning.

Furthermore, group discussions revealed the emergence of socio-mathematical norms, as evidenced by students' ability to compare strategies and provide mathematical justifications. This finding is consistent with Yackel and Cobb (1996) and supported by Russo and Hopkins (2023), who argue that social interaction strengthens mathematical argumentation. Post-test results indicated that most students successfully transitioned from additive reasoning to formal multiplicative reasoning. Students began to employ tables, multiplicative factors, and systematic calculations to determine proportional quantities, corroborating Neidorf et al. (2020), who reported that context-based learning enhances students' performance in mathematical literacy.

The context of traditional Banyuasin snacks proved effective in strengthening conceptual understanding by providing rich quantitative structures. This finding reinforces the work of Rosa and Orey (2016) and Noto et al. (2022), who argue that the integration of local culture can enhance students' motivation and mathematical understanding. Through the overall design research process, a Local Instructional Theory (LIT) was developed to describe the trajectory of students' reasoning development from understanding the context, distributing quantities evenly, determining multiplicative factors, generalizing through ratios, to expressing direct proportional relationships in formal representations. The illustration of students' reasoning development trajectory is presented in Figure 5.

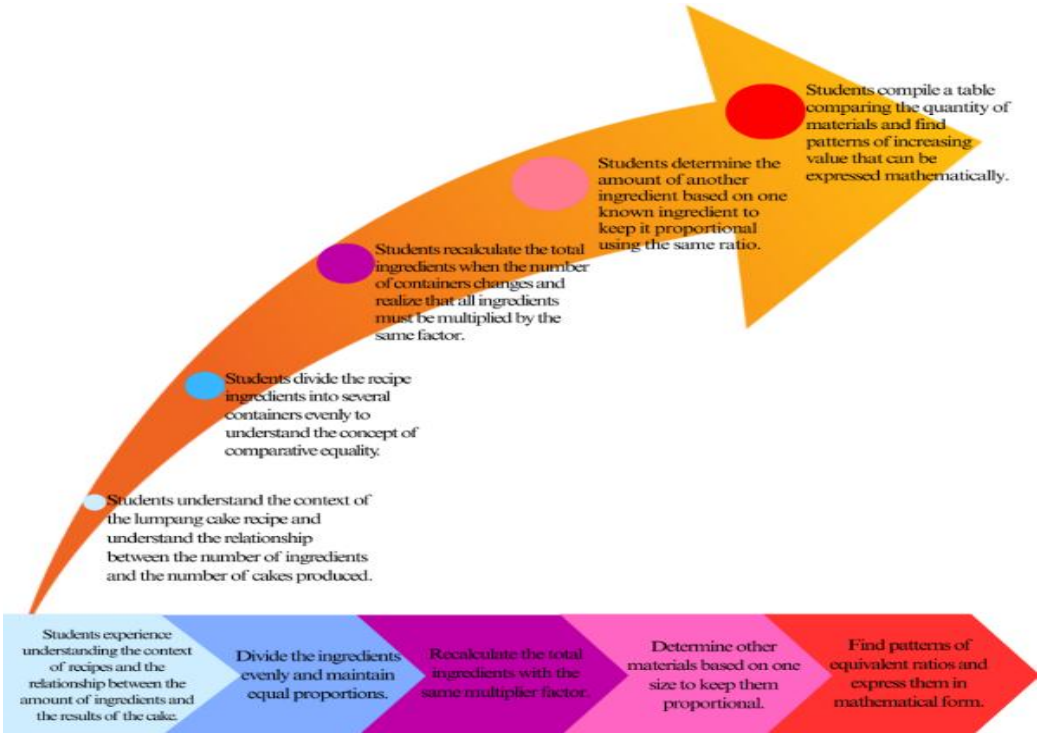


Figure 5. Learning Trajector

Overall, the findings of this study indicate that a learning design based on the context of traditional snacks and a systematically revised Hypothetical Learning Trajectory (HLT) was able to effectively facilitate the development of students' mathematical reasoning. The visualization of students' reasoning trajectories through the Local Instructional Theory (LIT) strengthens the theoretical contribution of this study while also providing practical guidance for teachers in teaching ratio and proportion concepts. These findings provide a strong foundation for drawing the conclusions of this study.

This study has several strengths, including the use of authentic traditional snack contexts that are closely related to students' everyday experiences, as well as the development of a learning trajectory designed iteratively through pilot and teaching experiments. This approach enabled an in-depth understanding of the processes underlying students' mathematical reasoning development. However, this study also has limitations. The teaching experiment was conducted in a single class with a limited number of participants, which restricts the generalizability of the findings. In addition, the study focused solely on direct proportion, suggesting the need for further research to examine the application of similar learning trajectories to other mathematics topics.

The findings of this study offer theoretical implications by reinforcing the concept of emergent modeling in learning ratio and proportion, particularly highlighting the role of tabular representations as a bridge from contextual understanding to formal mathematical understanding. Practically, this study provides an alternative instructional design for junior high school teachers to teach ratio and proportion through meaningful and systematic local cultural contexts. The results may also serve as a reference for designing learning activities that support the development of students' mathematical reasoning ability.

Based on these overall findings, the developed learning trajectory was able to describe students' stages of understanding in ratio and proportion learning while simultaneously guiding the development of their mathematical reasoning ability,

particularly in identifying proportional relationships, constructing logical arguments, and systematically generalizing ratios.

CONCLUSION

This study resulted in the development of a learning trajectory for ratio and proportion based on the context of traditional Banyuasin snacks, which was able to guide seventh-grade junior high school students in gradually understanding ratio and proportion concepts, from exploring contextual situations to using formal mathematical representations. The developed learning trajectory demonstrated its role in supporting students' mathematical reasoning ability, particularly in identifying proportional relationships between quantities, constructing logical arguments, and systematically generalizing ratios. Through the implementation of the revised learning trajectory, students not only understood the procedures for calculating ratios and proportions but were also able to reason multiplicatively about quantitative changes based on meaningful contexts. Therefore, the learning trajectory based on traditional Banyuasin snack contexts contributes to the development of contextualized ratio and proportion learning that is oriented toward strengthening junior high school students' mathematical reasoning ability.

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