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Learning fraction with vacation: Integrating Musi Rawas tourism in designing learning trajectory on fraction

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Abstract

Fraction learning has gained significant attention in mathematics education research, with a growing body of literature addressing the instructional challenges inherent in teaching fractions effectively. Establishing a solid conceptual foundation in fractions is critical to fostering broader mathematical proficiency, yet many students continue to struggle with core fractional concepts. This study addresses these issues by integrating a real-world context—Musi Rawas tourism—into fraction instruction, targeting pre-service elementary teachers enrolled in an elementary mathematics education program. Adopting a design research methodology, specifically a validation study, the study progresses through three structured phases: preliminary design, design experiments (encompassing pilot and teaching experiments), and retrospective analysis. Data collection involved teaching materials, observational checklists, and documentation to capture the instructional dynamics and learning outcomes. The study's primary contribution is a localized instructional theory for teaching fractions within a tourism context, organized across five progressive learning activities: problem identification in the Gegas Water Lake tourism setting, contextual model development, model-based problem-solving, context-specific solution formulation, and abstraction of mathematical conclusions. This framework offers an innovative pedagogical approach, illustrating the potential for enhancing fraction learning through contextualized instruction in tourism, with detailed insights into the methodology and outcomes presented in the full study.

Keywords: Design Research, Fraction, Gegas Water Lake Tourism, Local Instructional Theory, Multiplication of Fractions

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Understanding fractions is essential for students due to its foundational role in various real-world applications (Bush, 2021). Fractions are widely applied across fields; in finance, for example, they appear in decimal forms in loan calculations and debt statements (Lamon, 2020). Time measurement also depends on fractional understanding, as hours, minutes, and seconds are divided into fractions to facilitate precise scheduling and time management (Charalambous & Pitta-Pantazi, 2007). Additionally, fields such as architecture and accounting frequently rely on fractional and decimal measurements to achieve accuracy in material estimation and financial documentation (Ni & Zhou, 2005). Given this pervasive use of fractions, it is essential for students to build a solid understanding of the topic (Siegler et al., 2011). Research suggests that students with a strong grasp of fractions are better prepared to tackle advanced mathematical tasks, both in higher education and in professional environments (Bailey et al., 2012). Consequently, providing students with foundational skills in fractions is critical for their academic and professional development.

In the reality, research consistently shows that fractions pose significant challenges for learners across all age groups, with difficulties often extending into adulthood (Hunt et al., 2019; Wortha et al., 2020). A primary issue lies in students' reliance on whole-number reasoning, which can hinder their ability to understand fractional concepts—a phenomenon termed "whole number bias" (Sidney & Alibali, 2017; Xu et al., 2024). This bias is especially evident in fraction operations, such as addition and subtraction. For example, when instructed to add fractions with different denominators, students often misinterpret the process, attempting to equalize denominators without fully grasping its necessity (Jarrah et al., 2022; Moyo & Machaba, 2021). Similarly, errors in fraction subtraction frequently involve the direct subtraction of numerators and denominators independently, resulting in incorrect solutions (Safriani et al., 2019). These persistent misunderstandings underscore the urgent need for instructional strategies that address whole-number bias while fostering a foundational understanding of fraction operations. Ultimately, enhancing students' comprehension of fractions is critical for their success in more complex mathematical concepts and practical applications.

Numerous research has identified common errors in fractional arithmetic, underscoring the challenges students face in mastering fractions (Alkhateeb, 2019; Purnomo et al., 2022; Prediger et al., 2022; Lenz et al., 2024). A prevalent issue is the incorrect handling of denominators during addition and subtraction; many students attempt to add or subtract fractions with different denominators directly, neglecting to find a common denominator, which leads to erroneous results (Alkhateeb, 2019). Another frequent error arises in multiplication and division, where students mistakenly apply addition rules, treating these operations as if they were dealing with whole numbers. This reflects a conceptual gap in distinguishing between operations for fractions and whole numbers (Purnomo et al., 2022). Additionally, whole-number bias, where students overgeneralize rules from whole-number arithmetic to fractions, causes misunderstandings across various fractional operations (Braithwaite & Siegler, 2024). This bias is especially apparent when students independently subtract or add numerators and denominators, revealing a fundamental gap in understanding fractional relationships (Safriani et al., 2019). Such consistent error patterns highlight the need for targeted instructional strategies to bridge the conceptual divide between whole numbers and fractions, fostering students' accurate comprehension of fractional arithmetic and strengthening their overall mathematical competency.

There is a critical need for teachers to enhance their ability to foster students' understanding of fractions, given the common difficulties students face with this fundamental concept (Lamon, 2020). Research suggests that effective instructional strategies should connect with students' prior knowledge and experiences, making learning more relatable and engaging (Johnston et al., 2023; Kalogeropoulos et al., 2024). One promising approach is Realistic Mathematics Education (RME), which leverages real-world contexts to support mathematical understanding. RME encourages teachers to present fractions through familiar, everyday scenarios, helping bridge the gap between abstract concepts and practical applications (Van den Heuvel-Panhuizen & Drijvers, 2020; Zulkardi et al., 2021). This approach not only aids in comprehension but also fosters critical thinking and problem-solving skills, as students actively engage in meaningful mathematical processes (Prahmana et al., 2020; Risdiyanti et al., 2024). Implementing RME in the classroom creates a supportive environment where students can explore, discuss, and apply fractional concepts, ultimately improving mathematical proficiency and confidence (Jannah & Prahmana, 2019). Therefore, integrating RME strategies into fraction instruction is crucial for enhancing student learning outcomes and fostering a deeper understanding of mathematics.

The RME approach has been shown to significantly enhance students' cognitive processes in understanding mathematical concepts, particularly fractions (Van Galen et al., 2008; Anwar et al., 2012; Meryansumayeka et al., 2019). By embedding mathematical instruction within real-world contexts, RME fosters an environment that encourages active exploration and critical thinking, both essential for developing inductive reasoning skills (Soto-Andrade, 2020; Hanna, 2020). Additionally, RME provides a structured learning trajectory that progressively guides students through complex concepts, effectively addressing their misconceptions and weaknesses in fraction comprehension (Freudenthal, 1991). Consequently, the implementation of RME is essential for helping students overcome difficulties with fractions, ultimately resulting in greater mathematical proficiency and confidence.

One of the characteristics of RME approach is its emphasis on using real-life contexts as foundational elements in mathematical learning (Sembiring et al., 2008; Van Galen, 2013). This contextualization is crucial for effectively mathematizing information within mathematical problems, particularly with concepts like fractions. For example, using a teak wood block allows students to visualize fractions by modeling arithmetic expressions, aiding in their grasp of fractional numbers (Sidney & Alibali, 2017). Interlocked blocks of various sizes can illustrate fractional relationships, such as demonstrating that two parts equal three-thirds or one whole. Additionally, presenting students with fraction bars—whole, half, third, fourth, fifth, and sixth—facilitates more meaningful engagement with fractional representations. Contexts like dividing a pizza into slices also provide tangible ways to explore fraction relationships, appealing to students' sense of fairness as they consider equal distribution (Van Galen et al., 2008; Van Galen, 2013).

Other relatable scenarios, such as using hair ribbons (half a ribbon for tying), cooking measurements (like determining the flour needed for multiple apple pies), or practical problems in painting and distributing milk, further reinforce fractional understanding in accessible ways (Pierce, 2021; Ne, 2005; Olson & Olson, 2013; Kilic, 2015). Such diverse, real-world contexts are essential for engaging students, facilitating mathematization, and enhancing their comprehension of fractions. When mathematical concepts are connected to familiar scenarios, students are better equipped to understand the principles and applications of fractions. Thus, embedding fraction instruction within relatable situations enables educators to create a more meaningful and engaging learning environment, ultimately leading to improved mathematical outcomes for students.

Research on the application of contextual learning in fractions has demonstrated its effectiveness in improving students' conceptual understanding (Rau & Matthews, 2017; Misquitta, 2011; Mavrikis et al., 2022). Furthermore, Hunt et al. (2019) suggests that engaging students in contextualized fraction activities can facilitate an accurate grasp of fraction concepts. For example, using midpoints and "sameness" principles allows students to construct unit fractions as a foundational, one-level structure, which can then expand to connect unit fractions with numerical relationships. Through iterative processes, students build a more complex, two-level understanding of fractions. Context-based learning has also been shown to enhance student interest and engagement. Although students may initially struggle with operations involving different denominators—often due to early instruction that emphasizes adding fractions with the same denominator (Kilic, 2015)—introducing familiar contexts, such as pizza slicing, helps students gain a better understanding of these operations (Streefland, 2012; Van Galen, 2013).

Incorporating real-world contexts into fraction learning designs enables teachers not only to address and correct student misconceptions but also to enhance students' ability to solve fraction-related word problems both symbolically and procedurally (Shanty, 2023; Lee & Lee, 2023). Realistic contexts foster the modeling of core mathematical concepts, helping students generalize their understanding of fractions (Olson & Olson, 2013). Introducing fraction instruction through real-world contexts helps students distinguish between fractions and whole numbers, reducing confusion and misconceptions (Sidney & Alibali, 2017). Thus, embedding relevant contexts within fraction instruction positively impacts students' conceptual understanding.

Despite the benefits, tourism as a learning context remains underexplored in educational research. Given that engaging learning experiences contribute significantly to classroom success (Domínguez et al., 2013; Malone & Lepper, 2021), incorporating tourism contexts provides an innovative approach for educators to create stimulating and meaningful learning experiences (Bueddefeld & Duerden, 2022). Teaching concepts through "vacation-based" contexts can help students connect with mathematical concepts in memorable ways.

In Lubuklinggau, a city in the westernmost region of South Sumatra, Lake Gegas—a prominent attraction in the Musi Rawas tourism area—is well known among local residents, especially elementary students who visit frequently for recreation and camping. Activities at Lake Gegas inherently contain mathematical concepts, including fractions, inspiring this study to design a fraction learning trajectory based on tourism in Musi Rawas, with a specific focus on student activities at Lake Gegas. This study retrospectively analyzes learning outcomes from this approach, revealing that certain activities effectively support students' understanding of fractions and contribute to the development of a local instructional theory on fractions. Here, "local" refers to a theory tailored to fraction instruction within this specific context. Accordingly, the study’s research questions focus on two primary areas: students' cognitive processes in understanding fractions through tourism contexts and the learning trajectory they follow when grasping fraction concepts in these settings.

METHODS

This study employs a design-based research framework consisting of three key phases: the preliminary phase, the design experiment phase, and the retrospective analysis phase (Plomp, 2013). This structured approach allows for the systematic development and validation of the Hypothetical Learning Trajectory (HLT) on fractions using the Gegas Lake tourism context in Lubuklinggau as an applied setting.

Preliminary Design

At this stage, the researcher conducts a comprehensive literature review and designs the HLT. The literature review focuses on existing research related to elementary mathematics education concepts and Pendidikan Matematika Realistik Indonesia (PMRI), Indonesian version of RME, learning activities. This review provides foundational insights into effective instructional strategies and informs the subsequent design of the HLT.

To further contextualize the research, field observations are conducted with students from the Elementary School Teacher Education program. These observations aim to gauge the students' familiarity with PMRI methodologies and assess their baseline knowledge, helping the researcher identify areas that may benefit from targeted instructional interventions. Additionally, the researcher reviews the Elementary School Teacher Education program’s curriculum to select relevant courses where a tourism context can be effectively integrated, providing an authentic learning environment that aligns with the study’s educational objectives.

Following these preparatory activities, the researcher collaborates with an Elementary School

Teacher Education lecturer to design the HLT based on the literature review findings. Together, they develop supporting learning materials, including assessment instruments, students' worksheets, and lesson plans, tailored to facilitate the HLT's objectives. This collaborative approach ensures that the HLT and its associated learning tools are theoretically grounded and practically viable, setting a solid foundation for subsequent phases of the study.

Design Experiment

At this stage, the researcher conducted both a Pilot Experiment and a Teaching Experiment to test and refine the instructional design. In the Pilot Experiment, six students were selected to represent a range of abilities in problem-solving, covering low, medium, and high competency levels. This stage serves as a bridge between the Preliminary Design and the full-scale Design Experiment, with specific objectives: to assess the initial competencies of participants related to the learning material and to refine the HLT based on data collected from student interactions. Insights from this pilot phase are used to make adjustments to the HLT, ensuring it aligns with the students' needs and instructional goals.

In the Teaching Experiment, the revised learning design was implemented with a larger group of 30 participants. During this stage, the researcher observed and systematically analyzed student interactions and learning activities in a classroom setting. The purpose of this phase is to evaluate the assumptions embedded within the learning activities and to determine their effectiveness in fostering the intended learning outcomes. Through these observations, the researcher gains critical insights into the practical applicability and impact of the design, guiding further refinements to the instructional approach.

Retrospective Analysis

At this stage, the researcher conducts an in-depth analysis of the results from the Teaching Experiment activities. The analysis focuses on several key aspects: learning assumptions, assumptions about student learning processes, observations of classroom interactions, and the extent to which the learning objectives were achieved. If the predetermined learning objectives have not been met, a second cycle of the learning process is implemented to address gaps and improve outcomes. Conversely, if the objectives are successfully met, the designed HLT is refined and formalized into a Learning Instructional Trajectory (LIT), representing a validated and effective instructional approach.

RESULTS AND DISCUSSION

The findings indicate that employing a tourism-oriented context, specifically that of Air Gegas Lake, to facilitate the students' cognitive processes in understanding fractions through tourism contexts. The structured learning trajectory enabled students to progress systematically through phases of contextual problem comprehension, model construction, solution application, and mathematical inference. This context-driven approach aligns with established pedagogical models that prioritize real-world reasoning and interconnected learning, reinforcing outcomes noted in prior research. The instructional design was meticulously organized into three research stages: the preliminary phase, the design experiment phase, and the retrospective analysis phase.

Preliminary Design

In the preliminary design phase, the researcher began by conducting an in-depth literature review focused on teaching addition and subtraction of fractions within a realistic mathematics education (RME) framework, subsequently developing a Hypothetical Learning Trajectory (HLT). The researcher further reviewed curriculum materials, lesson plans, instructional activities, and selected appropriate learning media for teaching fractions. Observations were conducted, and discussions with colleagues focused on fraction learning activities, students' abilities to add fractions, and the research timeline. The HLT was constructed based on insights from the literature review, along with the design of activity sheets and lesson plans.

Furthermore, an initial survey, as shown in Figure 1, assessed Elementary School Teacher Education students' perceptions and understanding of RME. Findings indicated that only 11 of the 30 students were familiar with RME, though none had a detailed understanding of its specific characteristics and principles.

Figure 1. Initial perception survey process of students

In response, Dr. Anna Fauziah, M.Si., provided an in-depth session on RME principles to offer students a comprehensive overview of this instructional method (see Figure 2). Additionally, the researcher explored three notable tourist sites within Musi Rawas Regency—Beregam Park, Aur Lake, and Gegas Lake—as potential contexts for mathematics instruction.

Figure 2. RME material exploration

Situated in Muara Beliti Subdistrict, Musi Rawas Regency, South Sumatra Province, Beregam Park occupies a strategic location within the Muara Beliti Agropolitan Center along the Sumatra highway, approximately 15 minutes east of Lubuklinggau City. This 4.36-hectare green space, popular among Musi Rawas and Lubuklinggau residents, offers diverse recreational facilities, including children's rides, a flower garden, climbing walls, walking paths, and a storytelling center. Due to its popularity, Beregam Park presents a promising context for incorporating real-life applications into mathematics education, aligning with RME principles. Furthermore, Aur Lake, located in Sumber Harta Subdistrict, serves as a primary irrigation source for the Aur River, supporting local agricultural needs. Covering approximately 40 hectares with a depth of 20 meters, Aur Lake has served as a tourist destination since 2011, offering amenities such as gazebos, floating restaurants, pedal boats, fishing areas, and a floating library. This popular destination, about 40 minutes from Musi Rawas City and Lubuklinggau, offers an ideal context for real-world-based mathematics instruction. Finally, located in Sugih Waras Village, Sukakarya Subdistrict, Musi Rawas Regency, Gegas Lake spans 3000 hectares and is noted for its pristine, scenic beauty. Approximately 1.5 hours east of Lubuklinggau City, it attracts 300-600 visitors on regular weekends and up to 1,500 during major holidays such as Eid and New Year. The various activities and attractions at Gegas Lake offer significant potential for using real-world contexts in mathematics instruction.

The contextualization of mathematics in primary education supports Prahmana et al. (2020) assertion that mathematics should connect to real-life situations. This research's mathematical problem design aligns with numeracy dimensions established by Dole and Geiger (2020), encompassing focus on real-world contexts, application of mathematical knowledge to real-life problems, use of physical and digital tools for problem-solving, fostering a positive attitude toward practical mathematics applications, and developing a critical orientation for interpreting results and making evidence-based decisions. The researcher designed a fraction learning trajectory with five activities presented in Table 1, each representing a cognitive activity within the tourism context of Air Gegas Lake and implemented during the design experiment phase.

Table 1. HLT on multiplication of fractions

Activities	Objective	Conjecture
Understanding the Fraction Multiplication Problem	Determine the minimum water volume needed to prepare six 250 ml coffee cups from lake water.	• Students note that six cups require 250 ml each. • Students estimate total cooking water required for six cups of coffee.
Modeling the Problem	Develop a model representing six 250 ml cups and a pot for water sourced from the lake.	• Students illustrate a model with six cups each containing 250 ml. • Students include a pot in the model to represent the lake source.
Completing the Mathematical Model	Specify that 1,500 ml of water is needed to fill six cups of 250 ml each.	• Students calculate the required water as 1,500 ml by multiplying six by 250 ml. • Students confirm that 6 x 250 ml equals 1,500 ml.

Contextual Problem-Solving	Calculate and verify 250 + 250 + ... + 250 = 1,500, equating to 6 x 250 = 1,500, or 1.5 liters.	• Students relate the solution to integer multiplication principles. • Students apply multiplication principles to both integers and fractions.
Concluding on Fraction Multiplication	Conclude that 6 x 1/4 = 1.5, using repeated addition, validating that 6 x 1/4 equals 1.5.	Students generalize that fraction multiplication involves repeated addition, reinforcing formal principles of fraction operations.

Design Experiment

The design experiment phase involved two main activities: the pilot experiment and the teaching experiment. The pilot experiment served as an initial trial of the HLT by involving six students working in a single group to review the HLT design, particularly focusing on the readability, clarity of instructions, and student worksheets. Feedback was also gathered on the appeal and appropriateness of using Musi Rawas tourism contexts for teaching fractions.

During the pilot experiment, six students representing three different ability levels were selected to complete learning activity worksheets on fractions using the Musi Rawas tourism context. In the subsequent teaching experiment, the instructional design was tested on a larger group. The goal of this phase was to evaluate the learning trajectory and enhance the design's comprehension within that sequence. Revisions to the HLT were then implemented in a trial with 30 students in one class. Throughout the learning process, data were collected through lesson observations, student responses on worksheets, and interviews with students. This included group discussions and presentations of their work to the class. Observations helped assess the feasibility of the HLT, while interviews verified the alignment of actual learning activities with the HLT.

Figure 3 shows the fraction learning activities, using the Musi Rawas Tourism context, in class through student's worksheet. In these activities, students initially tackled fraction problems individually within the Musi Rawas tourism context, then collaboratively built mathematical models in pairs. Working in small groups, students completed the contextual mathematical model and developed solutions. After solving the contextual problem, the instructor facilitated a whole-class discussion to consolidate students' understanding of fractions. The activity concluded with students formally summarizing the concept of fractions.

Figure 3. Contextual problem understanding activity

The research data were analyzed through three approaches, namely students' learning trajectories in fraction multiplication, students' responses to the instruction, and the percentage of completion at each stage in the learning trajectory. Using the context of Gegas Lake tourism, students were presented with the following problem:

"On Sunday, Anton and five friends traveled to Gegas Lake. Upon arrival, they set up a tent. Once finished, they all wanted coffee. Anton fetched water from the lake to prepare it. Determine the minimum amount of boiled water required to fill each 250-milliliter cup with coffee. Measure the water in liters and determine the process for calculating the minimum amount of water needed to fill all cups."

Insights were gathered from an in-depth interview with a student, SA1, representing the group that arrived at the correct solution based on the contextual problem related to Gegas Lake provided to students. As outlined in Table 1, each activity within the HLT represents an activity and cognitive process through which students approached the problem based on the Gegas Lake tourism context. These activities are detailed as follows.

Activity 1: Understanding the Problem within the Gegas Lake Tourism Context

Students demonstrated an accurate understanding of the contextual problem related to Gegas Lake tourism based on the provided problem. The learning trajectory unfolded as followed interview (T: Teacher; SA: Student):

T : "What is your impression of the problem given to you?"
SA : "Well, Sir, I understand that we need to determine the minimum amount of water to brew six cups of coffee using hot water."
T : "What would be the next step?"
SA : "From the problem, we know that 6 cups are each 250 ml, and we need to determine the amount of boiling water in the pot required to brew these 6 cups of coffee."

The interview results indicate that SA1's responses reflect a strong comprehension of both the contextual and mathematical dimensions required to solve a practical problem: calculating the minimum amount of boiling water necessary to fill six 250-milliliter cups within the context of Gegas Lake tourism. SA1 precisely identifies the core task and successfully translates this real-world requirement into a measurable goal, recognizing that the volume per cup is a critical factor. This understanding illustrates SA1's capability to contextualize mathematical concepts within real applications, aligning well with the principles of RME. Moreover, SA1's decision to multiply the number of cups by the volume per cup underscores a foundational grasp of unit consistency, scaling, and volume aggregation, which are key in constructing an accurate mathematical model. This response demonstrates SA1's readiness for a quantitative solution and highlights sequential thinking, as well as skills in problem decomposition, supporting a methodical approach to problem-solving. SA1's application of mathematical operations, such as multiplication, to concrete quantities also suggests a sound understanding of proportionality and accumulation, essential for procedural task completion. Further instructional guidance could deepen this comprehension by connecting calculations more directly to practical aspects, such as confirming the pot's capacity for 1,500 ml and accuracy in measurement. Emphasizing unit conversions, like from milliliters to liters, could also enhance SA1's familiarity with metric measurements in applied contexts. This example underscores the importance of incorporating relatable settings, such as Gegas Lake, in mathematics education to ground abstract ideas in real-life scenarios, fostering student engagement and alignment with RME principles.

Activity 2: Constructing a Mathematical Model in Context

In constructing a mathematical model, students used a visual representation, as observed in the following interview.

T : "What can you do next?"
SA : "All right, I'll create a visual representation."
SA1 displays an illustration on a response sheet presented in Figure 4.
T : "What are your thoughts on this representation?"
SA : "There are six cups, each with a 250 ml capacity, and a pot for heating water sourced from the lake."

This visual model effectively translates abstract mathematical concepts into tangible forms, using real-life objects to facilitate comprehension. The consistent use of a 250 ml unit as a standard measure for each cup introduces a reliable framework for volume estimation, which is crucial for constructing accurate mathematical models. The choice to employ familiar, everyday objects demonstrates an intuitive understanding of volume and offers an accessible entry point for grasping fundamental measurement principles in a practical context.

Furthermore, Figure 4 demonstrates the student's engagement with both theoretical and practical aspects of mathematical modeling, showing proficiency in contextualizing mathematical representations. Future recommendations could involve introducing alternative representations or scaling exercises to deepen understanding.

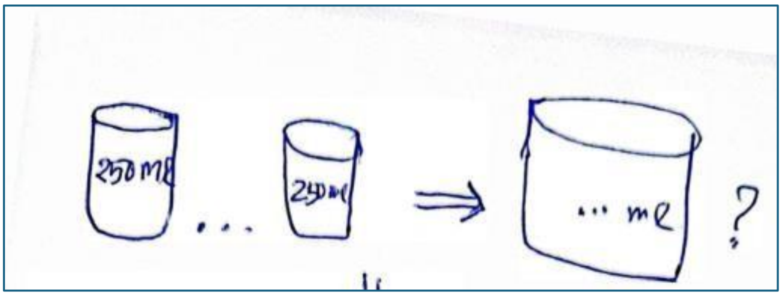

Figure 4. Pot and six 250 ml cups

This activity has several implications for mathematical learning. First, it highlights the student's ability to relate theoretical concepts to real-world applications, enhancing their relevance and applicability. Additionally, the model's simplicity provides a foundation that can be expanded upon, enabling students to explore more complex mathematical tasks, such as calculating total volume or engaging in proportional reasoning. By using a clear and relatable representation, the student sets the groundwork for future learning opportunities, fostering both critical thinking and a deeper understanding of mathematical modeling.

Activity 3: Solving Contextual Mathematical Models

In Activity 3, which emphasizes context-based problem-solving, the student effectively demonstrated their ability to tackle a mathematical problem grounded in a real-world scenario. The interview excerpt provides insight into the student's systematic approach to dividing a total of 1,500 ml of hot water among six glasses, each with a capacity of 250 ml, as detailed below:

T : Describe the next steps you completed.
SA : I poured 1,500 ml of water into six cups, each filled with 250 ml of hot water to make coffee, as shown in Figure 5.
T : What conclusion can you draw from this?
SA : This means that the 1,500 ml of water in the pan can be divided by 250 ml, resulting in six cups.

This context-driven problem required the student to utilize division to distribute the water evenly across the glasses. Such an approach enabled the student to connect and apply mathematical concepts in a meaningful way, facilitating cognitive engagement and enhancing their understanding of volume and division principles. This activity exemplifies how contextual learning bridges abstract mathematical ideas with concrete, relatable scenarios. The student's responses in the interview show a clear grasp of the logical steps involved in dividing 1,500 ml by 250 ml to determine that six glasses are necessary, as illustrated in Figure 5.

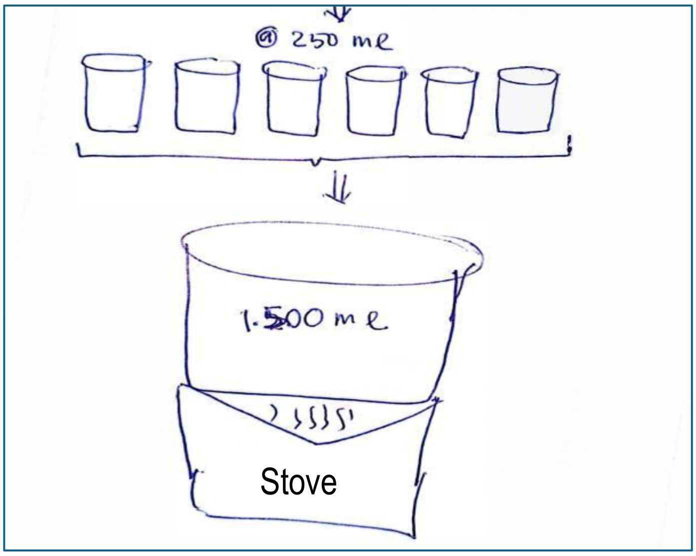

Figure 5. 1,500 milliliters of hot water in a saucepan, sufficient for six cups

Engaging in these types of problem-solving activities promotes not only mathematical accuracy but also encourages students to clearly articulate their reasoning, thus reinforcing their conceptual understanding and critical thinking abilities in mathematical contexts. This approach underscores the importance of contextual problem-solving for fostering mathematical literacy, equipping students with skills applicable to real-world situations. Students subsequently follow a structured learning path to solve contextual problems through mathematical processes.

Activity 4: Creating Contextual Problem-Solving Solutions

The students' participation in Activity 4 demonstrates significant progress in applying contextual problem-solving skills, specifically in translating real-life scenarios into mathematical expressions. Almost all students accurately followed a structured learning trajectory that involved developing solutions in line with mathematical problem-solving models. This capability is reflected in the following interview:

T : What is the next step?
SA : Based on the representation as illustrated in Figure 6, it would be incorrect to say that 250 + 250 + 250 + 250 + 250 + 250 = 1,500.
T : What can you conclude from that?
SA : 6 x 250 = 1,500.
T : What is that amount in liters?
SA : I concluded that 1,500 ml equals 1 ½ liters, and 250 ml equals ¼ liter, so 6 x ¼ = 1½.

The dialogue between the teacher (T) and the student (SA) illustrates this progression effectively. The student's response indicates a strong grasp of the concept of multiplication within a context, acknowledging the correct interpretation that $6 \times 250 = 1500$, a crucial step in representing the cumulative volume in milliliters.

Further analysis of this interaction highlights the depth of students' conceptual understanding of unit conversions, especially in linking millilitres to litres. SA's accurate conversion from millilitres (1,500 ml) to litres ($1\frac{1}{2}$ litres) and understanding that 250 ml $= \frac{1}{4}$ litres reflects a sound comprehension of fractional mathematics. This ability to transition smoothly between units not only reinforces mathematical operations like multiplication but also strengthens their grasp on fractions and measurement equivalencies. Such understanding is critical in building a foundation for more advanced mathematical concepts, illustrating the effectiveness of contextual learning in bolstering mathematical reasoning.

The representation in Figure 6 encapsulates students' proficiency in fraction multiplication through visual contextualization, reinforcing the concept. By associating numbers with real quantities and engaging in fractional calculations, students exhibited enhanced problem-solving strategies, indicating a successful alignment with learning objectives. The diagrammatic representation supports this, bridging abstract mathematical principles and tangible contexts, which is essential for fostering higher-order thinking skills in mathematical education. This activity, therefore, not only fulfills the learning goals but also exemplifies a pedagogical approach that successfully translates theoretical knowledge into practical understanding.

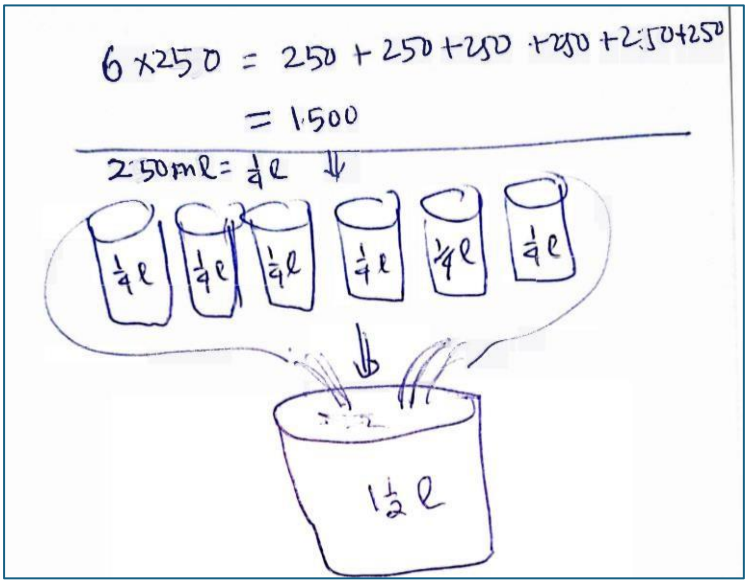

Figure 6. Representation of fraction multiplication by SA

Activity 5: Deriving Mathematical Conclusions

In Activity 5, students successfully demonstrated their ability to formulate mathematical principles formally through context-based problem-solving. This activity reflects a deep understanding of the concept of fraction multiplication, particularly in the representation of $6 \times \frac{1}{4}$. The dialogue between the teacher (T) and the student (SA) shows that SA can explain the mathematical process involving the repeated addition $\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}=1\frac{1}{2}$. This indicates that students not only understand multiplication operations procedurally but can also reformulate the concept into explicit mathematical statements as evidenced in the following interview excerpt.

T : What can you conclude mathematically?
SA : I can conclude mathematically that $6 \times \frac{1}{4}=\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}+\frac{1}{4}=1\frac{1}{2}$ *and it is* $6 \times \frac{1}{4}=1\frac{1}{2}$

The students’ ability to conclude that $6 \times \frac{1}{4}=1\frac{1}{2}$ signifies maturity in their understanding of fraction multiplication and conversion between different representational forms. This process shows how students can combine conceptual and procedural understanding, both of which are essential in developing advanced mathematical thinking skills. The formal mathematical statements created by the students also demonstrate their ability to generalize the process of fraction multiplication, which is a crucial indicator in concept-based mathematics learning.

Figure 7 illustrates SA’s formal representation of fractional multiplication, providing visual insight into the students' thought processes during this activity.

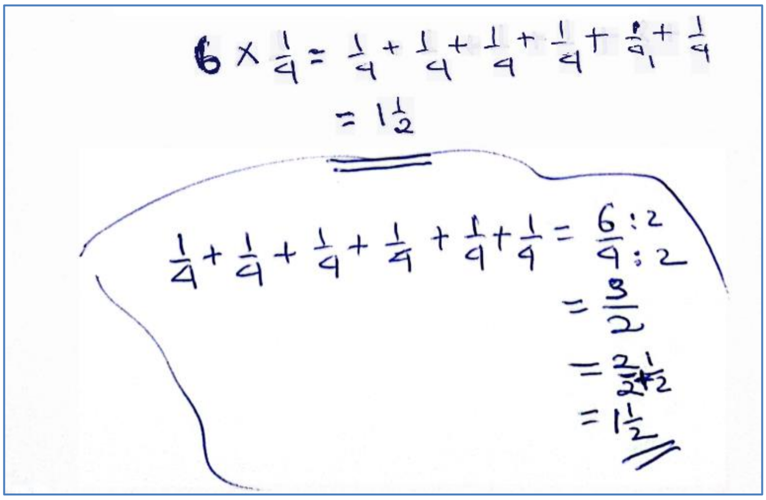

Figure 7. SA’s formal mathematical representation of fraction multiplication

This visual representation not only facilitates the students’ comprehension of fraction multiplication but also aids in their ability to clearly and persuasively convey the final result. The use of repeated addition in this context reinforces the students' understanding of fractional multiplication outcomes. Overall, this activity underscores the effectiveness of context-based learning in supporting students to formally and logically internalize and communicate mathematical concepts.

Retrospective Analysis

During the retrospective analysis phase, the researcher systematically compared students' actual learning trajectories with the hypothesized learning trajectory (HLT) to assess their comprehension, problem-solving processes, and conclusion-forming abilities in context-based tasks. Findings from this phase shed light on how the Musi Rawas tourism context supported students in identifying the contextual problem, reflecting on their understanding, planning problem-solving strategies, executing solutions, examining surface area problems within a tourism context, and ultimately internalizing fraction concepts.

Additionally, the responses of all students engaged in learning fractions through the Gegas Lake tourism context are presented in Figure 8.

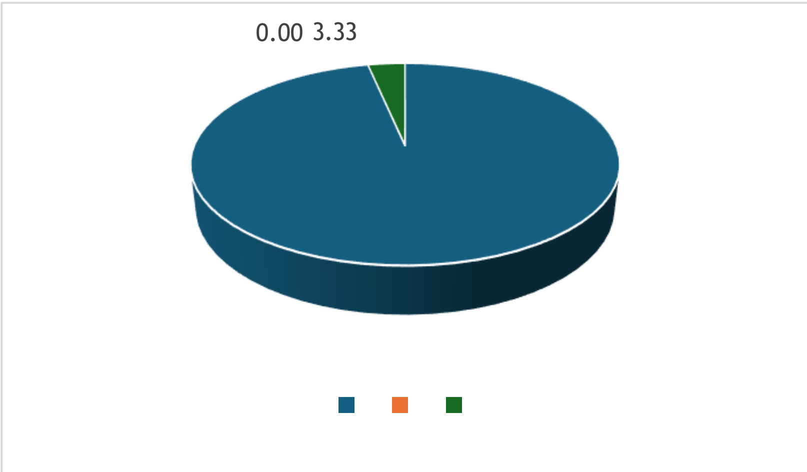

Figure 8. Student responses to learning fractions in a tourism context

As shown in Figure 8, 96.67% of students reported a positive reception toward learning fractions within the Gegas Lake tourism context, with no negative responses. Only one student out of 30 expressed neutralities. Upon inquiry, this student noted familiarity with mathematics through real-world media facilitated by private tutoring, indicating an established comfort with similar instructional methods. This result suggests a general preference among students for a contextual approach in learning mathematics.

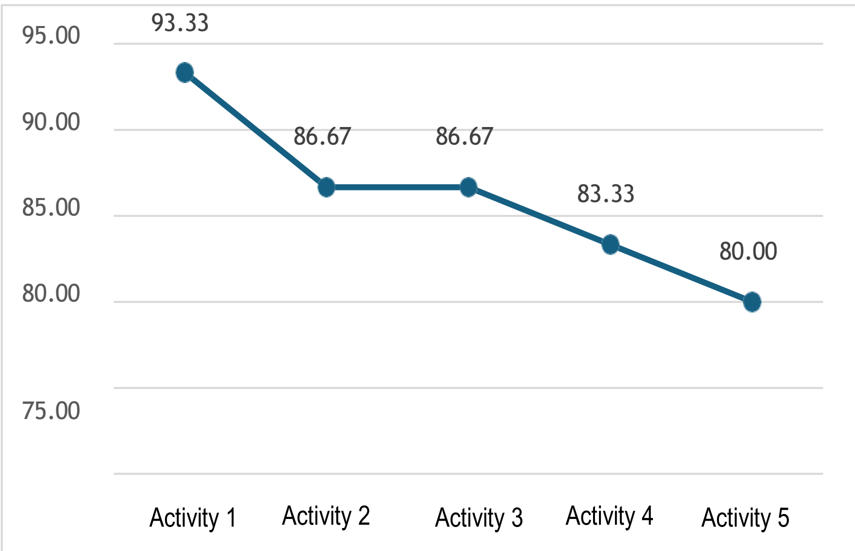

Figure 9. Distribution of student learning trajectory stages in fractions

The learning trajectory on fractions using Musi Rawas tourism for elementary students at Gegas Lake Tourism is structured in five activities, such as Activity 1 entails understanding problems within the Gegas Lake context; Activity 2 involves creating a mathematical model; Activity 3 focuses on completing this contextual model; Activity 4 entails solving context-related problems; and Activity 5 concludes with students drawing mathematical conclusions. Moreover, the data from the learning trajectory stages during fraction learning are presented in Figure 9. It illustrates the following findings on the learning trajectory of fractions stages: 93.33% of students effectively understood the problems within the Gegas Lake tourism context (Activity 1); 86.67% of students successfully created a mathematical model based on this context (Activity 2); 96.67% completed the mathematical models (Activity 3); 83.33% solved the context-based problems (Activity 4); and 80.00% reached accurate mathematical conclusions (Activity 5).

The findings of this study align with previous research, which demonstrated that students prefer fraction learning materials introduced through familiar local contexts as a starting point in the learning process and express interest in utilizing the RME approach with these contexts in classroom settings (Jannah & Prahmana, 2019; Shanty, 2023; Sukasno et al., 2024b; Risdiyanti et al., 2024). The majority of participants indicated that contextual learning, rooted in RME approach, prioritizes reasoning over dependence on mathematical formulas. This approach was well-received as it notably diverges from traditional instructional methods typically utilized by educators (Streefland, 2012). As one student noted, “I enjoyed this method because it enabled me to devise my own strategy. I visualized the scenario where the elephant prevailed by shifting left, which guided my decision.” Another student commented, “Mathematics no longer feels intimidating. With this innovative teaching approach, I understand the problem-solving process better, and collaborative discussions in group settings make tasks more approachable.”

Research further suggests that employing a RME framework enables educators to gauge students’ prior knowledge through their interaction with realistic contexts, which encourages the use of mathematical language (Streefland, 2012; Anwar et al., 2012; Meryansumayeka et al., 2019; Prahmana et al., 2020). Subsequently, students apply structured models, enhancing their understanding of symbolic and formal representations (Webb et al., 2011; Rau & Matthews, 2017). Ultimately, this method allows students to internalize, summarize, and develop complex schemas into deductive frameworks.

The progression of mathematical learning via contextual methods includes articulating learning objectives, presenting tourism-based visual problems, facilitating student exploration, guiding conclusion and summary activities, and culminating in students sharing insights on mathematical concepts and principles (Marleny et al., 2024; Sukasno et al., 2024a; Sukasno et al., 2024b). Contextual learning leverages real-life situations that students encounter daily, thus grounding educational experiences in relatable scenarios (Freudenthal, 1991; Olson & Olson, 2013). This approach enhances the relevance, significance, and appeal of learning by focusing on familiar contexts, which allows students to better understand and connect new concepts to existing knowledge.

In this framework, educators function as facilitators, guiding students through the exploration of contexts, identifying relevant issues, and encouraging the development of creative solutions. Teachers promote active participation through inquiry-based learning, investigation, and knowledge construction (Wang et al., 2022), shifting the learning experience from passive to dynamic and collaborative. Integrating tourism into education provides a robust framework for fostering student engagement and comprehension by linking academic content to practical, real-world contexts (Marleny et al., 2024). The tourism setting presents diverse, interdisciplinary content spanning history, geography, ecology, and cultural studies, making learning more engaging and holistic by connecting students with a breadth of knowledge fields (Farrell & Twining-Ward, 2004).

Furthermore, contextual learning based on tourism enhances motivation by associating academic concepts with tangible, real-life experiences (Sukasno et al., 2024a). When students observe practical applications of their classroom learning in the surrounding world, their interest and enthusiasm are naturally amplified (Günter et al., 2023; Brown et al., 2023). This connection between learning and real-world application fosters active engagement, encouraging students to immerse themselves more fully in the educational process.

Tourism-based education also strengthens critical thinking skills by presenting students with authentic challenges that require analytical and evaluative skills (Espinoza-Figueroa et al., 2021). Students are prompted to analyze complex situations, assess solutions, and work collaboratively to address issues, cultivating problem-solving abilities (Feng & Zhao, 2024). This experiential learning model prepares students to tackle challenges independently and supports a mindset oriented toward continuous inquiry and improvement. By connecting academic material with tourism contexts, students enhance their ability to relate theoretical knowledge to practical applications (Sukasno et al., 2024a; Sukasno et al., 2024b). This approach makes abstract concepts more accessible and relevant, enabling students to grasp not only theoretical frameworks but also how these ideas operate within their immediate environment, bridging the divide between classroom learning and the outside world.

Effective implementation of tourism-based learning requires several key activities (Sukasno et al., 2024a; Sukasno et al., 2024b). Initially, educators should identify local tourism resources—including natural, cultural, and historical elements—that can serve as rich learning contexts. Following this, they must design learning activities that incorporate these contexts, potentially involving field trips, interviews with stakeholders, or surveys and direct observations. Throughout the learning process, educators act as facilitators, supporting students in exploring, connecting, and building understanding through the tourism perspective (Sukasno et al., 2024b). Teachers can assign tasks that prompt students to analyze, address issues, and critically reflect on phenomena observed within the tourist environment, ensuring that students gain a meaningful learning experience rather than merely memorizing concepts (Marleny et al., 2024).

Additionally, schools should foster collaborations with relevant stakeholders, such as local tourism offices and attraction managers, to optimize educational resources and ensure the sustainability of tourism-based learning programs (Chai et al., 2024; Sukasno et al., 2024a). When education is grounded in a tourism context, student interest and motivation can significantly increase (Sukasno et al., 2024a). By linking academic content with real-world experiences, students become more inclined to participate actively, which contributes to enhanced comprehension and retention.

This contextual approach allows students to gain a deeper grasp of concepts by relating academic material to local situations and phenomena, thereby transforming abstract ideas into concrete, meaningful knowledge. Moreover, tourism-based learning facilitates the development of essential 21st-century skills, such as critical thinking, problem-solving, collaboration, and communication (Choe & Kim, 2024). Through activities in a tourism framework, students actively engage in observing, analyzing, and resolving real-life issues while working with peers to develop innovative solutions.

Tourist sites in Musi Rawas Regency offer diverse opportunities for students to learn numerical concepts in an engaging way (Sukasno et al., 2024a; Sukasno et al., 2024b). They can explore numerical principles, place values, basic arithmetic, and geometric shapes observed in natural environments (Sukasno et al., 2024a). These learning experiences enhance students' mathematical understanding and abilities by contextualizing fractions in real-world scenarios, such as loan calculations and debt statements (Lamon, 2020), scheduling and time management (Charalambous & Pitta-Pantazi, 2007), and material estimation and financial documentation (Ni & Zhou, 2005). Learning in these stimulating settings can significantly increase students' enthusiasm for mathematics.

Observing peer interactions in designated areas also enables students to engage with numerical concepts through counting, comparing, and estimating participants in zones for play, sports, and relaxation (Sukasno et al., 2024b). Tourist attractions in Musi Rawas Regency thus provide enriching avenues for students to engage with numbers, from foundational concepts to practical applications within natural settings, enhancing both learning and connection to family and nature (Sukasno et al., 2024a). Finally, tourism-context-based learning provides a promising method for enhancing student engagement and comprehension. By integrating academic content within a relevant tourism framework, students experience a more meaningful and enjoyable learning journey. With well-designed learning activities, students can master academic concepts while cultivating critical thinking, creativity, and problem-solving skills. This adaptable approach can be applied across educational levels and, with careful implementation, can yield more holistic educational outcomes that align with students' needs and sustainable community development principles.

CONCLUSION

In this study, we investigated the cognitive processes of students in understanding fractions through a tourism context. The findings indicate a structured learning trajectory consisting of five distinct phases: first, students identify and understand problems within the tourism context; second, they develop mathematical models based on the identified context; third, students solve these mathematical models; fourth, they create solutions to the contextual problems; and finally, they draw mathematical conclusions. This research contributes significantly to local instructional theory on fractions by demonstrating how students engage with fractions through meaningful, context-based learning experiences. The application of tourism as a contextual framework not only aids in the understanding of mathematical concepts but also enhances students' ability to apply these concepts to real-world situations.

Despite the promising results, this study has certain limitations that warrant acknowledgment. The research was conducted in a single location, specifically focusing on the context of Gegas Lake tourism, which may restrict the generalizability of the findings to other geographical areas or different tourist contexts. Additionally, the sample size was relatively small, which could impact the robustness of the conclusions drawn. The study primarily employed qualitative methods, and while these provide valuable insights into student cognition, a more comprehensive approach that includes quantitative measures would strengthen the validity of the findings.

To build upon this research, further studies are recommended to explore the dissemination of the fraction learning design using the Gegas Lake tourism context across a broader demographic. Implementing a precise quasi-experimental design could help assess the effectiveness of this instructional approach on a larger scale, providing more robust data regarding its impact on student learning outcomes. Future research should also consider integrating various contexts and subjects, which may offer deeper insights into how contextual learning influences students' understanding of mathematical concepts beyond fractions. Exploring diverse learning environments will help refine the instructional strategies and foster the development of more universally applicable teaching methods.

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Declarations

Author Contribution	:	S: Conceptualization, Writing - Original Draft, Editing, Formal analysis, Methodology, and Visualization. Z: Writing - Review & Editing, Methodology, Validation, and Supervision. RIIP: Writing - Review & Editing, Formal analysis, Validation, and Supervision S: Validation and Supervision.
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