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Design of Ethnomatematics-Based Mathematics Learning Activities Through the Traditional Game of *Bekel* in Elementary Schools

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ABSTRACT

This study aimed to develop an ethnomathematics-based mathematics learning activity design using the traditional *bekel* game as a context for learning addition in elementary school. The study employed Design Research integrated with the Realistic Mathematics Education (RME) approach and autoethnography. Mathematical concepts embedded in the *bekel* game were first identified and used to develop a Hypothetical Learning Trajectory (HLT) consisting of three sequential learning activities. The HLT was piloted with six second-grade students representing high-, medium-, and low-ability groups to examine its feasibility. The results showed that the *bekel* game contains mathematical concepts such as counting, addition, and number composition. The pilot experiment indicated that the activities enabled students to develop an understanding of addition by progressing from concrete play experiences to visual representations and formal mathematical symbols. The developed learning trajectory provides practical guidance for elementary school teachers in designing contextual and culturally responsive mathematics instruction, while supporting students' conceptual understanding of addition and promoting appreciation of local cultural heritage.

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Mathematics and culture are two inseparable aspects of human life. Until now, mathematics has often been viewed as a universal, objective science detached from socio-cultural contexts. However, various studies have shown that mathematical concepts are born and developed through the cultural activities of society (Andelia,et al., 2022). Mathematics is not merely a collection of symbols and formal formulas but is the result of human construction in responding to problems

encountered in everyday life (Qadry et al., 2021). This perspective is consistent with the view that mathematics is a cultural product that develops through human activities and social practices (D'Ambrosio & Rosa, 2017).

To bridge the gap between formal mathematics and students' cultural experiences, an approach known as ethnomathematics has emerged. The concept of ethnomathematics was introduced by Ubiratan D'Ambrosio, who views mathematics as an inseparable part of human cultural activities. Ethnomathematics is a learning approach that connects mathematical concepts with the culture and daily life of local communities, enabling students to develop a deeper understanding of abstract mathematical concepts (Fajria Septiani, 2024). Furthermore, (Kencanawaty et al., 2020) explain that ethnomathematics integrates mathematical concepts embedded in culture into classroom learning. This approach also provides opportunities for students to construct mathematical meaning through contexts that are familiar to their daily experiences while appreciating local cultural values (Meaney et al., 2022).

In addition to ethnomathematics, the Realistic Mathematics Education (RME) approach provides a strong theoretical foundation for developing contextual learning. Developed by Hans Freudenthal, RME views mathematics as a human activity that should be learned through meaningful situations familiar to students (Gravemeijer, 1994). Through guided reinvention, students are encouraged to rediscover mathematical concepts gradually with teacher guidance, making learning more active and student-centered (Rahmawati & Humaira, 2024). Learning progresses from contextual situations to models and eventually to formal mathematical reasoning, enabling students to construct conceptual understanding through meaningful experiences (Gravemeijer & Cobb, 2006). Meaningful learning design should also consider the integration of learning objectives, students' characteristics, and the social and cultural contexts in which students learn so that the learning process truly becomes student-centered (Mariana et al., 2024).

Mathematics teaching practices in elementary schools often present mathematics as an abstract discipline detached from students' everyday experiences. Teachers tend to begin lessons with explanations of formal concepts and procedures, followed by routine exercises (Fauzi et al., 2020). Consequently, students become more oriented toward procedural fluency than conceptual understanding. According to Wiryanto et al., (2018), elementary school students are in the concrete operational stage; therefore, they require concrete learning experiences to support their conceptual development. Teachers also need to transform students' perceptions of mathematics from being difficult and rigid into enjoyable learning experiences. In line with this, Nursafitri et al., (2023) reported that game-based learning can increase students' interest and motivation in learning mathematics. Through play, students not only experience enjoyable learning but also develop logical thinking, problem-solving abilities, and an understanding of mathematical relationships.

Traditional Indonesian games constitute an important part of the nation's cultural heritage and have considerable potential to be integrated into mathematics learning. According to Hidayati, (2020), traditional games contain educational, social, and cognitive values that foster children's thinking skills while strengthening character values such as cooperation, sportsmanship, perseverance, and empathy. One traditional game that has strong mathematical potential is the *bekel* game. In this game, players bounce a ball while picking up *bekel* seeds according to predetermined stages. These activities naturally involve counting, grouping, sequencing, and

recognizing numerical patterns. Such characteristics make traditional games meaningful contexts for learning mathematics because students experience mathematical ideas through authentic cultural activities (Rosa et al., 2016).

Previous research by Hendriawan & Faridah (2022)showed that the traditional *bekel* game contains mathematical concepts such as addition, grouping, modulo, probability, and geometry. Similarly, numerous ethnomathematics studies have successfully explored mathematical concepts embedded in traditional games, cultural artifacts, and community practices (Kencanawaty et al., 2020). These studies have demonstrated that culture provides meaningful contexts for mathematics learning. However, most previous studies have primarily focused on identifying or describing mathematical concepts embedded in cultural activities. As a result, limited attention has been given to transforming these findings into systematic instructional designs that explicitly describe how students progressively construct mathematical understanding through carefully sequenced learning activities.

Furthermore, although Realistic Mathematics Education has been widely implemented to promote contextual mathematics learning, the integration of ethnomathematical contexts with RME principles in the development of a structured Hypothetical Learning Trajectory (HLT) remains limited. Existing studies generally discuss ethnomathematics as a source of learning contexts or apply RME using contextual problems, yet few explicitly integrate ethnomathematics, RME principles, and the iceberg model into a coherent learning trajectory that guides students from informal cultural experiences toward formal mathematical understanding. This gap is particularly evident in studies focusing on the development of addition concepts for lower elementary school students, where learning trajectories grounded in local cultural practices remain underexplored (Gravemeijer & Cobb, 2006).

Based on preliminary observations conducted at SDN Pakal 1, mathematics learning in Phase A is still dominated by lecture-based instruction and routine exercises. Teachers explain addition procedures before asking students to solve problems similar to the examples provided. Learning activities involving concrete experiences or local cultural contexts are rarely implemented. Consequently, students' understanding of addition tends to be procedural rather than conceptual. This condition indicates the need for innovative learning designs that enable students to construct mathematical understanding through meaningful activities that are closely related to their cultural experiences.

Therefore, this study aims to develop ethnomathematics-based mathematics learning activities using the traditional *bekel* game as a context for learning addition in elementary schools. Unlike previous studies that primarily identified mathematical concepts embedded in the *bekel* game, this study develops a structured Hypothetical Learning Trajectory by integrating ethnomathematics, the principles of Realistic Mathematics Education, and the iceberg model into a coherent instructional design. The proposed learning trajectory was subsequently examined through a pilot experiment to investigate how students progressively developed their understanding of addition from concrete play experiences, to visual representations, and finally to formal mathematical symbols. Accordingly, this study contributes to the literature by extending the integration of ethnomathematics and RME in learning trajectory design while providing elementary school teachers with a culturally responsive framework for designing meaningful mathematics

learning activities.

METHODS

This study employed Design Research using the framework proposed by Gravemeijer and Cobb. The study was limited to the preliminary design and pilot experiment phases, aiming to develop and obtain an initial validation of a Hypothetical Learning Trajectory (HLT) for learning addition through the traditional *bekel* game.

During the preliminary design phase, an autoethnographic study was conducted to identify mathematical concepts embedded in the traditional *bekel* game based on the researcher's cultural experiences. The findings were supported by a literature review on ethnomathematics, Realistic Mathematics Education (RME), and elementary mathematics learning, as well as curriculum analysis and classroom observations. These activities were used to develop the initial Hypothetical Learning Trajectory (HLT 1), including learning objectives, learning activities, anticipated students' thinking, and supporting learning materials.

The pilot experiment was conducted with six second-grade students representing high-, medium-, and low-achieving ability groups. The participants were selected purposively to obtain diverse responses to the proposed learning activities. During this phase, students participated in the learning activities designed in HLT 1 using the traditional *bekel* game as the learning context. Data were collected through classroom observations, interviews, students' worksheets, field notes, and documentation.

The collected data were analyzed qualitatively by comparing the anticipated learning processes described in HLT 1 with the students' actual learning processes during the pilot experiment. The analysis focused on identifying students' learning strategies, misconceptions, and difficulties encountered in each activity. The findings were then used to revise and refine HLT 1 before its implementation in the next phase of Design Research.

RESULTS AND DISCUSSION

Mathematical Concepts from Elementary School Found in the Traditional Game of *Bekel*

Based on the results of autoethnographic and literature studies, several elementary school mathematics concepts were identified in the traditional game of *bekel*. The mathematical concepts that emerged include counting, addition of whole numbers, and the composition and decomposition of numbers.

The concept of counting

The concept of counting is evident when players count the number of bekel beads they have successfully collected at each stage of the game. Students count the *bekel* they have obtained one by one so that they can determine the total number of *bekel* they possess.

Addition concept

The concept of addition emerges when students combine the *bekel* collected from several stages of the game. For example, a student collects 3 *bekels* in the first round and 4 *bekels* in the next

round. These two sets of *bekels* are then combined, resulting in a total of 7 *bekels*.

The concepts of number composition and decomposition

In addition, the concepts of composition and decomposition of numbers were also identified. In the game of *bekel*, a number can be obtained through various different combinations of selections. For example, the number 7 can be obtained from the combinations of 1 and 6, 2 and 5, or 3 and 4. This activity demonstrates that students can understand a number as a combination of several different parts.

Based on the results of autoethnographic analysis and literature review, the traditional *bekel* game incorporates several elementary school mathematics concepts, such as counting, composition and decomposition of numbers, number representation, and addition of whole numbers. Among these concepts, the researcher selected the concept of addition as the focus of the study because this concept emerged naturally and dominantly throughout the game. In the *bekel* game, students not only count the number of *bekel* seeds successfully collected at each stage but also combine the results from several stages to obtain the total. This activity is a concrete form of the addition operation that aligns with the characteristics of Phase A students, who are still in the concrete operational stage.

In addition, addition is one of the core competencies that serves as the foundation for mathematics learning at the next grade level. A solid understanding of the concept of addition helps students develop their numeracy skills, problem-solving abilities, and comprehension of more complex mathematical operations. The *bekel* game provides a meaningful context that is closely tied to students' experiences, enabling them to build an understanding of addition through play. Therefore, the concept of addition was selected as the focus for the development of the HLT (Hypothetical Learning Trajectory) in this study.

Design of Mathematics Learning Activities Using the Traditional *Bekel* Game as a Context in Elementary School.

The learning activities were designed using an ethnomathematics approach by integrating the traditional *bekel* game as a context for teaching addition to second-grade students at a elementary public school in Surabaya, East Java, Indonesia. The development of the activity design began with the formulation of a Hypothetical Learning Trajectory (HLT) that included learning objectives, a sequence of activities, and predicted student responses during the learning process. The HLT consisted of three learning activities designed in stages to help students build an understanding of the concept of addition, progressing from play experiences to formal mathematics, with HLT 1 presented in **Table 1**.

Table 1. Hypothetical Learning Trajectory 1

Activity	Math Goals	Activity Descriotion	HLT 1
Recording the Multiplication Table Facts	Students are able to identify the components of a number through hands-on experience.	1. Students play the *bekel* game 2. Students record the number of *bekel* they have collected to	1. Students can find various combinations of picks to form the target number. For example, to pick up 7 *bekels*, students pick up 4 *bekels* on

		reach a specific goal	the first pick and 3 *bekels* on the second pick. 2. Students begin to realize that a single number can be formed in several different ways. 3. Students can correctly record the number of *bekel* taken on each turn. 4. Students focus only on playing and forget to record the results of their selections accurately. 5. Students make mistakes when counting the number of *bekel* they have successfully taken. 6. Students assume there is only one way to form the target number.
Drawing the Position of *Bekel* and Circling It	Students are able to translate real-life situations into visual models to reinforce their understanding of concepts	Students draw the distribution of *bekel* (using dot symbols) and circle the groups of dots according to the order in which they were picked up, as previously recorded.	1. Students can accurately represent the results of the game using dot diagrams. For example: Number of *bekel* taken = 7  2. Students understand the relationship between the groups of dots and the number of *bekel* taken. 3. Students begin to understand the concept of grouping as the basis for addition. 4. Students draw the number of dots incorrectly relative to the number of *bekel* taken. 5. Students are confused about which group to circle according to the order in which the seeds were taken. 6. Students focus more on the picture than on the meaning of quantity and grouping
Let's write the addition problem	Let's write a sum Students are able to construct formal mathematical sentences based on visual representations.	Students write the number combinations they find in the form of addition problems.	1. Students can express the result of a calculation as a mathematical sentence, for example, 7 = 4 + 3. 2. Students understand that addition represents the combination of groups that have already been identified. 3. Students discover more than one form of addition for the

	same number (for example, 7 = 5 + 2, 6 + 1). 4. Students write addition operations that do not match the game results. 5. Students simply copy their classmates' answers without understanding the connection to the previous activity.

Based on the results of the Hypothetical Learning Trajectory (HLT) 1, the focus is on introducing the concept of addition through hands-on experience playing *bekel*, recording the results of the draws, representing the game results in pictorial form, and converting them into simple mathematical sentences. Through this learning trajectory, students are expected to understand that a number can be formed from various combinations of different numbers.

Pilot Experiment

In HLT 1, mathematics instruction was implemented in a small class consisting of six students from Class 2C. The students were selected based on their ability levels: high, medium, and low. The six students are listed in **Table 2**.

Table 2. Pilot Experiment Subjects

Student Code	Student Abillity Level
AS	High
SA	High
KA	Medium
KE	Medium
WA	Low
RI	Low

Activity 1: Recording the Multiplication Table Facts

This activity is illustrated in **Figure 1**.

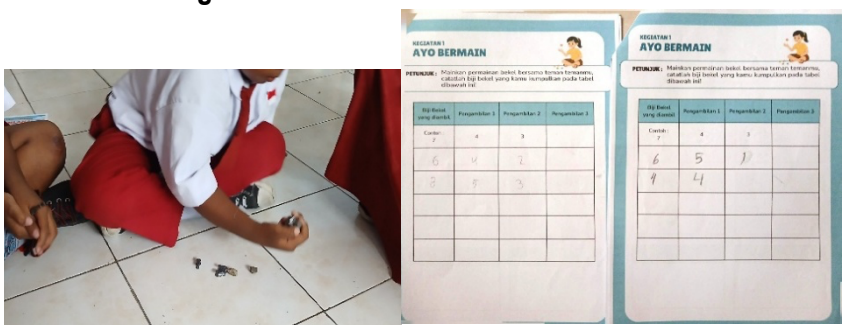


Figure 1. Student activity in recording multiplication table facts

Researcher :"Now, please play the *bekel* game. After you're done picking up the *bekel,* write down the total number in the table."

AS : "I got three first, Ma'am."

(AS continues playing and manages to pick up three more *bekel*)
Researcher : "So, what's the total now?"
AS : "Six."
Researcher : "How do you write that in the table?"
AS : "Three, then three more."
(A few moments later, KA looked at her friend's work).
KA : "Ma'am, six doesn't have to be three plus three, does it?"
Researcher : "How else do you think it could be?"
KA : "Five plus one is also six."
Researcher : "That's right. So one number can be formed in several ways."

The results showed that most students were able to play the *bekel* game and record the number of *bekel* they obtained on each turn. The students began to understand that a single number can be formed through several different combinations of numbers. This was evident when one student discovered that the number six could be obtained not only from the combination 3 + 3, but also from the combination 5 + 1.

Nevertheless, some students still struggled to divide their attention between playing and recording the game results. Some students forgot the number of *bekel* they had obtained and had to recount them before filling out the table. This situation indicates that the simultaneous activities of playing and recording still place a fairly high cognitive load on the students. This finding served as the basis for revising the HLT by moving the recording activity to after the students had created their pictorial representations.

Activity 2: Drawing the Position of the Marker and Circling It

This activity is illustrated in **Figure 2**.

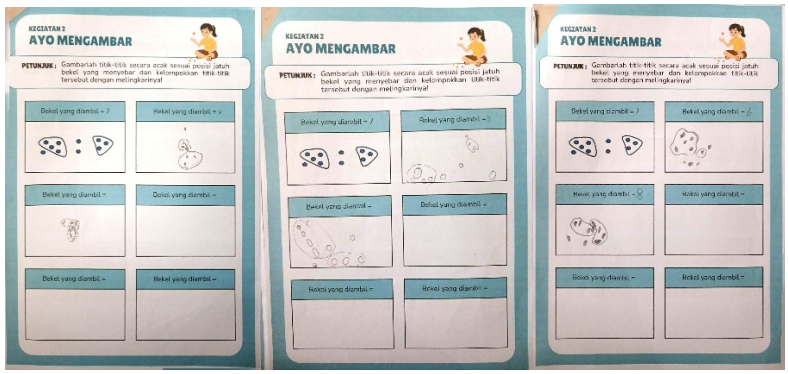


Figure 2. Student activity in drawing the position of *bekel* and circling it

Researcher : "Now draw the results of your game using dots."
(KE began drawing six dots).
Researcher : "Why did you draw six dots?"
KE : "Because I got six seeds earlier."
Researcher : "Good. Now circle them in the order you picked them up."
KE : "Should I circle the first three or all of them?"
Researcher : "Try to remember how many times did you pick them up?"
KE : "Twice."

In this activity, most students were able to transform their gaming experience into a visual representation in the form of dot patterns. Students began to understand the relationship between the number of *bekel* obtained and the dot patterns they drew. These representations helped students recall the process of collecting *bekel* during the game.

However, some students still drew a number of dots that did not match the number of bekel they had collected. In addition, some students were still confused about which group of dots to circle based on the order in which the *bekel* were collected. These findings indicate that students still need guidance in connecting concrete experiences with visual models. Nevertheless, the drawings they created served as a bridge to understanding the concept of addition.

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Activity 3: Writing Addition Sentences

This activity is illustrated in **Figure 3**.

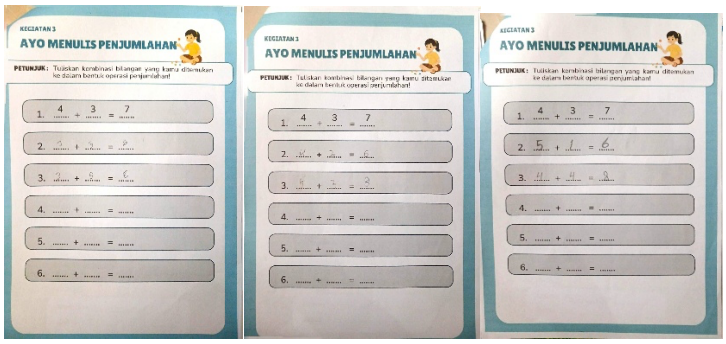


Figure 3. Writing the addition problem

Researcher: “Now turn that picture into an addition sentence.”
(AS wrote 3 + 3 = 6).
Researcher : “Why did you write it that way?”
AS : “Because I took three, then three more.”
Researcher : “Is there another way to get six?”
KA : “You can add five and one.”
Researcher : “Is the result still the same?”
KA : “Yes, it’s still six.”

The results of the observations showed that most students were able to write addition problems based on the outcomes of the game and the pictures they had drawn earlier. The students began to understand that addition problems represent the combining of groups of *bekel* obtained during the game.

In addition, some students began to discover more than one way to add numbers to produce the same sum. This finding indicates a developing understanding of the concept of number composition. However, there were still some students who tended to copy their classmates’ answers without connecting them to the results of the games they had played. Therefore, teachers still need to ask guiding questions so that students can establish connections on their own between their play experiences, drawings, and mathematical symbols.

Discussion

Elementary School Mathematics Concepts Found in the Traditional Game of Bekel

The results of autoethnographic studies and observations indicate that the traditional game of bekel incorporates several elementary school mathematics concepts, namely counting, number composition and decomposition, and addition of whole numbers. Of these concepts, addition was chosen as the focus of this study because it emerged naturally and was the dominant activity throughout the game. In the *bekel* game, students count the number of *bekel* seeds they successfully collect on each turn, then combine these results to obtain the total count. This activity demonstrates that the concept of addition emerges as the process of combining several groups of concrete objects into a single larger group.

This finding aligns with the research by Hendriawan & Faridah (2022), which revealed that the traditional *bekel* game contains various mathematical concepts, one of which is the addition operation that emerges through the activity of counting the number of *bekel* seeds obtained during the game. Furthermore, Karina & Supardi (2021) explain that traditional games are cultural activities that naturally give rise to mathematical concepts such as counting, grouping, and number operations. These findings reinforce the view that mathematical concepts are not only found in formal schooling but can also emerge in everyday cultural activities.

From an ethnomathematics perspective, the emergence of the concept of addition in the *bekel* game demonstrates that cultural activities can serve as a meaningful source of mathematical learning. D'Ambrosio states that every culture possesses practices containing mathematical ideas and can be utilized as a learning context. The *bekel* game, as a local cultural heritage, allows students to learn the concept of addition through real-life experiences closely tied to their daily lives. Thus, mathematics learning is no longer viewed as an activity separate from daily life but rather as an integral part of the culture long practiced by the community.

In addition to being relevant to the ethnomathematics approach, the concept of addition found in the *bekel* game also aligns with the Phase A mathematics learning outcomes, which emphasize the use of concrete objects in understanding basic arithmetic operations. Therefore, the *bekel* game has great potential to be used as a learning context that helps students build a concrete, contextual, and meaningful understanding of addition.

Design of Mathematics Learning Activities Using the Traditional Bekel Game Context in Elementary School

HLT 1 is designed as an introductory learning pathway to help students understand the concept of addition through the context of the traditional game of *bekel*. This HLT consists of three main activities: recording a *bekel* number table, drawing the positions of the *bekel* and circling the results of the draws, and writing the addition equations. These three activities are arranged sequentially so that students can build their understanding from concrete experiences toward formal mathematical representations.

In the first activity, students play the *bekel* game and then record the number of *bekel* pieces they successfully obtained to reach a specific target number. This activity aims to help students

identify the components of a number through direct experience. Based on the conjectures they formulate, students are expected to be able to find various number combinations that yield the same sum; for example, 7 can be obtained from the combinations 4 + 3 or 5 + 2.

These findings align with the research by Aini et al., (2022), which showed that the *bekel* game can help students understand number concepts through play activities involving concrete objects. Additionally, Suryawan (2020)stated that traditional games can enhance counting skills and logical thinking because students are directly engaged in counting activities throughout the game.

In the second activity, students represented the game results as dot diagrams and circled groups of dots according to the order of selection. This activity serves as a bridge between play experiences and mathematical representation. From an RME perspective, drawing is a form of "model of" that helps students organize concrete experiences into visual representations before moving toward formal mathematical symbols. The research results show that most students were able to depict the game results well, although some students still had difficulty determining the groups of dots according to the order of selection.

In the third activity, students wrote down the grouping results in the form of addition operations. This activity is a stage of concept formalization, where students begin to use mathematical symbols to represent the play experiences they had previously engaged in. Students did not merely write down a single addition equation but began to discover several number combinations that yielded the same sum. This indicates that students are beginning to understand the concepts of number composition and decomposition as part of their understanding of addition.

Nevertheless, the implementation of HLT 1 revealed several challenges. Some students struggled because they had to play, record the game results, and draw simultaneously. Consequently, some students lost focus while playing or forgot to record the results of their *bekel* bead counts. The pilot experiment results also showed that students needed to be reminded repeatedly to record the game results; some even recounted the number of beads obtained because they were still unsure of their calculations.

Despite these challenges, HLT 1 successfully demonstrated that the traditional *bekel* game can be used as a meaningful context for learning addition. Students began to understand that a number can be formed through various combinations of different numbers. This finding supports the research results of Fazriyah & Rahmawati (2023) who stated that the use of the *bekel* context in mathematics learning can help students connect concrete experiences with abstract mathematical concepts. Therefore, HLT 1 serves as an important foundation for revising and refining the learning pathway in subsequent HLTs to better align with the characteristics of elementary school students.

The findings of this study indicate that the contribution of the traditional *bekel* game extends beyond serving as a contextual medium for introducing addition concepts. More importantly, this study demonstrates how a cultural practice can be transformed into a systematic learning trajectory that supports students' conceptual development. Previous studies on ethnomathematics have mainly focused on identifying mathematical concepts embedded in traditional (Hendriawan & Faridah, 2022). In contrast, the present study contributes by designing a sequence of learning activities based on the principles of Realistic Mathematics Education (RME) and validating the

predicted learning process through a pilot experiment. This finding suggests that the educational value of ethnomathematics does not merely lie in recognizing mathematical ideas within cultural practices, but in designing meaningful instructional experiences that enable students to construct mathematical understanding through those cultural contexts.

The progression of learning activities developed in this study also illustrates the process of progressive mathematization proposed in RME. Students first engaged with the concept of addition through direct experience while playing the traditional *bekel* game. They subsequently represented these experiences using drawings and grouping activities before expressing them as formal addition sentences. This gradual transition from concrete activities to symbolic representations reflects the iceberg model (Gravemeijer, 1994), in which students develop formal mathematical understanding from meaningful real-life experiences. Rather than introducing addition as an abstract algorithm, the learning trajectory enabled students to reinvent the concept by organizing, representing, and interpreting their own experiences during the game. This finding reinforces the theoretical perspective that contextual learning is more effective when students actively construct mathematical ideas instead of receiving them directly from the teacher.

Another important contribution of this study lies in the refinement of the Hypothetical Learning Trajectory (HLT) through the pilot experiment. The implementation revealed that several students experienced difficulties because they were required to play, record the results, and draw representations simultaneously. Instead of viewing these difficulties as failures of implementation, they were interpreted as valuable evidence for improving the instructional design. This iterative revision process represents a key characteristic of Design Research, where instructional theories are continuously refined based on empirical evidence from students' actual learning processes. Therefore, the HLT developed in this study should be understood not as a fixed sequence of activities but as a theory-informed learning trajectory that evolves through classroom experimentation to better accommodate students' learning needs.

Overall, this study contributes to both ethnomathematics and Design Research literature. From the perspective of ethnomathematics, it demonstrates that local cultural practices such as the traditional *bekel* game can become meaningful mathematical contexts when systematically integrated into classroom instruction. From the perspective of Design Research, this study provides an empirically grounded learning trajectory that explains how students progressively develop an understanding of addition from informal strategies toward formal mathematical reasoning. Consequently, the proposed learning trajectory offers not only a practical instructional design for elementary school teachers but also a theoretical reference for developing Local Instructional Theory (LIT) in ethnomathematics-based mathematics learning.

CONCLUSION

Based on the findings of this study, it can be concluded that the traditional game of *bekel* contains elementary school mathematics concepts, particularly addition. These concepts naturally emerge as students count and combine the number of *bekel* seeds collected during the game. The findings indicate that the traditional *bekel* game can be used as a meaningful mathematics learning context that aligns with the Mathematics Learning Outcomes for Phase A of the Merdeka Curriculum.

This study also developed an ethnomathematics-based mathematics learning activity design using the traditional *bekel* game as a learning context. The design consists of three sequential activities: recording number combinations, drawing and grouping the *bekel* seeds, and writing addition sentences. The implementation results demonstrate that these activities support students in constructing their understanding of addition progressively, moving from concrete experiences, to visual representations, and finally to formal mathematical symbols.

Practically, this learning design can serve as an alternative reference for elementary school teachers in designing contextual and meaningful mathematics learning by integrating local cultural heritage into classroom instruction. The use of traditional games not only supports students' conceptual understanding but also contributes to preserving local culture and increasing students' engagement in learning mathematics.

This study has several limitations. The pilot experiment was conducted with only six second-grade students in one elementary school, so the findings cannot yet be generalized to broader educational contexts. In addition, the learning trajectory was evaluated only at the pilot experiment stage and has not yet been refined through subsequent teaching experiments and retrospective analyses. Therefore, future research is recommended to implement the learning design in larger and more diverse classroom settings, validate and refine the learning trajectory through complete Design Research cycles, and investigate the effectiveness of the *bekel* based learning activities in improving students' mathematical understanding and other mathematical competencies.

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