Glocal Praxis in Elementary Education

Journal homepage: journal.unesa.ac.id/index.php/GPrEEc

Design of Mathematics Activities Based on the Pottery-Making Process of Tondowulan Village to Develop Number Sense of Elementary School Students

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ARTICLE INFO

Received: 29 January 2025
Revised: 1 August 2025
Accepted: 14 September 2025
Published Online: 12 November 2025

Keywords:
Hypothetical Learning Trajectory, Number Sense, Local Culture, Tondowulan Pottery, Realistic Mathematics Education

ABSTRACT

This research aims to design mathematics learning based on local culture through the context of pottery crafts in Tondowulan Village to develop the number sense of elementary school students. The background of this research is based on mathematics learning in elementary school which still focuses on procedures so that it is less meaningful for students. The Realistic Mathematics Education (RME) approach is used because it emphasizes the process of mathematical thinking through real situations that are close to the lives of students. The method applied was design research with the subject of grade II elementary school students who participated in five learning activities in the Student Worksheet (LKPD) with the theme "The Pottery Craftsman". Data was obtained through observation, student work results, and notes on the learning process. The results of the study show that the cultural context of pottery is able to facilitate the mathematical thinking process from the concrete to the symbolic and foster number sense indicators, such as understanding the meaning of numbers, flexibility of counting strategies, and the ability to relate addition and subtraction operations logically.

How to Cite: Fajri, S.U.N., Mariana, N, Huda, M.N. (2025). Design of Mathematics Activities Based on the Pottery-Making Process of Tondowulan Village to Develop Number Sense of Elementary School Students. *Glocal Praxis in Elementary Education*, 2(1), 65-80.

Mathematics is a discipline that plays a strategic role in the global education system, because it contributes to the development of critical, logical, and systematic thinking skills (Saviraningrum & Wahidin, 2023). One of the basic competencies that must be mastered in education is mathematics, considering its role as a science that is built through the reasoning process and taught systematically from elementary school to university level (Rahmah, 2018). Mathematics can be interpreted as a science that studies forms, quantities, and various concepts that are interconnected (Ghoni & Hidayati, 2023).

The National Council of Teachers of Mathematics (NCTM) has formulated Principles and Standards for School Mathematics (PSSM) which contains five content standards as the basis for mathematics learning, one of which is related to numbers and number operations (NCTM, 2000). The concept of numbers and number operations is an important foundation in forming number sense (Fahlevi, 2022). Number sense itself is the ability to understand numbers creatively through manipulation and number games (Anwar & Manuharawati, 2021). This ability plays a role in supporting students' reasoning and logical mindset (Widyasari et al., 2021). However, the results of PISA 2022 show that only 18% of Indonesian students are able to reach the minimum level of mathematical literacy (OECD, 2023). Meanwhile, the Indonesian Education Report (2025) noted that the numeracy achievement of elementary school students in general is still in the medium category, with 69.58% of students achieving minimum competence. This shows that students' number sense skills are still low.

Students' number sense skills can be developed by learning contextual mathematics (Patmaniar et al., 2024). Contextual learning can be interpreted as a learning approach that shows the natural state of knowledge through relationships inside and outside the classroom (Rahmadani et al., 2022). Contextual learning can be done using the Realistic Mathematic Education approach. RME is a learning approach that starts with real problems (Angraini et al., 2023). In addition, culture-based mathematics learning is seen as an approach that is able to make the learning process more meaningful (Wulandari et al., 2024).

Every region in Indonesia has a culture, including Jombang Regency. Pottery crafts are one of the cultural forms found in Jombang Regency. The pottery craft industry that develops in Jombang is in Tondowulan Village which is located in Plandaan District. Tondowulan Village pottery crafts have existed since 1890 and have been maintained to this day (Desita et al., 2020). Pottery

crafts in Tondowulan Village also play an important role in the field of education and the maintenance of local cultural values. This village is often used as an educational visit by schools, especially from the elementary school and junior high school levels. Through a culture-based approach, students not only gain practical knowledge and skills, but also better understand local advantages in the area around where they live (Mufidah & Suprayitno, 2021).

Tondowulan Village pottery crafts have great potential to be used as a learning resource across subjects, including in mathematics learning that can be integrated through an ethnomathematical approach. However, SD Negeri Tondowulan 1 is an elementary school located near the center of pottery craftsmen in Tondowulan Village. Teachers have never implemented a learning approach based on local culture. In mathematics learning, students should be able to solve problems that are closely related to daily life (Masjudin et al., 2024). It was also found that the problem of grade 2 students in elementary school still had difficulty in understanding the meaning of numbers. They more often memorize number operations without really understanding the underlying concepts. Learners also tend to be fixated on lengthy formal calculation procedures, without resorting to more efficient mental strategies. This is not in accordance with the ability of number sense developed by McIntosh et al., (1997), namely the understanding of number meaning, equivalent representation, and computational strategies. In fact, students who have a sense of numbers are often also referred to as students who have a sensitivity to numbers and numbers, a good understanding of numbers, representations and counting operations (Fahlevi, 2022). One of the solutions that can be done is to carry out mathematics learning in the cultural context of a community group called ethnomathematics (Fauzi et al., 2020).

Based on the research of Najwa (2025) who designed ethnomathematics learning with the context of local weaving in flat building materials in elementary schools. This study shows that LKPD is feasible and receives a positive response from students. In addition, research conducted by Melinda & Mariana, (2025) revealed that the context of the Pottery Shop can support the development of number sense, make it easier for students to understand the concept of number comparison concretely, and facilitate meaningful mathematical discussions. Based on the findings of previous research, the researcher was encouraged to design a mathematical activity with the context of pottery crafts in Tondowulan Village in developing the number sense of elementary school students.

METHODS

This research uses the Design Research (DR) method with a qualitative approach. Design Research is used as a method in the field of education that aims to design, develop, and evaluate learning interventions, such as teaching tools, strategies, and learning models, in response to real challenges in educational practice (Plomp & Nieveen, 2010). This method consists of three phases, namely preliminary design, teaching experiment and retrospective analysis.

Preleminary Design

In this phase, the researcher formulated a Hypothetical Learning Trajectory (HLT), which is a hypothesis or prediction about the development of students' thinking in understanding the material during the learning process. HLT consists of three main components, namely learning objectives, activity designs that will be carried out to achieve these goals through the use of ethnomathematics-based LKPD, and learning hypotheses that are prepared to anticipate possible student responses to learning activities. After designing HLT 1 and LKPD, the researcher conducts expert validation and will then be implemented in the experimental class.

Teaching Experiment

In the second phase, the learning design that has been prepared by the researcher is tested on students to find out whether the predictions made at the preliminary design stage are in accordance with the reality in the field. The trial stage of this learning design consists of two cycles, namely pilot experiment and teaching experiment (Prahmana, 2017). In this study, the researcher only applied it at the pilot experiment stage which was carried out at SD Negeri Tondowulan 2 with 6 subjects of grade II students representing the categories of low, low and high cognition. Researchers do not only act as observers, but collaborate directly with classroom teachers through a co-teaching approach. This aims to ensure that the implementation of the design of learning activities can run according to plan.

Retrospective Analysis

In this phase, the researcher collected data from the second phase to be analyzed retrospectively. In conducting this analysis, the researcher will involve teachers as a reflection partner to review the implementation of learning that has taken place. Retrospective analysis was carried out by comparing the suitability between the results of observations during the actual learning process, or Actual Learning Trajectory (ALT), with the Hypothetical Learning Trajectory (HLT) that had been designed beforehand. The purpose of this stage is to assess the effectiveness of the implemented learning trajectory as well as evaluate the development of learners through the

cognitive responses they demonstrate.

Data collection techniques include observation, interviews, LKPD results of student work and documentation with instruments in the form of field notes. Data analysis was carried out through retrospective analysis involving teachers. To ensure the validity of the data, the researcher verifies teachers and students using member checks.

RESULTS AND DISCUSSION

Result

The result of this study is the design of HLT which includes the learning trajectory in the calculation operation of grade II elementary school in developing students' number sense using the context of pottery crafts in Tondowulan Village. In this activity, the researcher outlined the results obtained from the application of HLT and LKPD that have been designed.

Preleminary Design Phase

In this phase, the researcher made a number of preparations to ensure that the research process runs in a directional manner and according to the goal. The first step is for the researcher to formulate the purpose of the study. Next, the researcher conducted a literature review to determine the initial stages of learning and compiled a Hypothetical Learning Trajevtory (HLT). In addition, the researcher also developed a mathematical thinking process model using the iceberg approach as a visual reference in designing a gradual sequence of learning activities. As for the icebergs that the researchers have designed:

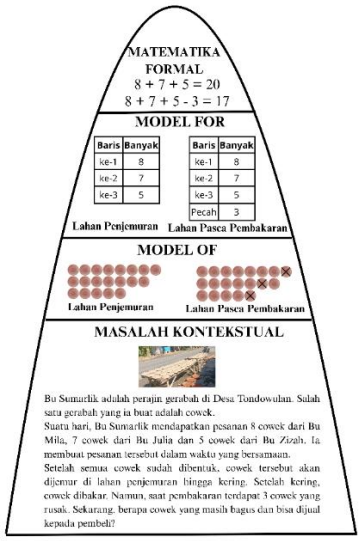


Figure 1. *Ice Berg*

Whereas HLT is presented in the table below:

Table 1. *Hypothetical Learning Trajectory*

Activity	Level	Hypothetical Learning Trajectory
Students read the story "The Pottery Craftsman"	Situational	Students may already understand the problem-solving flow obtained through the sequence of instructions in the story questions. Peserta didik mulai menghitung dengan mengangkat jari untuk operasi penjumlahan dan menurunkan jari untuk operasi pengurangan
Siswa menggunting gambar gerabah dengan jumlah sesuai dengan permasalahan	Model of	Peserta didik mengenali bentuk cowek dengan bentuk sederhana yaitu lingkaran. Peserta didik menggunting gambar cowek sesuai dengan jumlah pada permasalahan.
Siswa menempel gambar cowek pada lahan penjemuran dan setelah pembakaran		Siswa menyusun dengan pola sesuai dengan pesanan Siswa menyusun dengan pola 10-10 Siswa mencoret 3 cowek pada lahan setelah pembakaran untuk menunjukkan operasi pengurangan
Siswa menghitung banyak cowek tiap baris pada lahan penjemuran dan setelah pembakaran	Model for	Siswa menuliskan banyak cowek pada tabel penjemuran sesuai dengan pesanan. Siswa menuliskan banyak cowek pada tabel penjemuran dengan isi 10-10. Siswa menuliskan banyak cowek pada tabel setelah pembakaran sesuai tata letak dan banyak cowek yang pecah.
Siswa menuliskan bentuk matematika formal pada lahan penjemuran dan setelah pembakaran	Formal	Pada lahan penjemuran siswa menuliskan dengan bentuk $\boxed{8}+\boxed{7}+\boxed{5}=20$ or $\boxed{10}+\boxed{10}=20$ Pada lahan setelah pembakaran siswa menuliskan dengan bentuk $\boxed{8}+\boxed{7}+\boxed{5}-\boxed{3}=17$ atau $\boxed{10}+\boxed{10}-\boxed{3}=17$

Teaching Experiment Phase

In the Pilot Experiment stage, HLT was tested in small class groups at SD Negeri Tondowulan 2 which were divided into 3 groups, namely high ability, medium ability, and low ability.

The following are the subject data from this study:

Table 2 *Subject Data*

Cognitive Abilities	Student	Group
High Ability	FI ZAM	Group 1
Medium Ability	DAAS MGAF	Group 2
Low Ability	REAR GKP	Group 3

In this study, the classroom teacher implements the LKPD that has been designed by the researcher, while the researcher acts as a co-teacher who helps manage the course of learning, provides assistance to students, and observes the thinking process and strategies used by students during the activity.

Activity 1

In the activity "Let's Help Craftsmen", it is hoped that students can understand the problems related to counting operations in the story "The Pottery Craftsman". The first stage of the teacher explored the students' initial knowledge related to pottery and the students listened to the video of pottery production.

Next, students read the story "The Pottery Craftsman". There are students who still do not understand the problem-solving flow of the text. In addition, there are students who answer problems without counting with their fingers. At this stage, students show high enthusiasm during learning using videos of the pottery production process. The media has proven to be effective in building a cultural context and relating students' real experiences to the math problems given. In solving story problems, most students are able to identify important information and understand the flow of problem solving. The strategy used is still concrete, namely counting with the finger to perform addition and subtraction operations. This shows that students are at the informal counting strategy stage that is commonly found in lower grades.

This activity supports the development of number sense indicators, especially in the aspects of understanding the meaning and effects of operations as well as the use of computational strategies. The findings are in accordance with the predictions in HLT 1, where students are expected to have understood the problem-solving flow and used simple calculation strategies.

Activity 2

The learning purpose of this activity is so that students can recognize the basic shape of the *cowek* through the activity of cutting pictures. In its implementation, the teacher distributes

sticker paper with a picture of a *cowek* to each student, then the students are asked to cut the picture twice the number contained in the contextual problem.

Teacher : What does a guy look like?

GKP : Like a plate

Teacher : In mathematics, is it like a square, a rectangle or a circle?

FI : Circle

Figure 2. *Students cut picture of cowek*

Students first cut out the image in a square shape, then formed curved sides to resemble a circle. Through this activity, students begin to understand that the basic form or simple representation of the *cowek* is a circle.

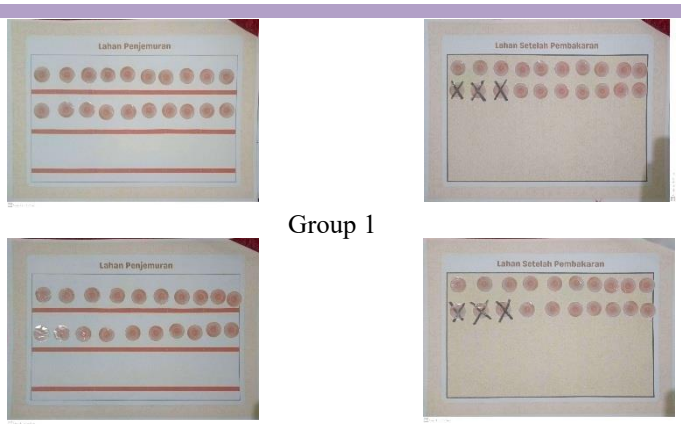
DAAS : Mom… mom (shows the result of the scissors that are not neat)

Researcher : Yes, it's okay, just cut it again.

In this activity, students have difficulty in cutting the shape of the *cowek* perfectly round. Students cut less neatly. Next, students calculated the number of cutouts correctly, which was 40 pieces. This activity not only trains precision and fine motor skills, but also fosters an understanding of basic geometric concepts as well as number operations in the context of local culture. Mathematically, this activity develops the ability to visualize and spatial sense, as well as strengthen the understanding of the relationship between concrete objects and geometric shapes. From the aspect of number sense, the activity of doubling the number of images reflects an understanding of the size of numbers and the equivalent relationships between sets of objects.

Activity 3

This activity aims to enable students to make drying and post-burning patterns of *cowek* according to contextual problems. In the sticking activity, students organized images of *cowek* in the "drying area" and the "post-burning area." The patterns that appear are quite diverse.



Group 1

Group 2

Figure 3. *Arrangement of cowek with 10 Patterns*

Researcher : "Why is one line filled with 10 images?"

MGAF : "The number is 20, so it's 10-10."

Groups 1 and 2 have similarities in sticking the *cowek* picture, namely with a pattern of 10-10 and crossing out 3 *cowek* in the second row.

Group 3

Figure 4. *Arrangement of cowek with Pattern of Ordering*

REAR : Mom, is this ripped up?

Teacher : Discuss with your group

The group 3 attached a picture of a *cowek* with a pattern like in the problem, namely 8-7-5. However, when showing the problem of damaged *coweks*, students tore up the *cowek* pictures. The action of students crossing out or tearing an image to show a broken *coweks* represents a reduction operation in a concrete way. Thus, students not only memorize the reduction procedure, but understand the meaning behind the operation.

This activity shows the achievement of number sense indicators in the aspect of understanding the meaning of operations and the use of equivalent forms and number representations. Students are able to display the concept of reduction through the act of crossing out or tearing a broken picture of a *cowek*. Although the paste results are not neat and some of the images are out of the ground, it is still natural considering the fine motor development of low-grade students and does not interfere with the conceptual understanding of the activity. Overall, the results of this activity corresponded to the prediction of HLT 1, where students pasted images with

patterns of 10–10 and 8–7–5 and showed a concrete representation of the reduction through the context of a broken *cowek*.

Activity 4

In the "Let's Count" activity, it is hoped that students can determine the number of cows in each row in the drying field and after burning. Students count the number of *cowek* and write them down in a table. The answers that emerged from this activity were very diverse.

FI : "Mom, if the 3rd row doesn't have a guy, what's the point?"

Teacher : "If there is nothing, what does it mean?"

FI : "Zero"

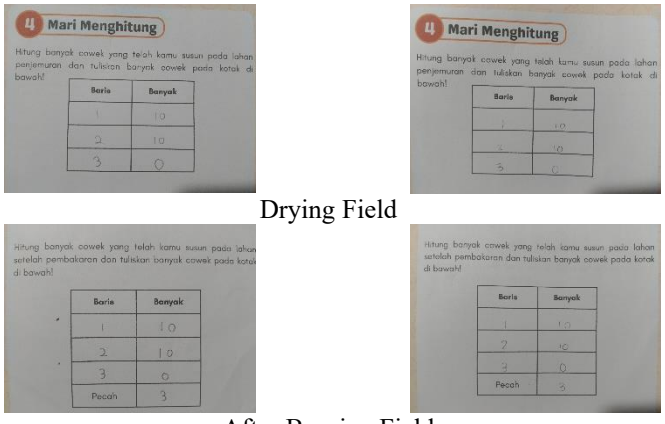


Figure 5. *Results of group 1 work in activity 4*

Group 1 in the first stage wrote that there were 10 *coweks* in the first row, 10 *coweks* in the second row, and 0 *cowek* in the third row. In the second stage, they wrote down the number of *coweks* in the first row 10, the second row 10, the third row 0, and 3 broken *cowek*.

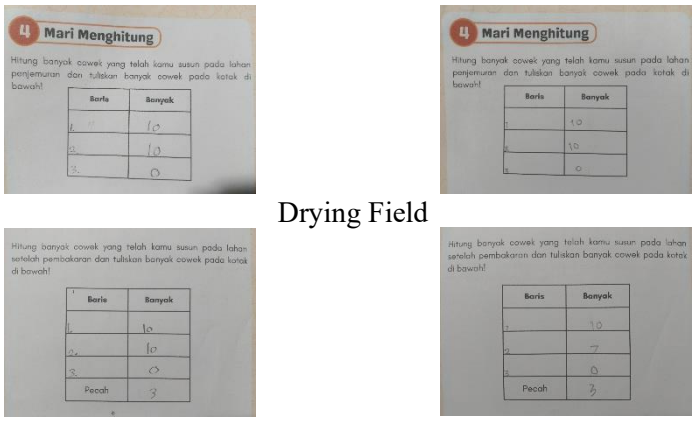
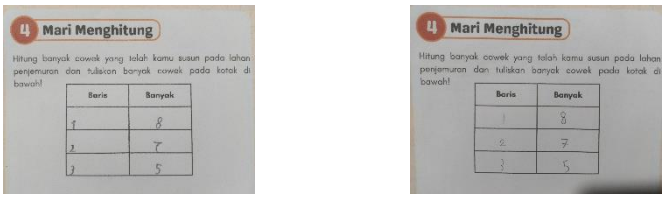


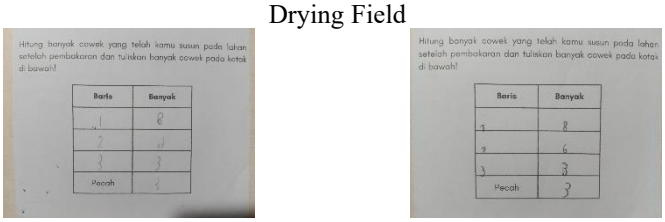
Figure 6. *Results of group 2 work in activity 4*

In the first stage, the students in group 2 fill in the table in the same way as group 1. However, in the second stage, there is a difference in the writing of the table. The first student wrote

the same result as group 1, while the second student wrote the number of *cowek* in the first line as 10, the second row 7, the third row 0, and the number of broken *cowek* as many as 3.



Drying Field



After Burning Field

Figure 7. *Results of group 3 work in activity 4*

The results of group 3's work on filling in the drying land table showed that students wrote 8 *cowek* in the first row, 7 *cowek* in the second row, and 5 *cowek* in the third row. However, on the post-burning table, students wrote 8 *cowek* in the first row, 6 *cowek* in the second row, 3 *cowek* in the third row, and 3 broken *cowek*.

Activity 5

The purpose of this activity is to calculate several numbers of concave numbers on each land using the addition or subtraction calculation operation. This activity consists of two stages, namely writing down many *cowek* on the drying land and post-burning with reference to the data contained in activity table 4.

FI : "Mom, if 0 is also written as 0?"

Teacher : "Yes, write according to the table"

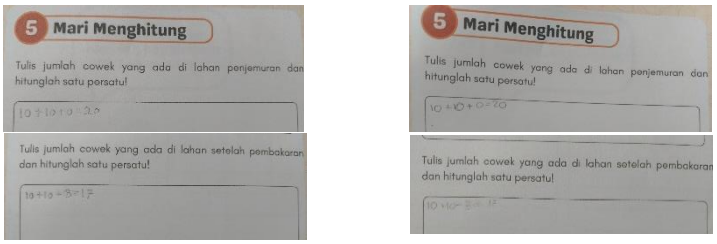


Figure 8. *Results of group 1 work in activity 5*

In the first stage, group 1 students write down the formal mathematical form of the problem with 10 + 10 + 0 = 20 and 10 + 10 -3 = 17 in stage 2.

***Figure 9**. Results of group 2 work in activity 5*

Group 2 students showed quite varied answers. The first student wrote the mathematical form on the drying land with 10 + 10 = 20, and on the post-drying land with 10 + 10 + 0 = 20 – 3 = 17. Meanwhile, the second student wrote the mathematical form on the drying land with 10 + 10 + 0 = 20 and on the post-burning land with 10 + 7 = 17.

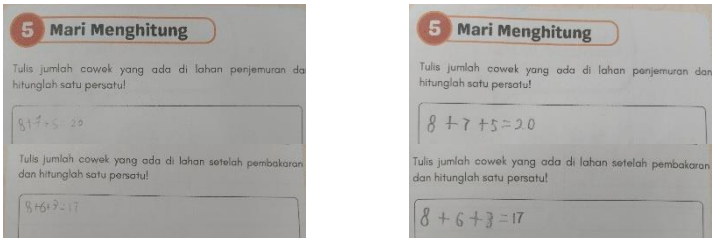


***Figure 10.** Results of group 3 work in activity 5*

Group 3 in the first stage wrote down the operating form 8 + 7 + 5 = 20, and in the second stage wrote 8 + 6 + 3 = 17. This activity shows that students are able to represent contextual situations in the form of summation operations and understand the changes in the number due to *cowek* damage that occurs. In addition, the variety of answers shows the ability to think flexibly in composing number representations and understanding the effects of operations.

Discussion

The design of mathematics activities in learning is designed through the Realistic Mathematics Education (RME) approach using the Hypothetical Learning Trajectory (HLT) framework. Nurhayanti et al., (2022) emphasized that RME puts students' real experiences as the basis for understanding mathematical concepts. The learning process is carried out through discussion, collaboration, and discovery activities independently, where the realistic context acts as a bridge to a more meaningful mathematicization process. HLT contains a series of alleged student thought processes that are compiled with a real context, namely the pottery production process, more precisely the drying and burning stages. In this study, it consists of 5 activities to develop students' number sense skills.

Activity 1

This activity is designed as an initial stage to introduce students to problems related to the pottery production process in Tondowulan Village. Students are invited to read and understand stories about pottery craftsmen who face problems in the process of burning process, namely

broken *cowek*. The use of real context provides a more meaningful learning experience because students can relate mathematical concepts to situations that are close and relevant to their daily lives (Febrianti et al., 2024). In addition, the use of realistic problems in this activity is in line with Apriyanti (2023) view that mathematics should be learned through contextual experiences so that students realize that mathematical concepts are not separate from the real world. Through this activity, students began to develop number sense skills, including:

1. Understanding of numerical values: students are able to correctly name the number of orders from each buyer. Some students count by raising their fingers to show the number of *cowek* ordered.
2. Understanding the meaning of operations and their effect on numbers: some students can mention problem-solving flows to solve problems. Although there is 1 group that is still struggling. There are students raising their fingers when adding and lowering their fingers when subtracting.

Activity 2

Activity 2 is designed to connect between the first activity and the next one. Students cut out the picture of the *cowek* according to the number of problems. This activity is related to the indicator of number sense ability, namely number representation. Through cutting and counting the image of a boy, students learn to associate symbols or numbers with real objects, so that the concept of numbers is no longer abstract. As explained by Citra (2022), number representation allows students to see problems that originally seemed complex to be simpler and easier to understand.

Activity 3

The activity of 3 students attached a picture of a cowek to the drying land and after burning. Students practice representing contextual situations into concrete forms that can be observed directly. In the process, several indicators of number sense ability emerge which can be seen from the way students arrange and adjust the number of cowek according to the context of the problem.

1. Relationship between numbers: there is a variation of answers from 3 groups. 2 groups compose with a 10-10 pattern and 1 group with an 8-7-5 pattern to produce the same amount.
2. Understanding the meaning of operations and number effects: 2 groups crossed out pictures of *cowek* to show how many *cowek* were damaged after the burning process and 1 group showed the problem by tearing them apart. Students understand subtraction as

the process of subtracting the sum of the whole, not just removing numbers.

3. Flexibility and efficiency of the calculation strategy: 2 groups arranged in a pattern of 10-10 to make calculations easier, while the other 1 group followed the pattern according to the context of the order.

Activity 4

In this activity, students count the number of *coweks* per row on the drying land and after burning. In this activity, there are several variations of answers and the ability of number sense indicators to appear.

1. Number representation: students begin to move from concrete representations (pictures of boys) to symbolic ones (numbers in tables).
2. Relationships between numbers: students understand that the numbers they write on the table are part of the overall total of 20.

Activity 5

In this last activity, students write down formal mathematical forms based on the data they have filled in in the table in activity 4. There are various variations of answers written by students, both in the order of summation and the way they present the results of subtraction. There are several indicators that emerge from this activity, including:

1. Flexibility and efficiency of calculation strategies: there are many variations of formal mathematics to obtain the same results.
2. The meaning of the operation and its effect on numbers: students understand that the addition operation adds to the total number of *cowek*s, while the reduction operation reduces the result due to damage.
3. Number representation: Students move from concrete and visual experiences to formal mathematical symbols.

Overall, the design of math activities in the computational operations material with relevant contextual experience facilitates the development of students' number sense and the development of these skills. This is in line with the findings of Melinda & Mariana, (2025) which looks at the development of students' number sense in the context of Toko Madura. Wiryanto et al., (2024) show that the integration of local culture in mathematics education paves the way for a more effective and contextual approach in improving students' understanding and interest in learning. The research emphasizes that the use of familiar local cultures in students' lives is able to strengthen the connection between concrete experience and mathematical understanding.

CONCLUSION

Based on the results of the implementation of the entire series of learning activities developed, it can be concluded that the application of the local cultural context through the process of making pottery in Tondowulan Village has succeeded in becoming an effective means in relating students' real experiences with formal mathematics concepts. In this study, the researcher used the concept of counting operations as the main focus and developed it into five learning activities based on Hypothetical Learning Trajectory (HLT), namely: (1) reading the story of the pottery, (2) cutting out the picture of the *cowek*, (3) pasting the picture on the drying land and the land after burning, (4) counting the number of *cowek* in each row, and (5) writing the form of calculation in a formal representation.

The series of activities not only facilitates students to understand the pottery production process contextually, but also helps them construct the meaning of counting operations in a more natural and meaningful way. Through this learning, students show the development of number sense skills which include understanding numbers, the meaning of operations and their effects on numbers, the ability to represent numbers, and the ability to recognize relationships between numbers. In addition, this activity also encourages the emergence of flexibility and efficiency of students' calculation strategies in solving the problems presented. Thus, it can be concluded that the design of mathematical activities based on the culture of pottery crafts is not only contextually relevant, but also has the potential to significantly develop the basic numerical thinking skills of elementary school students.

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