JTAM (Jurnal Teori dan Aplikasi Matematika)
http://journal.ummat.ac.id/index.php/jtam
p-ISSN 2597-7512 | e-ISSN 2614-1175
Vol. 10, No. 4, October 2026, pp. 1530-1547

Interactive Fraction Learning for Elementary Schools: Integrating Ethnomathematics and Leap Motion

Khaerul Anam[1*], Kwang Sik Chung[2], Diki[3], Gunawan Wiradharma[4], Mario Aditya Prasetyo[5]
[1]Department of Primary School Teacher Education, Universitas Terbuka, Indonesia
[2]Department of Computer Science, Korea National Open University, South Korea
[3]Department of Biology, Universitas Terbuka, Indonesia
[4]Department of Communication Sciences, Universitas Terbuka, Indonesia
[5]Postgraduate Program in Communication Sciences, Universitas Indonesia, Indonesia
khaerul.anam@ecampus.ut.ac.id

Article History:
Received : 21-07-2026
Revised : 11-09-2026
Accepted : 14-09-2026
Online : 31-10-2026

Keywords:
Mobile Learning;
Ethnomathematics;
Leap Motion;
Realistic Mathematics Education;
Fraction.

ABSTRACT

In Indonesian elementary education, fractions are frequently taught without meaningful connections to real-life experiences, and conventional learning resources rarely enable students to explore mathematical concepts through interactive, hands-on activities. Previous studies have examined digital media or ethnomathematics separately, but rarely integrate motion-sensing interaction, Realistic Mathematics Education, and local culture in fraction learning. This study aimed to analyze learning needs and formulate specifications for Leap Motion–based ethnomathematics media for fourth-grade students. As the Analysis stage of an ADDIE-based Research and Development study, data were collected from 34 students and teachers at two public elementary schools in Bandung through classroom observations, semi-structured interviews, and student questionnaires. The instruments included observation sheets, interview guidelines, questionnaires, and document-analysis sheets. Questionnaire data were analyzed using descriptive statistics, while qualitative data underwent coding, thematic categorization, triangulation, and needs-to-specification mapping. The findings indicated a need for concrete–digital, interactive, and contextual media. The proposed specifications include hand gestures for sliding, rotating, separating, combining, and dividing virtual *surabi* pieces; circular *surabi* representations partitioned into equal parts illustrating 1/2, 1/3, 1/4, and other fractions; dynamic visualization; and immediate audiovisual feedback. These specifications connect formal fraction concepts with kinesthetic–visual learning and students' cultural experiences, supporting more inclusive and meaningful mathematics learning.

https://doi.org/10.31764/jtam.v10i4.41220

This is an open access article under the CC–BY-SA license

A. INTRODUCTION

The concept of fractions is one of the topics that is often considered difficult for elementary school students because of its abstract nature and its limited connection to real-life contexts (Jordan et al., 2024; Thang et al., 2018). Fraction instruction at the elementary level has generally been presented in a procedural or mechanistic manner, without encouraging students to construct their own conceptual understanding (Cahyaningsih et al., 2025). As a result, students' understanding of fraction concepts remains low, and many students experience difficulties in performing fraction operations. In addition, the instructional media and teaching aids commonly used by teachers are still largely static, such as pictures or text in

textbooks, which means that student interaction and learning experiences are not yet optimal (Dar et al., 2022). The limited variety and interactivity of instructional media make fraction learning monotonous, less engaging, and less relevant to students' needs, even though students actually require learning approaches that are contextual and visual in nature (Ahmad et al., 2021).

Theoretically, the cognitive characteristics of elementary school students fall within Piaget's concrete operational stage (approximately ages 7–11). At this stage, students benefit greatly from the use of concrete objects or visual representations to support their reasoning, while learning that is overly abstract tends to be less effective (Donovan & Fyfe, 2022). An implication of this developmental stage is the need for manipulative activities and visual representations in mathematics instruction, including in teaching fractions. The Realistic Mathematics Education (RME) approach offers a framework that aligns well with these needs (Siswantari et al., 2025). RME is rooted in Freudenthal's view that mathematics should be learned as a meaningful activity through students' own real-life experiences (Da, 2022). This means that concepts should be introduced through familiar everyday contexts so that students can gradually build understanding from the concrete to the abstract. With meaningful contexts, students find it easier to relate fraction concepts to concrete experiences, rather than memorizing formulas in isolation (Flores et al., 2022).

The ethnomathematics approach becomes particularly relevant within the RME framework to contextualize the teaching of fractions (Prahmana, 2022). Ethnomathematics integrates elements of local culture into mathematics instruction, allowing abstract concepts to be explained through cultural practices and objects that are familiar to students. This approach is considered effective in making learning more contextual and closely connected to students' everyday lives (Sari et al., 2023; Yanti, 2025). Recent studies indicate that the application of ethnomathematics can enhance students' interest and understanding in learning mathematics, as students encounter mathematical concepts embedded in their own culture, which increases motivation and supports more concrete comprehension of the material (Yuliana et al., 2022). For example, by exploring traditional games or local art motifs that embody fraction concepts, students are able to bridge their understanding of fractions through cultural elements that are already familiar to them (Fatimah et al., 2026). Thus, the combination of realistic contexts and local cultural elements is believed to help elementary school students overcome the abstract nature of fraction concepts and engage more actively in the learning process.

Although the potential of integrating interactive technology with local cultural contexts is very promising, there is currently a gap in the literature and educational practice regarding the systematic combination of these elements (Pan et al., 2025). Innovations in digital mathematics learning rarely incorporate ethnomathematics or local cultural elements explicitly. While the digitalization of mathematics education is advancing rapidly, it often overlooks the local mathematical knowledge embedded within specific communities (Agbata et al., 2024). As a result, there is still a lack of guidance or models for educators on how to integrate cultural context into digital mathematics learning media. Such integration, however, has the potential to make mathematics learning more culturally inclusive and relevant for students from diverse backgrounds (Leonard, 2018). Specifically for fractions in elementary school, the need for concrete, interactive, and contextual learning media has not been extensively explored. Motion-

sensing technologies, such as Leap Motion, which can detect hand movements to interact with virtual objects, offer opportunities to provide manipulative experiences digitally (Hidayati et al., 2026). Nevertheless, the use of Leap Motion in teaching fractions with local cultural content has been almost entirely undocumented in previous research.

Therefore, integrating Leap Motion technology with *surabi*-based ethnomathematics is important for providing elementary school students with concrete, interactive, and culturally contextual fraction-learning experiences. Leap Motion enables touchless hand gestures to manipulate virtual objects, while the circular shape of *surabi* can represent a whole divided into equal parts, such as 1/2, 1/3, and 1/4. Through gestures for sliding, rotating, separating, combining, and dividing virtual *surabi* pieces, students can visualize part–whole relationships and connect formal fraction symbols with familiar cultural experiences. Technology-supported manipulation and embodied interaction can facilitate students' understanding of mathematical representations, while digitally enhanced tangible materials have demonstrated positive outcomes in fraction learning (Fokides & Alatzas, 2023; Reinhold et al., 2020; Yeung & Ng, 2023). Furthermore, ethnomathematics-based instruction can strengthen mathematical understanding by connecting mathematical concepts with students' cultural knowledge and lived experiences (Näslund-Hadley et al., 2025). However, to the best of the authors' knowledge, no previous study has specifically combined touchless gesture technology with local ethnomathematics for teaching fractions in elementary schools. Thus, the novelty of this study lies in formulating media specifications that integrate Leap Motion–based gestural interaction with *surabi* as a culturally meaningful representation of fraction concepts.

Building on the discussion above, this study focuses on analyzing the learning needs for fractions in elementary schools and formulating the initial specifications for fraction learning media based on Leap Motion with an ethnomathematics approach. Needs analysis is an essential preliminary process for ensuring that digital learning media correspond to students' characteristics, teachers' pedagogical requirements, available learning facilities, and classroom conditions (Salas-Rueda et al., 2020; Zainil et al., 2024). Specifically, the study aims to map the characteristics of fraction topics that students find difficult to understand, teachers' preferences and challenges in teaching fractions, and local cultural elements relevant as learning contexts. The results of this needs analysis are then used to design a preliminary prototype or conceptual design of interactive, hand-motion-based learning media that incorporates local cultural contexts. Designing interactive mathematical media based on identified user needs can help align technological features, tangible interactions, and learning objectives with elementary students' characteristics (Zito et al., 2021). In the short term, the study aims to produce a needs-specification document and an initial design for Leap Motion–based fraction learning media with an ethnomathematics perspective. In the long term, this research is expected to provide a conceptual and empirical foundation for developing the final learning media in the next stage of the study.

In terms of contribution, the development of interactive learning media grounded in local cultural contexts aligns with efforts to improve the quality of inclusive education. Media designed with attention to cultural diversity can help all students feel accommodated in mathematics learning. Such a contextual-cultural approach also aligns with the Sustainable Development Goals agenda. High-quality and inclusive education plays a crucial role in

reducing disparities by ensuring that every child has access to learning that is relevant to their background. Thus, this study not only contributes to innovations in teaching fractions but also supports the Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education) and Goal 10 (Reduced Inequalities). Through the Leap Motion-based fraction learning media incorporating ethnomathematics, it is expected that students in diverse classrooms will experience learning that is fairer, more contextual, and more empowering.

B. METHODS

The research design follows a Research and Development (R&D) framework, using the ADDIE model (Analysis–Design–Development–Implementation–Evaluation) as the main reference. This R&D approach is suitable for developing learning media because it is systematic and iterative, emphasizing the initial analysis stage to understand learning needs before moving on to the design and development of the product. This study was limited to the Analysis stage, which focused on identifying learning problems, student characteristics, instructional conditions, cultural contexts, and user expectations as the basis for formulating the specifications of Leap Motion–based ethnomathematics media for fraction learning.

The participants comprised 34 fourth-grade students and five teachers from two public elementary schools in Bandung City. The students were selected purposively based on the criteria that they were enrolled in Grade IV, were 9–10 years old, and had studied basic fraction concepts. The teachers were selected because they taught or had previously taught fractions at the elementary-school level and were familiar with students' difficulties and the instructional media used in the classroom. Teachers served as the primary informants, while students participated in classroom observations and completed a guided needs-assessment questionnaire.

Data were collected using a classroom observation sheet, a semi-structured teacher interview guide, and a student needs-assessment questionnaire. The observation sheet covered four indicators: students' difficulties in understanding part–whole relationships, student engagement during fraction lessons, teacher–student interactions, and the types and interactivity of instructional media used. The teacher interview guide examined teaching methods and experiences, students' conceptual difficulties, limitations of existing learning resources, the use of concrete and digital media, required interactive features, perceptions of motion-gesture technology, and suggestions for integrating Leap Motion into fraction instruction. The student questionnaire measured prior understanding and experience of learning fractions, learning resources currently used, perceived learning difficulties, preferences for concrete and visual representations, experience with digital media, interest in game- and gesture-based learning, and preferred media features. Classroom observations were conducted during fraction lessons, after which teachers were interviewed, and students completed the questionnaire with guidance from the researchers. Curriculum documents, textbooks, worksheets, and other media used by the teachers were subsequently examined. The instruments were reviewed for content relevance, clarity, and consistency with the objectives of the needs analysis before data collection. Data validity was established through source and technique triangulation. Source triangulation compared information obtained from students, teachers, and curriculum or instructional documents. Technique triangulation compared

questionnaire responses, teacher interviews, classroom observations, and document-analysis results relating to the same indicators.

Questionnaire data were analyzed using descriptive statistics in the form of frequencies and percentages, whereas observation, interview, and document data were analyzed qualitatively. The qualitative analysis involved data organization, coding, categorization, comparison across sources, and thematic interpretation. The initial codes included conceptual difficulties, concrete and visual learning needs, kinesthetic engagement, limitations of existing media, interactive-feature expectations, immediate feedback, motion gestures, and local cultural relevance. These codes were grouped into broader themes describing the required characteristics of the media: concrete–digital, interactive, kinesthetic–visual, and culturally contextual.

The media-specification analysis was conducted by translating each validated learning need into a pedagogical requirement and subsequently into a technical feature. First, evidence from interviews, observations, questionnaires, and documents were summarized in a needs matrix. Second, each identified need was linked to a learning function. For example, difficulty understanding fractions as parts of a whole was translated into the need for dynamic part–whole visualization, while students' preference for direct manipulation was translated into gesture-based interaction. Third, each learning function was mapped onto a technical specification. The need for direct manipulation was mapped onto Leap Motion gestures for sliding, rotating, separating, combining, and dividing virtual objects. The need for familiar and concrete representations was mapped onto circular *surabi* objects divided into equal parts representing 1/2, 1/3, 1/4, and other fractions. The need to correct misconceptions was translated into immediate visual and audio feedback, while the need for contextual learning was mapped onto *surabi*-sharing activities based on RME and ethnomathematics principles. Finally, the proposed specifications were checked against the curriculum objectives, students' cognitive characteristics, teacher expectations, and Leap Motion's interaction capabilities. The resulting mapping of learning needs, pedagogical functions, cultural content, gestures, visualization, and feedback mechanisms served as the basis for the subsequent Design and Development stages.

C. RESULT AND DISCUSSION

This section presents the results of the analysis on the need for developing a fraction learning media based on Leap Motion with an ethnomathematics approach, which is relevant to the context of primary school mathematics education. The analysis process was conducted through interviews with classroom teachers, classroom observations, and a review of students' cognitive characteristics and local cultural context to explore their perceptions, experiences, and actual needs in learning fractions. The main objective of this analysis is to identify gaps in the classroom fraction learning process, assess the potential use of gestural technology, and formulate ideal features and design approaches for a digital learning media that is both contextual and manipulative. The analysis results are organized thematically, encompassing teachers' perspectives and students' learning needs. This structure aims to provide a conceptual and practical framework for designing learning media that is responsive to children's cognitive development, culturally contextualized, and innovative in utilizing digital technology.

Before presenting the findings thematically, the results of the needs analysis were synthesized to provide a comprehensive overview of the existing fraction learning conditions, student characteristics, teacher expectations, and the implications for the proposed learning media. The synthesis combines quantitative data from questionnaires completed by 34 fourth-grade students with qualitative evidence obtained from classroom observations and teacher interviews. As presented in Table 1, the findings reveal a substantial gap between students' concrete, visual, kinesthetic, and cultural contextual learning needs and the predominantly static learning media currently used in the classroom. This gap provides the empirical basis for developing Leap Motion-based fraction learning media that integrate Realistic Mathematics Education and ethnomathematics through the cultural context of *surabi*.

Table 1. Synthesis of Fraction Learning Needs and Media Development Implications

Analysis Dimension	Indicator and Data Source	Main Findings
Participant characteristics	Questionnaire and classroom observation involving 34 fourth-grade students from two public elementary schools in Bandung	Most students were aged 9–10 years (94.1%). The gender distribution was relatively balanced, consisting of 52.9% male and 47.1% female students.
Difficulty understanding fractions	Teacher interviews and classroom observations	Students had trouble imagining fractions as parts of a whole, distinguishing fractions such as 1/2 and 1/3, and understanding the process of dividing an object into equal parts. Students tended to memorize procedures without developing conceptual understanding.
Preference for concrete learning	Student questionnaire	A total of 85.3% of students preferred learning activities involving tangible objects or hands-on experiences.
Preference for visual representations	Student questionnaire and teacher interviews	A total of 76.5% of students reported that fractions were easier to understand through pictures or pieces of objects, particularly familiar foods.
Kinesthetic and exploratory learning needs	Teacher interviews and classroom observation	Students became bored when learning only through verbal explanations. They were more responsive when learning involved movement, play, exploration, and direct experimentation.
Current learning resources	Student questionnaire	Textbooks were used by 100% of students as the primary learning resource, while 61.8% used worksheets. Only 17.6% had experienced concrete media such as folded paper or circular cardboard.
Use of interactive digital media	Student questionnaire and teacher interviews	None of the students had used interactive digital media for learning fractions either at school or at home. Teachers generally relied on textbooks, blackboard illustrations, pictures, or PowerPoint presentations.
Interest in hand-manipulated media	Student questionnaire	A total of 82.4% of students expressed interest in trying to learn media that could be manipulated directly using their hands.

Analysis Dimension	Indicator and Data Source	Main Findings
Need for contextual learning	Student questionnaire and teacher interviews	A total of 88.2% of students preferred media using objects or foods that were familiar in their daily lives. Teachers also reported that students understood fractions more quickly when using cake-sharing examples.
Local cultural relevance	Teacher interviews and ethnomathematical analysis	*Surabi* was considered relevant because it is familiar to students in Bandung, has a circular geometric form, and can be divided into equal sections representing 1/2, 1/3, 1/4, and other fractions.
Need for direct manipulation	Teacher interviews	Teachers expected students to be able to slide, rotate, separate, combine, and divide visual fraction objects so that fractional values could be experienced more concretely.
Need for immediate feedback	Teacher interviews and analysis of learning gaps	Teachers emphasized that students required direct confirmation when performing learning activities so that misconceptions could be identified and corrected immediately.
Realistic Mathematics Education principles	Synthesis of interviews, observation, and curriculum analysis	Students understood mathematical concepts more effectively when they were connected to meaningful real-life situations rather than introduced solely through formulas.
Ethnomathematics integration	Cultural-context analysis and teacher interviews	Local cultural objects were found to increase familiarity, relevance, motivation, and students' ability to connect mathematics with everyday life.

The quantitative and qualitative findings showed consistent patterns across the data sources. The finding that 85.3% of students preferred tangible or hands-on activities supports Teacher 1's observation that students needed real-life examples rather than textbook illustrations alone. Similarly, the 76.5% preference for pictures or object pieces corresponds with Teacher 3's explanation that students had difficulty distinguishing 1/2 from 1/3 when fractions were presented only through static representations. Students' interest in hand-manipulated media (82.4%) was also consistent with Teacher 2's expectation that students should be able to grasp, slide, rotate, and separate fractional objects on the screen. Furthermore, the preference of 88.2% of students for familiar objects or foods reinforced Teachers 4 and 5's accounts that students understood fractions more easily when *surabi* was used as an example of dividing and sharing food. Finally, the finding that none of the students had used interactive digital media confirmed teachers' reports that existing fraction instruction remained dependent on textbooks, blackboard illustrations, and PowerPoint presentations. This convergence indicates that the proposed media specifications were derived from mutually reinforcing evidence rather than from a single data source.

The synthesis in Table 1 demonstrates that the main issue in fraction instruction is not merely students' limited ability to perform calculations, but the mismatch between their developmental learning characteristics and the instructional media currently available. Students require opportunities to observe, manipulate, and interpret fractions through concrete and meaningful experiences, whereas current instruction remains dominated by static textbooks, worksheets, and two-dimensional illustrations. Accordingly, the findings support the development of concrete–digital media that combines Leap Motion-based gestural interaction, dynamic visualization, immediate feedback, realistic learning situations, and *surabi*-based ethnomathematical content.

1. Teacher Needs Analysis

The analysis of needs from the perspective of primary school teachers revealed several important findings related to obstacles and expectations in teaching fractions. Interviews with fourth-grade teachers indicated that fraction concepts are often difficult for students to understand due to their abstract nature. One teacher stated:

"Children struggle to imagine parts of a whole when they only see pictures in the book; they need real-life examples" [Teacher 1].

This highlights a learning gap, as procedural explanations alone are insufficient to help students develop a deep understanding of fractions. According to Piaget's theory of cognitive development, children aged 7–11 are in the concrete operational stage and rely heavily on concrete experiences to grasp abstract concepts (Hayat et al., 2024). The teacher's statement aligns with findings that students require manipulative and visual activities connected to real-life experiences to effectively understand fractions (Amo-Asante & Bonyah, 2023). Classroom teachers reported that fraction topics often cause confusion among students. One teacher noted.

"If we only use textbooks or pictures on the blackboard, many students still do not understand why 1/2 is different from 1/3" [Teacher 3].

This finding indicates a conceptual gap: even though fraction operation rules are taught, students' fundamental understanding of parts and wholes has not yet developed. This challenge is compounded by conventional methods, which are insufficient for the cognitive context of primary school students. According to Piaget's theory, at the concrete operational stage, students still rely on tangible and visual objects to reason logically (Hayat et al., 2024). Therefore, the difficulties faced by teachers reflect a fundamental need for more concrete and manipulative learning media, enabling students to build fraction concepts gradually from concrete to abstract. Teachers emphasized the importance of concrete-digital and interactive learning media. One teacher explained:

"The current media is very static; students become less interested and only memorize formulas without understanding" [Teacher 2].

Teachers hoped for interactive media that allows students to engage directly with fraction representations so that the part-whole concept becomes tangible. This aligns with the Realistic Mathematics Education (RME) approach, which emphasizes learning through meaningful real-life situations (Khasanah et al., 2025). RME recommends introducing mathematical concepts

through authentic contexts so students can understand mathematics through their own experiences rather than rote procedures (Akhotmee et al., 2025). Consequently, teachers expressed the need for media features that support digital manipulation within relevant contexts to facilitate the construction of fraction concepts. Some teachers also highlighted the importance of linking fraction learning to local cultural elements. For example, one teacher stated:

"I often explain fractions by dividing surabi cakes; students understand faster because they can see actual pieces of a food they know" [Teacher 5].

This finding supports the idea that integrating local culture can help students reason about abstract concepts. Previous studies have shown that applying ethnomathematics effectively enhances students' understanding of mathematical concepts (Batiibwe, 2025; Simbolon, 2024; Wulandari et al., 2024). By using traditional foods like surabi, teachers successfully bridge the formal world of mathematics with students' real-life experiences. Thus, teachers' needs include media that are not only interactive but also culturally contextual to give meaningful insight into fraction learning (Hwang et al., 2023). Teachers' observations indicate that many students have not yet achieved a deep understanding of fractions. One teacher expressed this concern,

"*Even though students have practiced fraction problems many times, many are still confused about dividing something into fractional parts; they tend to calculate without really understanding the concept*" [Teacher 5].

This situation reveals a learning gap in which students are familiar with formulas but lack meaningful conceptual connections. This gap is further reinforced by the fact that fraction concepts are highly abstract for children at the concrete operational stage. According to Piaget, elementary school students think logically based on concrete objects; overly abstract instruction limits their understanding. Therefore, from the perspective of students' needs, learning media must enrich concrete experiences so that this conceptual gap can be addressed (Nurmalisa et al., 2023). Teachers also observed that elementary students' cognitive characteristics influence how they learn fractions. One teacher noted,

"*Children get bored quickly if they only listen to explanations; they are more responsive when learning while moving or playing*" [Teacher 1].

This aligns with children's cognitive developmental characteristics, as learning that engages the senses and movement (kinesthetic–visual) is more effective. Students' preferences for contextual learning were also evident when teachers reported their desire to try out the concepts themselves (Febrina & Setiawan, 2024). The findings show that most students are more enthusiastic about media that combine elements of play and exploration rather than one-way information delivery. Considering these characteristics, students need accessible media that present fraction concepts through learning experiences that are appropriate to their age and cultural background. The interview results confirm that fraction learning media must be concrete, interactive, and facilitate direct manipulation. Teachers expressed a desire for media equipped with realistic illustrations and real-time feedback when students interact with it. For example, one teacher stated,

"*The media should allow students to slide or rotate visual parts so that they can truly feel what 1/2 or 1/4 looks like*" [Teacher 2].

This concept aligns with the principles of hands-on learning (Elsayed & Aloufi, 2023; Lee et al., 2024), as RME emphasizes concrete representations in mathematics learning. From a technological perspective, observations highlight the importance of hand-gesture detection features and dynamic visual graphics that can translate students' movements into virtual fraction manipulations. Media with such features are expected to bridge learning gaps by providing concrete–digital experiences that align with students' cognitive needs. To meet these kinesthetic–visual needs, Leap Motion was selected as the primary technology, as it is a hand-motion sensor capable of capturing movements without physical contact. With this device, students can operate virtual objects solely through hand and finger movements. One teacher welcomed this idea, stating:

"Elementary students will be more engaged if they learn using their own hands, for example by grasping or separating objects on the screen" [Teacher 2].

Leap Motion supports intuitive interaction without the use of a mouse or keyboard, making it well suited for kinesthetic learning. This hand-gesture support enables students to manipulate fractional parts directly and kinesthetically, which aligns with their need to learn through concrete experiences. Therefore, Leap Motion represents a rational choice due to its ability to provide digital hands-on learning within a visual context. The media concept also involves integrating local culture through *surabi* cake. *Surabi* was selected as an ethnomathematical context because it is familiar in Bandung and has a geometric form that is easy to partition (a circle that can be divided into equal parts). The teacher noted,

"Surabi is often used as an example of sharing cake; for instance, students can divide the circle into 1/2, 1/3, or 1/4—they understand it immediately" [Teacher 4].

Linking mathematics with local culture in this way has been shown to accelerate students' understanding. Similar ethnomathematics approaches can enhance learning motivation and engagement because students perceive the relevance of mathematical concepts in their everyday lives (Asare, 2026). Therefore, the designed media will incorporate *surabi* elements as concrete objects that can be slid or divided using hand gestures. This implementation not only fulfills the RME principle of learning through real-life contexts but also strengthens conceptual understanding through culturally familiar contexts for students.

Overall, the teacher interviews, classroom observations, and student questionnaire results demonstrate the need for fraction learning media that are concrete–digital, interactive, and culturally contextual. These findings were translated into several product requirements. The media should present a circular digital *surabi* as a whole that can be divided into equal parts representing 1/2, 1/3, 1/4, and other fractions. Leap Motion should detect gestures for selecting or grasping a *surabi*, sliding its pieces, rotating the object, cutting or dividing it into equal sections, separating the resulting parts, and recombining them into a whole. Each action should produce immediate visual and audio feedback so that students can determine whether the selected gesture and fraction representation are correct.

The proposed interaction sequence begins with students selecting a whole *surabi* through an open-hand or grasping gesture. Students then use cutting or separating movements to divide the object according to a specified fraction. Sliding gestures allow the resulting pieces to be moved and compared, while rotation and combining gestures enable students to explore the relationships between fractional parts and the whole. The interface should simultaneously display the corresponding fraction symbol and provide corrective feedback when the pieces are unequal or do not match the requested fraction. Thus, Leap Motion was selected not only because it supports kinesthetic–visual learning, but because its touchless interaction capabilities can operationalize the specific manipulative activities identified in the needs analysis.

2. Analysis of Student Characteristics and Learning Media

The needs analysis in this study began with identifying the characteristics of fourth-grade elementary school students as prospective users of fraction learning media. A total of 34 students from two public elementary schools in Bandung City participated in classroom observations and completed guided questionnaire instruments. Most students were in the 9–10 age range (94.1%), with a relatively balanced gender distribution (52.9% male and 47.1% female). Based on the analysis results, 85.3% of students showed a preference for learning activities involving tangible objects or hands-on experiences. In addition, 76.5% of students reported that they found fraction concepts easier to understand through images or object pieces such as food. These findings reinforce the results of classroom observations and teacher interviews, which indicate that students are at the concrete operational stage in accordance with Piaget's theory.

From the perspective of learning media currently used, 100% of students reported textbooks as the primary source for learning fractions, followed by worksheets (LKS) at 61.8%. However, only 17.6% of students used concrete media, such as folded paper or circular cardboard pieces, during fraction instruction. Furthermore, none of the students reported having used interactive digital media when learning fractions, either at school or at home. Teachers confirmed this condition by stating, "We have never used interactive digital media for fractions; at most, we only use pictures in books or PowerPoint presentations."

When asked about preferred learning media, 82.4% of students expressed interest in trying media that could be directly manipulated by hand, and 88.2% favored learning media that use objects or foods familiar from their daily lives. One student even commented, "If we could share cake like in a game, it would definitely be fun, Ma'am." These findings indicate that students not only need learning media that are concrete and interactive but also ones that are connected to their cultural experiences.

The integration of these findings produced three connected design implications. First, students' preference for concrete objects (85.3%) and visual representations (76.5%) requires the media to display fraction transformations dynamically rather than as fixed images. Second, their interest in hand-manipulated media (82.4%) requires an interaction system in which gestures have clearly defined mathematical functions, including cutting, sliding, rotating, separating, and combining *surabi* pieces. Third, their preference for familiar objects (88.2%) requires the fraction activities to be situated within recognizable practices, such as dividing and

sharing *surabi*. Consequently, the proposed product specifications integrate content representation, interaction mechanisms, and cultural context instead of treating these elements as separate media features.

From these findings, it can be concluded that there is a gap between students' learning characteristics and the instructional approaches and media currently in use. The available media tend to be static and passive and do not yet facilitate visual–manipulative exploration that aligns with students' cognitive developmental stages. Therefore, new learning media that integrate concrete, interactive, and contextual elements are needed. Leap Motion was selected because it supports hand-gesture–based interaction, while the cultural artifact *surabi* was chosen due to its suitability for representing fractions and its close connection to students' local experiences. This combination enables the development of learning media that are more adaptive, meaningful, and relevant both culturally and technologically.

3. Discussion

The results of the needs analysis for fraction learning indicate that elementary school students require learning media that are concrete–digital, interactive, and contextual to help visualize abstract fraction concepts. These findings are consistent with cognitive development theory, which places students at the concrete operational stage. At this stage, students' thinking abilities are greatly supported by the use of tangible objects or visual and manipulative representations (Byrne et al., 2023), while overly abstract instruction tends to be less effective. Therefore, students need manipulative and visual activities that are closely connected to their everyday experiences.

Moreover, local cultural contexts strengthen students' conceptual engagement. The Realistic Mathematics Education (RME) approach emphasizes that mathematics should be learned through meaningful experiences situated in everyday contexts. Similarly, ethnomathematics integrates local cultural elements (such as the traditional *surabi* food from Bandung) to bridge abstract concepts into concrete representations (Prahmana, 2022). The findings of this study indicate that utilizing cultural objects familiar to students (such as *surabi* cake slices) can enhance contextual relevance and improve students' understanding of fraction concepts.

The findings both support and extend previous research on technology-assisted fraction learning. Reinhold et al. (2020) found that interactive digital environments can support fraction learning when technological representations are aligned with students' learning needs. Similarly, Fokides and Alatzas (2023) reported that digitally enhanced tangible materials produced better fraction-learning outcomes than conventional materials. The present study supports the importance of manipulation but extends these studies by proposing touchless hand gestures rather than touchscreen or physical-object interaction. However, students' reported interest in gesture-based media should not be interpreted as evidence of its instructional effectiveness. Although 82.4% expressed interest in hand-manipulated media, prototype testing is still required to determine whether gesture detection is sufficiently accurate, intuitive, and cognitively appropriate for elementary school students.

Based on the interpretation of the findings above, the design of fraction learning media should be guided by several key principles. First, the media should enable direct manipulation

through hand movements using Leap Motion sensors. Leap Motion is selected for its ability to recognize hand gestures, allowing kinesthetic and visual interaction to occur simultaneously. In this way, students can digitally manipulate fractional objects, such as sliding pieces of *surabi* cake that represent fractional parts. Second, dynamic visualization is essential: representations of fractional objects (e.g., *surabi* slices) should move and transform in real time in response to students' hand movements. Third, the media should provide real-time visual and audio feedback whenever students interact, enabling them to immediately observe the results of their manipulations and construct conceptual understanding. Fourth, the media design should incorporate local cultural contexts as the instructional framework (for example, fraction representations embedded in *surabi* preparation activities or patterns of sharing *surabi*).

The integration of RME and ethnomathematics approaches in media design is also essential. In line with RME principles, the media should present fraction concepts within situations that are familiar to students. For example, students' real-life experiences (such as cutting a cake or sharing food) can be adapted into digital simulations, allowing students to "mathematize" their own experiences. The ethnomathematics approach guides the media design to present cultural artifacts (*surabi*) as an integral part of mathematics learning. Consequently, media design becomes more contextual by building meaningful connections between formal mathematics and students' everyday cultural practices.

The ethnomathematical findings are also consistent with Näslund-Hadley et al. (2025), who demonstrated that culturally grounded mathematics instruction can improve students' mathematical and ethnomathematical outcomes. Nevertheless, the present study differs by transforming a cultural object into an interactive digital representation rather than using culture only as instructional content. The circular form of *surabi* functions simultaneously as a familiar cultural artifact, a geometric model of a whole, and an object that can be manipulated through hand gestures. This integration is important because adding cultural imagery to digital media would not, by itself, ensure conceptual learning. The cultural object must be connected explicitly to mathematical actions, such as dividing the *surabi* into equal sections, comparing the sizes of its pieces, and matching those pieces with fraction symbols.

Overall, the design implications of this learning media point to the development of an interactive Leap Motion–based application that enables a digital hands-on approach. The media should present an interface in which students can use hand gestures to manipulate fractional parts (e.g., *surabi* slices) while receiving immediate feedback. Dynamic visualization features and the integration of local content (RME) will make fraction concepts more concrete and meaningful. The use of Leap Motion technology also supports both kinesthetic and visual learning, making it well suited to the learning characteristics of students at the concrete operational stage.

This specification is consistent with the review by Yeung and Ng (2023), which showed that embodied actions in technology-supported mathematics learning should be meaningfully connected to the mathematical concepts being represented. In the proposed media, gestures are therefore not included solely to make learning more engaging. Each gesture represents a conceptual operation: cutting represents partitioning a whole, sliding supports comparison, separating emphasizes individual fractional parts, and combining demonstrates the reconstruction of a whole. Unlike touchscreen-based embodied learning, Leap Motion enables

these actions without direct contact with the display. Nevertheless, this difference also introduces possible challenges involving gesture-recognition accuracy, movement sensitivity, student fatigue, and the correspondence between intended and detected actions. These technical and usability considerations must be examined during prototype validation.

Theoretically, this study reinforces the argument for the importance of integrating ethnomathematics with gesture-based digital interaction in teaching abstract mathematical concepts. The findings indicate that combining local cultural contexts (*surabi*) with gestural learning media can enhance the meaningfulness and relevance of mathematical content for students (Azhary & Fatimah, 2024). This study addresses a gap in literature, as prior research has rarely integrated motion-sensing technologies such as Leap Motion with RME/ethnomathematics approaches. Accordingly, these findings provide a new conceptual foundation suggesting that mathematics learning can be developed through interactive, culturally contextualized media, while also contributing an innovative discourse to elementary mathematics education.

From a practical perspective, this study produces a student needs map and a media-requirements specification for the subsequent design and development stages. The specification connects each empirical finding with a pedagogical function and technical feature. Students' difficulty understanding part–whole relationships are addressed through dynamic *surabi* partitioning; their preference for direct manipulation is translated into cutting, sliding, rotating, separating, and combining gestures; their need for confirmation is addressed through immediate audiovisual feedback; and their preference for familiar contexts is incorporated through *surabi*-sharing activities. This mapping provides developers with a more operational reference than a general recommendation to create interactive media because it specifies the learning content, gesture functions, visual responses, cultural context, and expected interaction flow.

The main limitation of this study is that it remains at the needs-analysis stage and has not yet produced a fully developed learning-media prototype. The data were obtained from 34 fourth-grade students and five teachers at two public elementary schools in Bandung City; therefore, the findings may not represent students and teachers in different school, technological, or cultural contexts. In addition, students' interest in gesture-based media and teachers' expectations regarding its benefits do not constitute evidence of improved fraction-learning outcomes. Future research should validate the proposed specifications through expert review and iterative prototype testing with teachers and students. Usability testing should examine gesture-recognition accuracy, ease of interaction, cognitive load, student engagement, and accessibility. Subsequent experimental evaluation is also necessary to determine the media's effects on students' conceptual understanding of fractions and to assess whether the *surabi*-based context can be adapted to other cultural settings.

D. CONCLUSION AND SUGGESTIONS

This study analyzed the need for Leap Motion–based fraction learning media incorporating an ethnomathematics approach for elementary school students. The needs analysis involving 34 fourth-grade students and five teachers from two public elementary schools demonstrated that the required media should be concrete–digital, interactive, visual–kinesthetic, and

culturally contextual. Specifically, 85.3% of students preferred learning with tangible objects or hands-on activities, 76.5% understood fractions more easily through visual representations or object pieces, 82.4% were interested in media that could be manipulated directly using their hands, and 88.2% preferred familiar objects or foods as learning contexts. These findings were reinforced by classroom observations and teacher interviews showing that students had trouble visualizing part–whole relationships, distinguishing fractions such as 1/2 and 1/3, and dividing a whole into equal parts. Existing instruction remained dominated by textbooks, worksheets, blackboard illustrations, and PowerPoint presentations, while none of the students had previously used interactive digital media for learning fractions.

The primary output of the ADDIE Analysis phase is an initial media-requirements specification derived directly from these needs. The proposed media should present a circular digital *surabi* that can be divided into equal parts representing 1/2, 1/3, 1/4, and other fractions. Leap Motion should detect touchless gestures for selecting, cutting, sliding, rotating, separating, and combining virtual *surabi* pieces. Each gesture should represent a specific mathematical operation: cutting illustrates the partitioning of a whole, sliding enables comparison between fractional parts, separating emphasizes individual parts, and combining demonstrates the reconstruction of a whole. The media should also display corresponding fraction symbols, provide dynamic visualization, and deliver immediate visual and audio feedback when students perform correct or incorrect actions. Thus, *surabi* is not merely used as a decorative cultural element but as an ethnomathematical model that connects formal fraction concepts with students' familiar experiences of dividing and sharing food.

In the subsequent Design and Development phases, these specifications should be translated into storyboards, interface designs, learning scenarios, gesture–function mappings, assessment activities, and a functional prototype aligned with fraction-learning objectives and RME principles. The design should ensure clear *surabi* representations, meaningful correspondence between hand gestures and mathematical operations, a systematic progression from concrete visualization to fraction symbols, and accessible instructions and feedback. The prototype should then be assessed for content, media, and technical validity by mathematics education, ethnomathematics, educational technology, and Leap Motion experts before undergoing individual and small-group trials with teachers and students. Practicality testing should examine ease of use, gesture-recognition accuracy, instructional clarity, visual attractiveness, student engagement, response time, and suitability for classroom use. Subsequent implementation and effectiveness testing should determine the media's contribution to students' conceptual understanding of fractions across broader educational and cultural contexts.

ACKNOWLEDGEMENT

The researchers would like to express their sincere gratitude to LPPM-UT for funding this research project in 2026. In addition, the researchers extend their appreciation to the resource persons and informants who provided valuable input for the development of the application.

REFERENCES

Agbata, B., Obeng-Denteh, W., Asante-Mensa, F., Arivi, S., Kwabi, P., Abraham, S., Amos, J., & Abah, E. (2024). Digital Preservation and Promotion of Indigenous Mathematics: A Global Initiative. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, *10*(4b), 65–77. https://doi.org/https://doi.org/10.4314/dujopas.v10i4b.7

Ahmad, S. Z., Rosmani, A. F., & Muhammad Nazri, N. A. (2021). A Game-based Learning Approach using Interactive Multimedia to Learn Fraction (Mathematics) Among Primary School Children. *2021 6th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, 1–6. https://doi.org/10.1109/ICRAIE52900.2021.9703915

Akhotmee, P., Toopsuwan, C., & Duangpummet, P. (2025). Developing Mathematical Activities Using Realistic Mathematics Education to Promote Mathematical Connection Ability in Real-Life of High School Students. Research Theme: Innovative and Digital Learning in Education, 234. *NICE 2025: The 7th International Conference on Education*, 234.

Amo-Asante, K., & Bonyah, E. (2023). Building students' conceptual understanding of operations on fractions using manipulatives: A junior high school perspective. *Mediterranean Journal of Social & Behavioral Research*, *7*(3), 151–159. https://doi.org/10.30935/mjosbr/13381

Asare, B. (2026). Influence of ethnomathematics-based instruction on students' attitudes, participation, and cultural connections in mathematics learning in Ghana. *Cogent Education*, *13*(1), 2612395. https://doi.org/10.1080/2331186X.2025.2612395

Azhary, L., & Fatimah, S. (2024). The integration of local cultures in english teaching materials in promoting culturally responsive teaching. *Al-Ishlah: Jurnal Pendidikan*, *16*(2), 2045-2056.. https://doi.org/10.35445/alishlah.v16i2.4998

Batiibwe, M. S. K. (2025). Ethnomathematics as a pedagogical tool for mathematics education: opportunities and challenges. *SN Social Sciences*, *5*(12), 221. https://doi.org/10.1007/s43545-025-01260-0

Byrne, E. M., Jensen, H., Thomsen, B. S., & Ramchandani, P. G. (2023). Educational interventions involving physical manipulatives for improving children's learning and development: A scoping review. *Review of Education*, *11*(2), e3400. https://doi.org/10.1002/rev3.3400

Cahyaningsih, U., Salimi, M., Nahdi, D. S., Jatisunda, M. G., & Rasyid, A. (2025). Improving Understanding of Fraction Concepts Through Problem-Based Learning in Elementary Schools. *Journal of Innovation and Research in Primary Education*, *4*(3), 1356–1366. https://doi.org/10.56916/jirpe.v4i3.1497

Da, N. T. (2022). Designing a teaching model based on the Realistic Mathematics Education (RME) approach and its application in teaching calculus. *Journal of Mathematics and Science Teacher*, *2*(1), 1-10, em006. https://doi.org/10.29333/mathsciteacher/11918

Dar, M. A., Kudare, R., Dar, Y. A., Ali, I., & Mohammed, S. (2022). Role Of Projected And Non-Projected Teaching Aids In Teaching Learning Process. *Journal of Positive School Psychology*, *2022*(10), 1725–1743. https://www.researchgate.net/publication/365181541_Role_Of_Projected_And_Non-Projected_Teaching_Aids_In_Teaching_Learning_Process

Donovan, A. M., & Fyfe, E. R. (2022). Connecting concrete objects and abstract symbols promotes children's place value knowledge. *Educational Psychology*, *42*(8), 1008–1026. https://doi.org/10.1080/01443410.2022.2077915

Elsayed, A. M., & Aloufi, F. (2023). Assessing the Efficacy of Hands-On Games for Expanding Understanding of Probability Concepts in Mathematics Education. *Migration Letters*, *20*(3), 912–921. https://doi.org/https://doi.org/10.59670/ml.v20iS3.3977

Fatimah, S., Nusantara, T., Sa'dijah, C., Subanji, Atmoko, A., & Ekawati, R. (2026). Mathematical critical thinking through Malangan mask art: a fraction-based assessment in Indonesian elementary schools. *SN Social Sciences*, *6*(6), 241. https://doi.org/10.1007/s43545-026-01520-7

Febrina, V., & Setiawan, D. (2024). Analysis of the Use of Learning Media on the Learning Interest of Learning Science Students and Environmental Themes. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 5702–5709. https://doi.org/10.29303/jppipa.v10i8.7497

Flores, M., Morano, S., Meyer, J., & Hinton, V. (2022). Teaching Fraction Magnitude to Elementary Students. *Journal of Education for Students Placed at Risk (JESPAR)*, *27*(2), 127–146.

https://doi.org/10.1080/10824669.2021.2009346

Fokides, E., & Alatzas, K. (2023). Using Digitally Enhanced Tangible Materials for Teaching Fractions: Results of a Project. *Technology, Knowledge and Learning*, *28*(4), 1589–1613. https://doi.org/10.1007/s10758-022-09605-x

Hayat, F., Khan, M., Ahmad, S., Kamran, M., & Maleeha. (2024). Exploring the Characteristics of Concrete Operational Stage among Primary School Students. *Qlantic Journal of Social Sciences and Humanities*, *5*(1), 124–132. https://doi.org/10.55737/qjssh.786349315

Hidayati, Y. M., Arifin, A. J., Kholid, M. N., & Kusuma, A. A. S. (2026). MathFrac Edu as an interactive learning media for enhancing elementary students understanding of fraction concepts. *Discover Education*, *5*(1), 620. https://doi.org/10.1007/s44217-026-01675-8

Hwang, W.-Y., Luthfi, M. I., Hariyanti, U., & Wardani, R. (2023). Evaluation of fraction learning in authentic context using Ubiquitous Fraction App. *Education and Information Technologies*, *28*(6), 6755–6779. https://doi.org/10.1007/s10639-022-11453-2

Jordan, N. C., Dyson, N., Guba, T.-P., Botello, M., Suchanec-Cooper, H., & May, H. (2024). Exploring the impact of a fraction sense intervention in authentic school environments: An initial investigation. *Journal of Experimental Child Psychology*, *244*, 105954. https://doi.org/10.1016/j.jecp.2024.105954

Khasanah, A. K., Wiryanto, & Siswono, T. Y. E. (2025). The Effectiveness of Realistic Mathematics Education To Improve Student'S Problem Solving Skills in Elementary Schools: Literature Review. *JCP: Urnal Cakrawala Pendas*, *11*(1), 188–199. https://doi.org/https://doi.org/10.31949/jcp.v11i1.12186

Lee, H.-Y., Wu, T.-T., Lin, C.-J., Wang, W.-S., & Huang, Y.-M. (2024). Integrating Computational Thinking Into Scaffolding Learning: An Innovative Approach to Enhance Science, Technology, Engineering, and Mathematics Hands-On Learning. *Journal of Educational Computing Research*, *62*(2), 211–247. https://doi.org/10.1177/07356331231211916

Leonard, J. (2018). *Culturally specific pedagogy in the mathematics classroom: Strategies for teachers and students*. Routledge.

Näslund-Hadley, E., Hernández-Agramonte, J., Santos, H., Albertos, C., Grigera, A., Hobbs, C., & Álvarez, H. (2025). The effects of ethnomathematics education on student outcomes: The JADENKÄ program in the Ngäbe-Buglé comarca, Panama. *International Journal of Bilingual Education and Bilingualism*, *28*(5), 579–595. https://doi.org/10.1080/13670050.2024.2446987

Nurmalisa, Y., Sunyono, S., Yulianti, D., & Sinaga, R. M. (2023). An Integrative Review: Application of Digital Learning Media to Developing Learning Styles Preference. *International Journal of Information and Education Technology*, *13*(1), 187–194. https://doi.org/10.18178/ijiet.2023.13.1.1795

Pan, H., Lin, Q., & Zhu, W. (2025). Overcoming the gap in technology integration in limited conditions in rural classrooms. *The Journal of Educational Research*, *118*(5), 413–424. https://doi.org/10.1080/00220671.2025.2490025

Prahmana, R. C. I. (2022). Ethno-Realistic Mathematics Education: The promising learning approach in the city of culture. *SN Social Sciences*, *2*(12), 257. https://doi.org/10.1007/s43545-022-00571-w

Reinhold, F., Hoch, S., Werner, B., Richter-Gebert, J., & Reiss, K. (2020). Learning fractions with and without educational technology: What matters for high-achieving and low-achieving students? *Learning and Instruction*, *65*, 101264. https://doi.org/10.1016/j.learninstruc.2019.101264

Salas-Rueda, R.-A., Salas-Rueda, É.-P., & Salas-Rueda, R.-D. (2020). Analysis and Design of the Web Game on Descriptive Statistics through the ADDIE Model, Data Science and Machine Learning. *International Journal of Education in Mathematics, Science and Technology*, *8*(3), 245. https://doi.org/10.46328/ijemst.v8i3.759

Sari, N., Saragih, S., Napitupulu, E. E., Rakiyah, S., Sari, D. N., Sirait, S., & Anim, A. (2023). Applying Ethnomathematics in Learning Mathematics for Middle School Students. *Acta Scientiae*, *25*(5), 250–274. https://doi.org/10.17648/acta.scientiae.7690

Simbolon, R. (2024). Literature study: Integration of ethnomathematics in mathematics learning in schools. *JMEA: Journal of Mathematics Education and Application*, *3*(2), 70-76. https://doi.org/10.30596/jmea.v3i2.20332

Siswantari, Sabon, S. S., Listiawati, N., Wirda, Y., Zulkardi, & Riyanto, B. (2025). Bridging mathematics and communication: Implementing realistic mathematics education principles for skill development. *Journal on Mathematics Education*, *16*(2), 729–752. https://doi.org/10.22342/jme.v16i2.pp729-752

Thang, N. C., Giang, N. T. C., & Nhung, N. T. P. (2018). Organizing Students of Primary Education Major to Design Situations of Teaching Fractions in the Direction of Connecting to the Real World. *American Journal of Educational Research*, *6*(5), 455–460. https://doi.org/10.12691/education-6-5-14

Wulandari, D. U., Mariana, N., Wiryanto, W., & Amien, M. S. (2024). Integration of Ethnomathematics Teaching Materials in Mathematics Learning in Elementary School. *IJORER : International Journal of Recent Educational Research*, *5*(1), 204–218. https://doi.org/10.46245/ijorer.v5i1.542

Yanti, S. (2025). The Role of Ethnomathematics in Enhancing Contextual. *IJHABS: International Journal of Humanity Advance, Business & Sciences*, *2*(4), 321–330. https://doi.org/https://doi.org/10.59971/ijhabs.v2i4.402

Yeung, W.-L., & Ng, O.-L. (2023). Characterizing touchscreen actions in technology-enhanced embodied learning for mathematics instruction in K-12 setting – A systematic review (2010–2023). *Computers & Education*, *205*, 104881. https://doi.org/10.1016/j.compedu.2023.104881

Yuliana, Y., Usodo, B., & Riyadi, R. (2022). The New Way Improve Mathematical Literacy in Elementary School: Ethnomathematics Module with Realistic Mathematics Education. *AL-ISHLAH: Jurnal Pendidikan*, *15*(1), 33–44. https://doi.org/10.35445/alishlah.v15i1.2591

Zainil, M., Helsa, Y., Sutarsih, C., Nisa, S., Sartono, & Suparman. (2024). A needs analysis on the utilization of learning management systems as blended learning media in elementary school. *Journal of Education and E-Learning Research*, *11*(1), 56–65. https://doi.org/10.20448/jeelr.v11i1.5310

Zito, L., Cross, J. L., Brewer, B., Speer, S., Tasota, M., Hamner, E., Johnson, M., Lauwers, T., & Nourbakhsh, I. (2021). Leveraging tangible interfaces in primary school math: Pilot testing of the Owlet math program. *International Journal of Child-Computer Interaction*, *27*, 100222. https://doi.org/10.1016/j.ijcci.2020.100222