Journal on Mathematics Education
Volume 16, No. 3, 2025, pp. 765-782

Translating mathematical representations through cultural contexts: Affective responses of Indonesian preservice teachers

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Received: 21 March 2025 | Revised: 7 August 2025 | Accepted: 11 August 2025 | Published Online: 18 August 2025

Abstract

Research on mathematical representations has predominantly emphasized their cognitive and conceptual benefits; however, limited attention has been given to their emotional dimensions, especially within culturally grounded or ethnomathematical contexts. This gap is critical because emotions play a significant role in shaping preservice teachers' engagement and long-term attitudes toward mathematics. Addressing this issue, the present study introduces a novel perspective by examining how mathematical representations influence the affective responses of prospective primary teachers when tasks are embedded in cultural practices. Employing a mixed-methods design, the study involved 62 preservice teachers who completed a patterning task based on the Javanese *Sedekah Bumi* ceremony, followed by a researcher-developed questionnaire measuring enjoyment. The results reveal that 79.03% of participants successfully translated verbal descriptions into graphical forms, reflecting a strong visual preference, and that flexible use of multiple representations (72.54%) enhanced both conceptual understanding and positive emotional engagement. Conversely, reliance on a single representation was associated with lower confidence and reduced enjoyment. Notably, 19.35% of participants explicitly reported that the integration of cultural elements increased their motivation and interest. These findings highlight the potential of culturally embedded mathematical tasks not only to foster representational fluency but also to enrich the affective domain, offering valuable implications for the design of teacher education curricula that promote both cognitive and emotional development in mathematics learning.

Keywords: Affective Response, Ethnomathematics, Mathematical Representation, Preservice Primary School Teachers, Translation Process

How to Cite: Aprinastuti, C., & Kovács, Z. (2025). Translating mathematical representations through cultural contexts: Affective responses of Indonesian preservice teachers. *Journal on Mathematics Education, 16*(3), 765–782. https://doi.org/10.22342/jme.v16i3.pp765-782

Mathematics learning is shaped by both cognitive and affective dimensions. Silva et al. (2022) highlight the significance of these dimensions in the mathematics teaching–learning process, noting that emotions and feelings can influence learning outcomes. An imbalance between cognitive and affective aspects may contribute to learning difficulties in mathematics. Similarly, Blanco et al. (2013) report that prospective primary teachers often rely on rote problem-solving approaches and lack effective representational tools to analyse problems. Such limitations not only restrict the exploration of alternative strategies but also affect teachers' confidence and emotional engagement with mathematics.

The interplay between affect, identity, and participation is further illuminated by Boaler (2002), who, drawing on Wenger's (1998) theory of communities of practice, argues that "learning is a process of identity formation" (p. 131). From this perspective, students' experiences of belonging within culturally resonant mathematical activities become central to their learning and professional development.

Against this backdrop, the present study investigates how engagement with different mathematical representations influences the emotional responses of preservice primary teachers in Indonesia when solving mathematical problems. The task employed number sequences and incorporated elements of ethnomathematics, thereby providing a cultural dimension. This design enabled us to examine how identity, cultural relevance, and emotional engagement intersect within mathematical activity, consistent with the principles of culturally responsive representation pedagogy (Abdulrahim & Orosco, 2020; Hutchison & McAlister-Shields, 2020; Ladson-Billings, 1995).

Ethnomathematics offers "*a broader view of how mathematics relates to the real world*" (D'Ambrosio, 2001, p. 67), positioning mathematics as an intellectual instrument for describing and interpreting human experience. This perspective challenges the view of mathematics as solely abstract concepts and procedures, instead emphasising its embeddedness within cultural, social, and practical contexts. Across cultures, mathematical ideas and practices have emerged in response to distinct environmental conditions and lived experiences.

Ethnomathematical approaches seek to integrate cultural knowledge and daily practices into mathematics education. Such integration enables students to establish meaningful connections with mathematical concepts, thereby fostering deeper conceptual understanding and sustained engagement. Incorporating these approaches into curricula not only supports intellectual and social development but also enhances students' emotional and political learning by affirming their cultural identities. In this way, mathematics education becomes both academically rigorous and personally relevant (Rosa & Orey, 2011). Research further indicates that cultural practices significantly shape mathematical comprehension and representation, underscoring the importance of ethnomathematics in teacher education (Harding-Dekam, 2007). Developing preservice teachers' awareness of ethnomathematics equips them to implement culturally responsive pedagogies and create inclusive classrooms that respect and integrate diverse cultural perspectives. Such awareness promotes equitable participation in mathematics and empowers students to succeed academically while maintaining strong cultural identities.

Recent scholarship has illustrated how mathematical ideas can be drawn from traditional games, dances, and artistic practices. For example, the Rangku Alu game from Indonesia involves seven distinct numerical patterns generated through player movements and formations (Pangestuti et al., 2024). Similarly, Musawwir et al. (2021) identified number sequences embedded in the spatial arrangements of the Rapa'i Geleng dance from Aceh, while Alghar et al. (2022) demonstrated that Minangkabau carvings on Singok Gonjong exhibit arithmetic sequence patterns applicable to school mathematics instruction. These cases illustrate how cultural artefacts can serve as pedagogical resources for teaching mathematical concepts such as patterns and sequences.

A solid understanding of number sequences contributes significantly to the comprehension of broader mathematical concepts (Pasnak et al., 2016). For prospective primary school teachers, developing a robust conceptual grasp of number sequences is particularly important, as these foundational structures support essential arithmetic skills, pattern recognition, and cognitive development (Griffin, 2009; Olive, 2000), all of which are critical in early mathematics education. Research has shown that engaging with number sequences enables pre-service teachers to establish meaningful connections between additive and multiplicative structures within number systems (Zazkis & Liljedahl, 2002).

Moreover, such engagement fosters logical reasoning and strengthens understanding of mathematical fundamentals (Ferreira, 2024). The role of representations is central in this process. Both Zazkis and Liljedahl (2002) and Ferreira (2024) highlight that the use of multiple representations facilitates connections between additive and multiplicative reasoning, thereby enhancing both cognitive and conceptual development. In addition to these cognitive benefits, embedding number sequence activities within learners' cultural contexts can nurture more positive affective relationships with mathematics (Göbel et al., 2011; Bartolini Bussi, 2018).

These affective dimensions are not peripheral but integral to learning, as they shape how students experience mathematics. Affective theory provides a useful framework for understanding these dimensions, particularly the ways emotions, attitudes, and beliefs influence mathematical engagement. McLeod (1992) identified three key categories of affect—emotions, attitudes, and beliefs—that exert a considerable influence on mathematical learning. Emotions, in turn, are closely related to other affective constructs, including values, motives, social norms, and identity (Hannula, 2020). Such affective responses play a central role in shaping students' mathematical identity, motivation, and sense-making processes (Gómez-Chacón, 2000). Gómez-Chacón (2011) further demonstrated that students' beliefs and emotions regarding mathematics are deeply intertwined with their social identities, influencing how they approach problem-solving tasks. When mathematics is presented in ways that are meaningful and connected to learners' cultural contexts, students are more likely to engage productively with the content. This perspective aligns with Heffernan et al. (2020), who argued that interventions addressing mathematical identity can strengthen students' motivation and commitment to learning mathematics.

In mathematical problem-solving, emotions are multifaceted, encompassing physiological reactions, personal experiences, and expressive behaviours (Hannula, 2020). Emotional responses can exert a strong influence on students' cognitive outcomes, including their performance on mathematical tasks (Batchelor et al., 2019). Recent research has extended this perspective by examining the relationship between mathematical representations and affect. For example, Thorup Eich-Høy (2023) investigated how representations shape affective experiences, particularly the ways emotions and identity are articulated or revealed through interactions with these representations (Batchelor et al., 2019; Skinner & Belmont, 1993).

In mathematics education, the concept of representation is complex, encompassing both external and internal dimensions. External representations refer to observable forms—such as spoken or written language, diagrams, or symbolic notation—while internal representations are mental and cognitive in nature (Pape & Tchoshanov, 2001). A representation becomes meaningful when it maintains a well-interpreted relationship to the underlying mathematical problem. Conventional external representations, such as tables or symbolic expressions, are widely recognised and readily interpretable, whereas pictorial or verbal forms are often more idiosyncratic. Although shaped by personal interpretation, these idiosyncratic forms can still capture and communicate mathematical content, thereby becoming shareable representations. Among internal forms, situational representation is particularly important. By linking abstract mathematical ideas to real-life scenarios, it enables learners to interpret and make sense of mathematical content in personally meaningful ways (Goldin, 2020).

Problem-solving often requires students to translate between different forms of representation. Janvier (1987) described this translation process as involving, for example, sketching (from verbal description to pictorial representation), reading off (from graph to table), or fitting (from table to formula). As illustrated in Table 1, these transformations are not automatic, but demand deliberate cognitive effort.

Students frequently resort to indirect strategies, such as first translating a problem into a familiar form before moving toward the intended target representation (Janvier, 1987).

Table 1. Translation process (Janvier, 1987)

From/To	Situations, Verbal Description	Tables	Graphs	Formulae
Situations, Verbal Description	-	measuring	sketching	modelling
Tables	reading	-	plotting	fitting
Graphs	interpretation	reading off	-	curve fitting
Formulae	parameter recognition	computing	sketching	-

While extensive research highlights the cognitive benefits of engaging with multiple representations (Janvier, 1987; Goldin, 2020), considerably less is known about how such engagement shapes the emotional experiences of preservice teachers. Addressing this gap, and drawing on identity-oriented perspectives of mathematics learning (Wenger, 1998), the present study investigates how Indonesian preservice teachers respond emotionally to a culturally embedded mathematical task involving number sequences and representations. In particular, we focus on the roles of enjoyment and cultural identity during problem-solving, thereby contributing to international discussions on culturally responsive representation pedagogy and its potential to foster inclusive, meaningful, and affective mathematics learning environments.

METHODS

Research Setting

The study involved 62 preservice primary school teachers in Yogyakarta, Indonesia, with an average age of 21. The participants were divided into two groups: 31 students in the first semester and 31 students in the third semester. While no comparative analysis was conducted between the two groups, we note that first-semester students had limited formal exposure to pedagogical strategies, whereas third-semester students had already taken an introductory course in mathematics education. Moreover, first-semester students attended two mathematical courses (mathematical logic and basic algebra), and third-semester students attended two additional subjects (geometry and introduction to analysis). This academic background provides useful context for interpreting participants' commitment to the task. Ethical approval was obtained, and all participants provided informed consent. Data were collected using a mixed-methods approach, combining quantitative and qualitative techniques. Participants completed a task that involved solving a problem using various mathematical representations (e.g., table, pictorial, symbolic). The task integrated the Indonesian cultural context. Especially in Yogyakarta, the ethnomathematics approach offers a rich source of mathematics learning for teacher students because of the region's rich, deeply rooted traditional practices. As pre-service primary school teachers, they should also integrate art and culture in thematic learning, as mentioned in the national curriculum. Particularly in this mathematics lesson task, pre-service primary school teachers are supposed to meet the objectives of recognising patterns, enhancing pattern-recognition abilities, and integrating mathematical ideas. Afterwards, participants completed a questionnaire to assess their affective responses. The questionnaire measured several affective factors, but we focus on task enjoyment and cultural identity in this paper. This mixed-methods design allowed for a nuanced examination of both affective and cognitive responses.

Task Design and Instruments

The task was designed as an instructional activity that incorporated formative assessment elements. Although only one task was used, it required students to engage in multiple cognitive and representational processes. The task elaboration and lesson organisation are as follows:

1. The instructor provides context about the traditional ceremony *Sedekah Bumi* and its meaning
   The *Sedekah Bumi* ceremony is a traditional Javanese ceremony. It is carried out as an expression of gratitude for the harvest. During the ceremony, the community makes mountains of agricultural products. Figure 1 is an illustrative example of the *Sedekah Bumi* ceremony using durian fruit.

Figure 1. The *Sedekah Bumi* traditional ceremony

2. The participants and instructor discussed that the mountain shape of fruits may contain potential number patterns. Moreover, they agreed on the following model of the situation.
   To make a mountain of fruit, you need wooden sticks to attach the fruits to. This wooden stick will connect the fruit from both sides of the mountain. One can construct the fruit mountain by following rules: (1) There is only one fruit placed at the top of the mountain, (2) In the second layer, four fruits and two sticks are needed to attach the fruit from both sides of the mountain, (3) In the next layer, the fruit should fill the space with twice the number of sticks used in the previous layer. This pattern will be followed in the next layer using the previous pattern.
3. The instructor provides students with coloured label stickers, which they can use to depict the fruit scheme.
4. Students complete a pre-prepared worksheet that includes the following tasks: (a) Based on the previous rules, make a schematic pattern of the layers of fruit! (b) Determine the general term that shows the number of fruits for the nth layer.
5. Participants completed a questionnaire about the activity. This questionnaire included open questions for reflecting on the activity and 12 four-point Likert scale questions, four related to enjoyment.

The photo provided in the worksheet functioned as a situational representation. “Some texts (e.g., literary texts) are studied in their own right; other texts are merely media by which information is transmitted,” writes Kintsch (1986, p.87). In our case, a photograph plays the role that Kintsch assigns to a text. However, the analogy between the two situations is clear: In this case, the picture, which also has an autonomous meaning for the students, becomes the carrier of a mathematical construct, a number sequence. Kintsch calls this a situation model. The photograph is also a situational representation of a number sequence. However, the picture also carries an easily interpretable meaning for the participants, which they discuss in a group at the start of the session. This idiosyncratic verbal representation provides an internal representation of the later formulated mathematical problem. In short, the photo is a presented representation in a sense by Cox (1999) that, through personal memories and classroom discussion, helps externalise the mathematical meaning. This image was not merely decorative but served as a cognitive bridge that grounded abstraction in a meaningful context (Radford, 2008).

During the task, the students’ performance was assessed in several aspects, but in this paper, we will limit ourselves to the students’ use of different representations. A total of four points could be attained in this area, up to two points for the graphical representation (the total of two points are awarded if both the number of fruits and the number of bars are correct in the graph; if only one of them is accurate, the student gets one point); a further one point is awarded for a correctly filled-in table, and finally, one point for the symbolic formulation of the result. The students rated their enjoyment of the activity on a 4-point Likert scale questionnaire of 4 questions. The enjoyment scale is part of a larger instrument that was developed by the authors and grounded in affective research literature (Batchelor et al., 2019; McLeod, 1992). Items were context-specific, targeting emotional responses to the culturally contextualised mathematics task.

1. How much did you enjoy understanding and creating number patterns using the media and the worksheet provided during the lessons? (Scale: 1 = strongly not enjoy, 2 = somewhat not enjoy, 3 = somewhat enjoy, 4 = strongly enjoy)
2. Do you enjoy the integration of mathematics tasks (and ethnomathematics), which helps you better understand the concept of number patterns? (Scale: 1 = strongly not enjoy, 2 = somewhat not enjoy, 3 = somewhat enjoy, 4 = strongly enjoy)
3. How does this learning approach help you enjoy sharpening your problem-solving skills? (Scale: 1 = strongly not helpful, 2 = somewhat not helpful, 3 = somewhat helpful, 4 = strongly helpful)
4. To what extent do you feel confident applying and explaining the concept of number patterns after participating in this activity? (Scale: 1 = strongly not confident, 2 = somewhat not confident, 3 = somewhat confident, 4 = strongly confident)

The construct validity was checked by exploratory factor analysis (KMO = .73) and a parallel-analysis scree test supported a single factor, with all four items loading strongly (with factor loadings between .625 and .788). The scale showed acceptable internal consistency (Cronbach’s α = .792; average Inter Item Correlation r = .494), confirming that the four Likert items form a reliable, unidimensional measure. The scale’s mean and standard deviation were 2.895 and 0.435, respectively. Content validity was supported by adapting items from prior studies on affective engagement in culturally responsive mathematics education (e.g., Batchelor et al., 2019), and through expert review by mathematics educators familiar with ethnomathematics at Yogyakarta. Qualitative responses were gathered through open-ended reflection questions in the post-task questionnaire and classroom discussions. These were analysed using thematic coding focused on affective dimensions such as enjoyment and cultural identity. Representative quotes were selected to illustrate each theme.

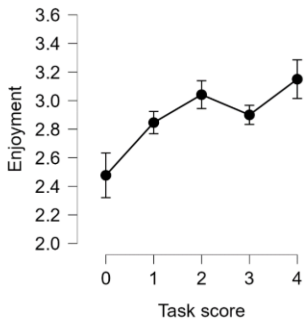
RESULTS AND DISCUSSION

Performance in the Translation Process and Affective Response with Cultural Reference

Our primary finding reveals a strong association between students' success in using mathematical representations and their enjoyment of the task. This relationship was examined using ANOVA, which indicated that task performance had a significant effect on affect scores ($F(4,57) = 4.963$, $p = 0.002$, $\eta^2 = 0.258$). Higher task performance was consistently associated with more positive affect, suggesting that proficiency in translating among representations enhances emotional engagement presented in Table 2.

Table 2. Enjoyment and task performance

Task Score	N	Enjoyment Mean score	SE
0	11	2.477	0.156
1	13	2.846	0.078
2	18	3.042	0.097
3	10	2.900	0.067
4	10	3.150	0.135



As shown in Table 2, students with higher task scores reported more positive emotions, indicating that representational fluency predicts enhanced affective responses during problem-solving. This finding is consistent with the success rates observed in the translation process summarized in Table 3.

Table 3. Translation process success rate

Translation Process			Total of students	Percentage	Technique
Phase 1	Phase 2	Phase 3			
sketching	-	-	14	22.58%	uni-representation
measuring	-	-	1	1.61%	uni-representation
sketching	curve fitting	-	4	6.45%	multi-representation
sketching	curve fitting	computing	4	6.45%	multi-representation
sketching	reading off	-	3	4.84%	multi-representation
sketching	reading off	fitting	9	14.52%	multi-representation
sketching	reading off	reading	1	1.61%	multi-representation
sketching	interpretation	-	5	8.06%	multi-representation
sketching	interpretation	modelling	9	14.52%	multi-representation
measuring	plotting	curve fitting	2	3.23%	multi-representation
measuring	plotting	interpretation	2	3.23%	multi-representation
measuring	plotting	-	8	12.90%	multi-representation
		Total	**62**	**100%**	

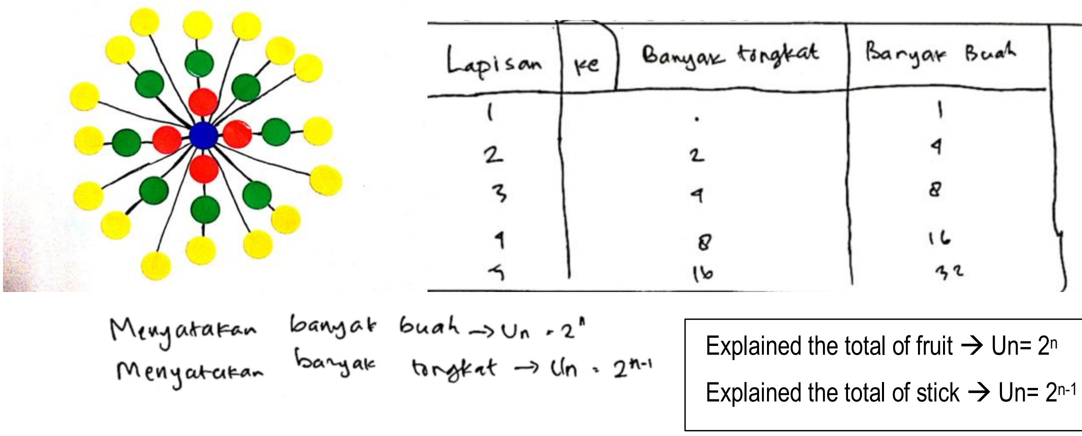
Analysis of Table 3 indicates that the highest success rates occurred in sketching tasks, i.e., translating from verbal description or situational contexts to graphical representations (49 students, 79.03%). This finding contrasts with Nurrahmawati et al. (2021), who reported that students often struggle when transitioning from symbolic to verbal or graphical representations. In the present study, the higher success rates in concrete translations suggest that students prefer to engage with graphical representations before moving toward more abstract forms, a pattern consistent with Koedinger and Terao (2019), who found that pictorial representations support sense-making and cue appropriate computational strategies.

Conversely, the lowest success rates were observed in measuring and reading-off tasks (1.61%), highlighting the cognitive challenges posed by symbolic representations, which require abstract reasoning. Translating symbolic concepts into more concrete forms such as graphs or tables enhanced clarity and reduced cognitive load. This aligns with Rosyidin and Rosyidi (2022), who identified difficulties in interpreting symbolic representations and structuring keywords as key barriers to successful translation. Collectively, these findings underscore the importance of developing instructional strategies that scaffold students' ability to bridge abstract symbols and intuitive visual formats, thereby improving comprehension, representational fluency, and success rates in mathematical problem-solving tasks.

Translation between representations fosters a tangible sense of achievement, as successfully converting verbal descriptions into graphs, tables, or formulas provides students with direct confirmation of their understanding. In particular, tasks incorporating culturally familiar elements—such as traditional Indonesian patterns or local fruits—were associated with higher engagement and greater accuracy in the translation process. Although the success rate for sketching was high (79.03%), only 50% of students in this group successfully derived a formula representation. This pattern reflects affective responses: students reported feeling comfortable and enjoying the cultural context embedded in the tasks. These results align with Webb et al. (1990), who argue that the use of diverse representation types can enhance both cognitive and emotional outcomes in mathematics learning.

To illustrate these findings, four students were selected based on the pictorial representations they produced and the corresponding affective responses. Pictorial representation was emphasized because it is the most idiosyncratic form of external representation, reflecting personal interpretation and understanding.

Firstly, in the case of student S5 as shown in Figure 2, the translation process involved three steps: sketching (from verbal description to picture), reading off (from picture to table), and fitting (from table to formula). S5's work included multiple representations, achieving a task score of 4. The figure produced has the same number of layers as the table, suggesting a strong correspondence between these two representation forms. Although the formula construction cannot be fully traced from the output, the numerical sequence (from the second element onward) derived from empirical experience is easily identifiable. In this case, S5 demonstrates proficiency in visual pattern recognition, sequence comprehension, and understanding of growth patterns.



Explained the total of fruit → $U_n = 2^n$
Explained the total of stick → $U_n = 2^{n-1}$

Figure 2. External representations created by S5

S5 reported an enjoyment score of 2.67 out of 4. In their reflection, the student emphasized that the cultural context enhanced their enthusiasm: "The interesting thing is that when I learn mathematics in relation to culture, it makes me enthusiastic." This positive emotional engagement likely supports sustained attention and motivation in mathematics learning. These observations are consistent with Agup and Agup (2020), who note that integrating local cultural elements, religious values, and real-world applications can render mathematics more meaningful and engaging for learners.

Secondly, in the case of student S32 as shown in Figure 3, the translation process involved two steps: measuring (from verbal description to table) and plotting (from table to picture). S32 produced multi-representational outputs, achieving a task score of 2, but did not generate a formula. Unlike S5's graph, S32's representation depicts fruit without sticks, and while the table shows data up to the fourth layer, the graph only includes the third layer. This suggests that S32 inferred the pattern from the table after translating the verbal descriptions but did not fully complete the second representation. Consequently, S32 demonstrated competency in visual pattern recognition and sequence comprehension, yet their ability in pattern generalization remains underdeveloped.

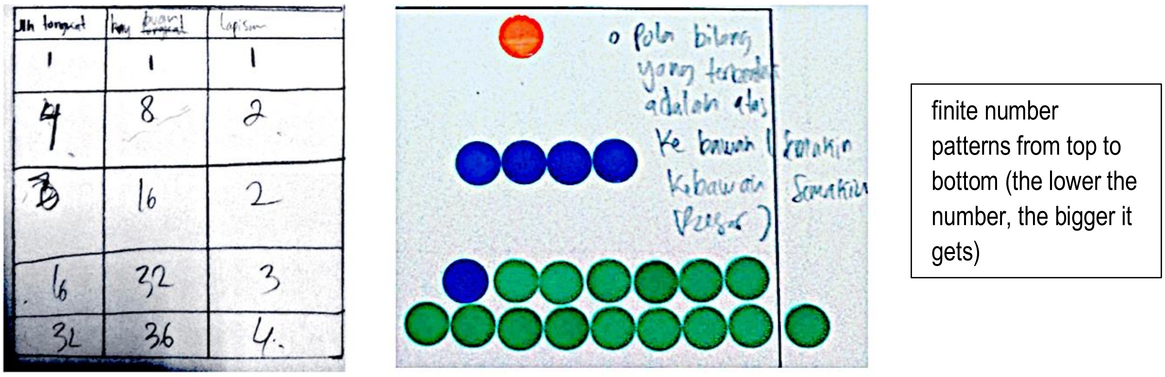
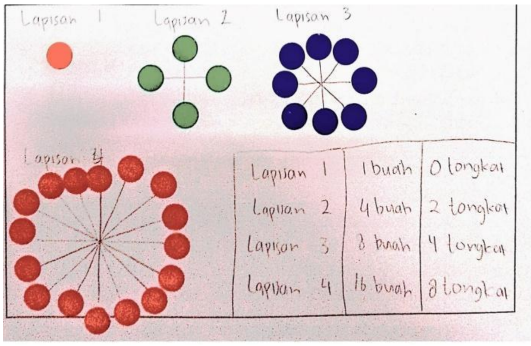


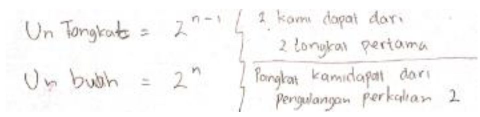
Figure 3. External representations created by S32

In terms of affective response, S32 reported an average enjoyment score of 3 out of 4. The student reflected: "*It's exciting because we learn about ethnomathematics (mathematics and culture), recognise number patterns in shapes and layers, and create patterns using schemes. This task helps us understand patterns and explore creativity in forming patterns for each shape*." These remarks indicate that engagement with culturally embedded tasks can stimulate both excitement and interest in exploring mathematical structures.

Thirdly, student S40 produced a graph for each layer, resulting in a structured and highly personalized pictorial representation presented in Figure 4. S40's work included multiple representations, achieving a task score of 4. The student demonstrated a strong understanding of visual pattern identification, sequence comprehension, and growth pattern recognition.

S40's affective response was similarly positive, with an enjoyment score of 3 out of 4. The student noted: "*[I liked] creating patterns with colourful stickers and tables to understand how culture is connected to mathematics*." For S40, mathematical representations provided a structured and visual method for linking cultural patterns to mathematical concepts, highlighting how mathematics can serve as a systematic medium for communicating ideas across cultures and time (Wood, 2000).





Un stick = 2^{n-1} 2 we get it from 2 first stick
Un fruit = 2^n We get the power from repeating the multiplication of 2

Figure 4. External representations created by S40

The final case involves student S49 as shown in Figure 5. The translation process for S49 included three steps: sketching (from verbal description to graph), interpretation (from graph to verbal description), and modelling (from verbal description to formulas). Although S49 achieved a task score of 2, the student produced multi-representational outputs. Compared with previous students, S49's representation of fruits was more abstract, as it did not preserve the geometric layout of the photographed situation but accurately reflected the underlying mathematical relationships. Specifically, the student recognised the rule of doubling the number of fruits. While the symbolic translation was essentially correct, it would benefit from additional explanation (the rule applies if the second layer of fruits is considered the first member of the sequence). This case illustrates that students can demonstrate visual pattern recognition, sequence comprehension, and growth pattern understanding even when representation is limited.

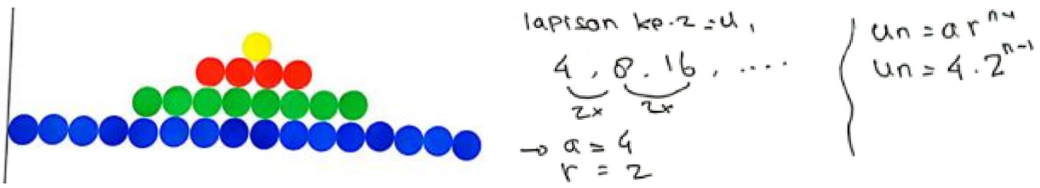


Figure 5. External representations made by S49

In terms of affective response, S49 reported an enjoyment score of 3 out of 4. The student reflected: "*[I liked] combining culture, mountain examples into mathematical material*," highlighting the value of integrating real-world and culturally relevant contexts into mathematics learning. This observation aligns with De Abreu and Cline (2003), who emphasised that formal mathematics practices are socially situated and can influence the development of learners' cultural identities.

Overall, the translation process appears to foster both cognitive clarity and emotional engagement. These findings support affective frameworks proposed by McLeod (1992) and Hannula (2020), which underscore the importance of emotion and identity in shaping mathematical learning. Moreover, as Turner and Drake (2016) emphasise, prospective teachers' understanding of children's thinking must incorporate awareness of cultural and emotional influences—an aspect central to the present study.

Translation Processes in Mathematical Representation with Cultural Contexts

The findings of this study indicate that students' translation processes typically begin with the provided cultural context, followed by the use of graphical, tabular, or combined representations to model the problem illustrated in Figure 6. Students who effectively utilise these representations while engaging with the cultural context are more likely to progress to formulaic representations. As demonstrated in the case studies, some students also articulated reflections on the cultural context through verbal descriptions, highlighting the interconnectedness of cultural understanding, representational fluency, and affective engagement in the translation process. The diagram in Figure 6 illustrates this progression, emphasising how cultural context, graphical and tabular representations, and affective responses collectively contribute to successful translation and positive emotional engagement.

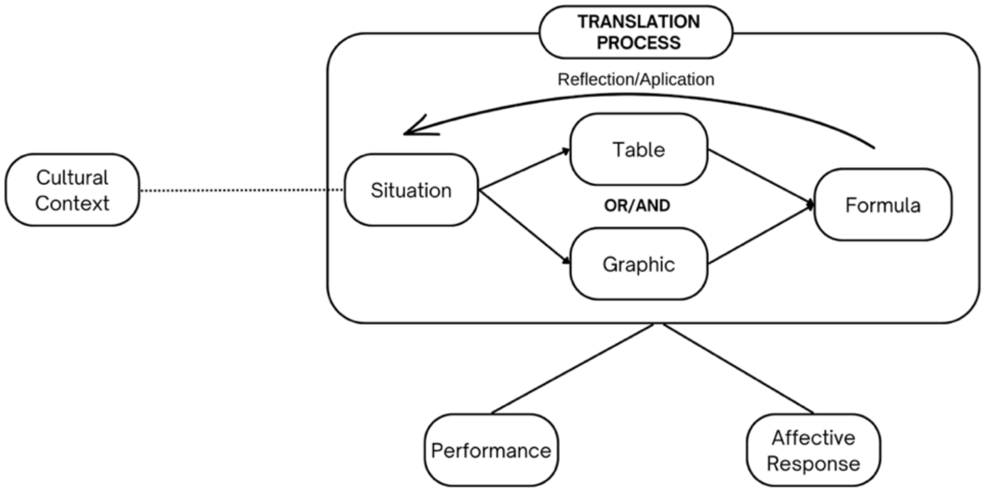


Figure 6. Translation process in mathematical representation with cultural context

Analysis of task performance and affective response revealed that higher performance is associated with greater enjoyment, indicating that proficiency in translating among representations predicts more positive emotional experiences. The case studies further demonstrate the benefits of culturally relevant tasks, such as those incorporating traditional Indonesian patterns, in supporting student engagement and conceptual understanding. For instance, S5 and S40 explicitly expressed enthusiasm for connecting cultural elements to mathematical concepts, underscoring the pedagogical value of integrating real-world contexts into mathematics learning.

These findings highlight the need for instructional strategies that facilitate the transition from concrete to abstract representations, thereby reducing cognitive load and enhancing comprehension. Figure 6 provides a conceptual framework for understanding the factors influencing both student success and engagement in the translation process, illustrating the dynamic interplay between cultural context, representational fluency, and affective response.

The Emotional Impact of Translation in Mathematical Representations

The findings indicate that effective use of multiple representations is closely associated with positive emotional responses, suggesting that the translation process plays a critical role in students' engagement with mathematical tasks. The act of translating between representations fosters emotional engagement by promoting a sense of achievement and reducing cognitive overload. When students successfully navigate among different forms—such as verbal descriptions, graphs, tables, and formulas—they demonstrate a clearer understanding of mathematical concepts presented in Table 4.

Analysis of student work revealed two distinct approaches to mathematical representation. The multi-representational technique, observed in 75.81% of students, enabled successful navigation across two or more representations. These students effectively translated between verbal, graphical, tabular, and formulaic forms, frequently establishing coherent links among diverse representations. Their work demonstrated a systematic progression from concrete to abstract representations and reflected a comprehensive understanding of the relationships among different forms.

Table 4. Representational technique (%)

Representational technique	Percentage	Flexibility
multi-representational	75.81%	multiple translations (more than one representation)
uni-representational	24.19%	single dominant or limited use of representations

By contrast, 24.19% of students employed a uni-representational technique, relying primarily on a single type of representation. While these students often demonstrated strong understanding within their preferred format, their ability to translate across multiple representations was limited. However, it is noteworthy that some students achieved substantial depth of understanding within their chosen representation, indicating that restricted representational use does not necessarily imply limited mathematical competence (Mustangin et al., 2020).

Students' proficiency in transitioning between multiple representations was strongly linked to both mathematical confidence and engagement. Those with multi-representational fluency not only performed better but also reported higher levels of enjoyment, suggesting that the ability to translate effectively fosters deeper conceptual understanding and greater emotional investment in learning. In contrast, students relying on a single dominant representation demonstrated a more constrained approach to problem-solving, which may limit engagement with more abstract mathematical reasoning.

These findings are consistent with previous research. Zulianto and Budiarto (2020) reported that students often struggle with symbolic-to-visual translations, highlighting the importance of instructional strategies that strengthen multi-representational thinking. Similarly, Mariyam et al. (2023) demonstrated that a multi-ethnic cultural learning model improved students' ability to translate mathematical representations, reinforcing the notion that translation serves as both a cognitive and affective bridge in mathematics education.

Cultural Context as an Emotional Catalyst in the Translation Process

Cultural context plays a significant role in shaping students' learning during mathematical translation processes. Student reflections indicated that 19.35% of participants explicitly attributed their enjoyment of mathematics tasks to the integration of cultural elements, suggesting that cultural relevance serves as a motivational scaffold for learning. When tasks were embedded in familiar cultural contexts, students demonstrated stronger connections to mathematical concepts, highlighting the role of culturally responsive materials in facilitating comprehension. Cultural components provided multiple access points for engaging with mathematical topics, enabling students to navigate diverse learning pathways. Importantly, students reported enjoyment while engaging with challenging mathematical tasks, regardless of their preferred representational style. These findings suggest that cultural context mediates the understanding of abstract mathematical concepts, supporting both cognitive and affective dimensions of learning (Schliemann, 2002; Rosa & Orey, 2011; Madusise, 2015).

The integration of cultural context in mathematical translation not only enhances comprehension but also strengthens engagement. In this study, 19.35% of students explicitly reported that cultural integration increased their enjoyment of mathematical tasks, reinforcing prior research on culturally responsive pedagogy. For example, García (2014) found that students performed better when mathematical problems were contextualised within their indigenous cultural settings, demonstrating that familiarity with real-world applications supports translation between representations. Similarly, Mariyam et al. (2023) observed that students exposed to a multi-ethnic culture-based learning model showed improved translation abilities, indicating that cultural familiarity fosters an emotional connection to mathematical problem-solving. These findings align with broader research suggesting that when mathematical representations are grounded in students' lived experiences, learners exhibit greater engagement, confidence, and motivation.

CONCLUSION

This study presents key findings regarding students' abilities in mathematical representation and their affective responses to culturally contextualised mathematics tasks. Results indicate that students performed more effectively with concrete translations, particularly when converting verbal descriptions into graphical representations, whereas abstract representations and algebraic translations posed greater challenges. Notably, 72.54% of students employed multi-representational strategies, successfully navigating across multiple forms of representation. A strong positive association was observed between task performance and enjoyment, suggesting that proficiency in mathematical problem-solving enhances student engagement. Additionally, cultural integration emerged as a significant factor, with 19.35% of students reporting a positive impact on enjoyment, highlighting that culturally relevant contexts promote deeper understanding and active involvement.

These findings have several pedagogical implications for culturally responsive mathematics education. This approach requires selecting cultural contexts that are relevant to the mathematical content, while providing opportunities for representational flexibility and maintaining mathematical rigor. Within teacher education programs, tasks of this nature prepare preservice teachers to design lessons that incorporate cultural contexts and draw on students' personal and community experiences. In practice, this strategy may improve students' conceptual understanding and foster more positive attitudes toward learning. Curriculum developers should consider embedding culturally responsive materials, particularly in early mathematics education. At the classroom level, educators can create inclusive learning environments by encouraging students to express mathematical ideas through diverse representational forms. While this study focused on the Indonesian context, similar principles apply globally, as every cultural setting offers values and experiences that can enhance cognitive and affective learning in mathematics.

This study has several limitations. First, potential confounding variables were not fully controlled, including participants' prior exposure to ethnomathematical tasks, familiarity with different types of mathematical representations, and variability in instructor delivery. Although efforts were made to standardize instructions, these factors may have influenced both affective responses and task performance. Second, the sample size and specific cultural context may limit the generalizability of the findings. Third, the study focused primarily on short-term outcomes, leaving the long-term effects of culturally integrated instruction unexplored. Future research should address these limitations by conducting longitudinal studies, examining cross-cultural contexts, investigating strategies to enhance students' representational flexibility, and exploring teacher beliefs and instructional implementation in culturally responsive mathematics education.

Acknowledgements

This study was funded by the Research Program for Public Education Development of the Hungarian Academy of Sciences (KOZOKT 2021-16) and the Sanata Dharma Foundation.

Declarations

Author Contribution	:	CA: Conceptualization, Data Curation, Investigation, Resources, Writing - Original Draft, Editing and Visualization. ZK: Formal Analysis, Writing - Review & Editing, Formal Analysis, Funding Acquisition, Project Administration, Methodology, Validation and Supervision.
Funding Statement	:	This study was funded by the Research Program for Public Education Development of the Hungarian Academy of Sciences (KOZOKT 2021-16), by University of Debrecen and the Sanata Dharma Foundation.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is not available for this paper

REFERENCES

Abdulrahim, N. A., & Orosco, M. J. (2020). Culturally responsive mathematics teaching: A research synthesis. *Urban Review*, *52*(1), 1-25. https://doi.org/10.1007/s11256-019-00509-2

Agup, R. M., & Agup, R. S. (2020). In math, culture also counts: A case study on the integration of Ilokano culture in teaching mathematics. *Asian Journal of Education and Human Development (AJEHD)*, *1*(1), 1–8. https://doi.org/10.69566/ajehd.v1i1.2

Alghar, M. Z., Susanti, E., & Marhayati, M. (2022). Ethnomathematics: Arithmetic sequence patterns of Minangkabau carving on Singok Gonjong. *Jurnal Pendidikan Matematika (JUPITEK), 5*(2), 145–152. https://doi.org/10.30598/jupitekvol5iss2pp145-152

Bartolini Bussi, M. G., Inprasitha, M., Arzarello, F., Bass, H., Kortenkamp, U., Ladel, S., Lajoie, C., Ni, Y., Rottmann, T., Sarungi, V., Soury-Lavergne, S., & Young-Loveridge, J. (2018). Aspects that affect whole number learning: Cultural artefacts and mathematical tasks. In M. G. Bartolini Bussi & X. H. Sun (Eds.), *Building the Foundation: Whole Numbers in the Primary Grades: The 23rd ICMI Study* (pp. 181–226). Springer International Publishing. https://doi.org/10.1007/978-3-319-63555-2_9

Batchelor, S., Torbeyns, J., & Verschaffel, L. (2019). Affect and mathematics in young children: An introduction. *Educational Studies in Mathematics*, *100*(3), 201–209. https://doi.org/10.1007/s10649-018-9864-x

Blanco, L. J., Barona, E. G., & Carrasco, A. C. (2013). Cognition and affect in mathematics problem solving with prospective teachers. *Mathematics Enthusiast*, *10*(1–2), 335–364. https://doi.org/10.54870/1551-3440.1270

Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches to teaching and their impact on student learning (Revised & expanded ed.)*. In Studies in mathematical thinking and learning. Routledge. https://doi.org/https://doi.org/10.4324/9781410606365

Cox, R. (1999). Representation construction, externalised cognition and individual differences. *Learning and Instruction*, *9*(4), 343–363. https://doi.org/10.1016/S0959-4752(98)00051-6

D'Ambrosio, U. (2001). *General remarks on Ethnomathematics*. *ZDM, 33*(3), 67–69. https://doi.org/10.1007/BF02655696

De Abreu, G., & Cline, T. (2003). Schooled mathematics and cultural knowledge. *Pedagogy, Culture and Society*, *11*(1), 11–30. https://doi.org/10.1080/14681360300200158

Ferreira. (2024). The importance of teaching mathematical number sequences: Strategies and approaches. *RCMOS-Revista Científica Multidisciplinar O Saber*, *1*(1), 1–6. https://doi.org/http://lattes.cnpq.br/8081351926653339

García, J. G. (2014). El contexto cultural y la resolución de problemas: Vistos desde el salón de clases de una comunidad Ñuu Savi. *Revista Latinoamericana de Etnomatemática*, *7*(1), 50–73. https://revista.etnomatematica.org/index.php/RevLatEm/article/view/105/313

Göbel, S. M., Shaki, S., & Fischer, M. H. (2011). Cultural effects on the mental number line. *Journal of Cross-Cultural Psychology*, *42*(4), 541–542. https://doi.org/10.1177/0022022111406019

Goldin, G. A. (2020). *Mathematical representations*. In Encyclopedia of Mathematics Education (pp. 409–413). Springer, Cham. https://doi.org/10.1007/978-94-007-4978-8_103

Gómez-Chacón, I. M. (2000). Affective influences in the knowledge of mathematics. *Educational Studies in Mathematics*, 43(2), 149–168. https://doi.org/10.1023/A:1017518812079

Gómez- Chacón, I. M. (2011). Beliefs and strategies of identity in mathematical learning. Current State of Research on Mathematical Beliefs. *XVII Proceedings of the MAVI-17 Conference*.

Griffin, S. (2009). Learning sequences in the acquisition of mathematical knowledge: Using cognitive developmental theory to inform curriculum design for pre-k–6 mathematics education. *Mind, Brain, and Education, 3*(2), 96-107. https://doi.org/10.1111/j.1751-228X.2009.01060.x

Hannula, M. S. (2020). *Affect in mathematics education*. In Encyclopedia of Mathematics Education (pp. 23–27). Springer. https://doi.org/10.1007/978-94-007-4978-8_174

Harding-Dekam, J. L. (2007). Foundations in ethnomathematics for prospective elementary teachers. *The Journal of Mathematics and Culture*, *2*(1), 1-19. https://journalofmathematicsandculture.wordpress.com/wp-content/uploads/2016/05/ethnomath-and-preservice-harding-final-v12.pdf

Heffernan, K., Peterson, S., Kaplan, A., & Newton, K. J. (2020). Intervening in student identity in mathematics education: An attempt to increase motivation to learn mathematics. *International Electronic Journal of Mathematics Education*, *15*(3), em0597. https://doi.org/10.29333/iejme/8326

Hutchison, L., & McAlister-Shields, L. (2020). Culturally responsive teaching: Its application in higher education environments. *Education Sciences*, *10*(5), 124. https://doi.org/10.3390/educsci10050124

Janvier, C. (1987). *Problems of representation in the teaching and learning of mathematics*. Lawrence Erlbaum Associates.

Kintsch, W. (1986). Learning from text. *Cognition and Instruction, 3*(2), 87-108. https://doi.org/10.1207/s1532690xci0302_1

Koedinger, K. R., & Terao, A. (2019). A cognitive task analysis of using pictures to support pre-algebraic reasoning. In *Proceedings of the twenty-fourth annual conference of the Cognitive Science Society* (pp. 542-547). Routledge. https://doi.org/10.4324/9781315782379

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, *32*(3), 465-491. https://doi.org/10.3102/00028312032003465

Madusise, S. (2015). Cultural villages as contexts for mediating culture and mathematics education in the South African curriculum. *Revista Latinoamericana de Etnomatemática Perspectivas Socioculturales de la Educación Matemática,* *8*(2), 11-31. http://www.redalyc.org/articulo.oa?id=274041586002

Mariyam, Wahyuni, R., Nindy Citroresmi, P., Husna, N., Yani, A., Masriani, & Mursidi, A. (2023). Model concept sentence learning based on multiethnic daycare to facilitate the translation ability mathematical representations of junior high school students. In *International Workshop on Learning Technology for Education Challenges* (pp. 93-106). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-34754-2_8

McLeod, D. B. (1992). *Research on affect in mathematics education: A reconceptualization. In Handbook of Research on Mathematics Teaching and Learning* (pp. 575–596). Macmillan Publishing Company. https://peterliljedahl.com/wp-content/uploads/Affect-McLeod.pdf

Musawwir, A., Suryadi, D., & Kusnandi. (2021). The exploration of ethnomathematics based on Rapa'i Geleng dance as mathematics learning media. *Journal of Physics: Conference Series*, *1882*(1), 012046. https://doi.org/10.1088/1742-6596/1882/1/012046

Mustangin, M., Suwarsono, S., & Lukito, A. (2020). The representation of students' mathematical concepts in algebraic problems solving based on mathematical ability. *International Journal of Trends in Mathematics Education Research*, *3*(2), 117–121. https://doi.org/https://doi.org/10.33122/ijtmer.v3i2.151

Nurrahmawati, Sa'dijah, C., Sudirman, & Muksar, M. (2021). Assessing students' errors in mathematical translation: From symbolic to verbal and graphic representations. *International Journal of Evaluation and Research in Education*, *10*(1), 115–125. https://doi.org/10.11591/ijere.v10i1.20819

Olive, J. (2000). Children's number sequences: An explanation of Steffe's constructs and an extrapolation to rational numbers of arithmetic. *The Mathematics Educator*, *11*, 4–9. https://www.researchgate.net/publication/242298873

Pangestuti, S., Prahmana, R. C. I., & Fran, F. A. (2024). Unlocking mathematical marvels: Exploring number patterns in the Rangku Alu traditional game. *Jurnal Elemen*, *10*(2), 441–458. https://doi.org/10.29408/jel.v10i2.25621

Pape, S. J., & Tchoshanov, M. A. (2001). The role of representation(s) in developing mathematical understanding. *Theory into Practice*, *40*(2), 118–127. https://doi.org/10.1207/s15430421tip4002_6

Pasnak, R., Schmerold, K. L., Robinson, M. F., Gadzichowski, K. M., Bock, A. M., O'Brien, S. E., Kidd, J. K., & Gallington, D. A. (2016). Understanding number sequences leads to understanding mathematics concepts. *Journal of Educational Research*, *109*(6), 640–646. https://doi.org/10.1080/00220671.2015.1020911

Radford, L. (2008). Iconicity and contraction: A semiotic investigation of forms of algebraic generalizations of patterns in different contexts. *ZDM - International Journal on Mathematics Education*, *40*(1), 83-96. https://doi.org/10.1007/s11858-007-0061-0

Rosa, M., & Orey, D. C. (2011). Ethnomathematics: the cultural aspects of mathematics. *Revista Latinoamericana de Etnomatemática Perspectivas Socioculturales de La Educación Matemática, 4*(2), 32-54. https://www.revista.etnomatematica.org/index.php/RevLatEm/article/view/32/378

Rosyidin, M. A., & Rosyidi, A. H. (2022). Translation failure from verbal to symbolic representations on contextual mathematics problems: Female vs male. *Jurnal Riset Pendidikan dan Inovasi Pembelajaran Matematika, 5*(2), 117-141. https://doi.org/10.26740/jrpipm.v5n2.p117-141

Schliemann, A. D. (2002). Representational tools and mathematical understanding. *Journal of the Learning Sciences, 11*(2-3), 301-317. https://doi.org/10.1080/10508406.2002.9672141

Silva, M. C. A. L., Silva, J. A. da, & Souza, R. M. de A. (2022). The construction of the mathematics teaching process in an affective approach. *International Journal of Human Sciences Research*, *2*(39), 2–11. https://doi.org/10.22533/at.ed.5582392215122

Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology*, *85*(4), 571–581. https://doi.org/10.1037/0022-0663.85.4.571

Thorup Eich-Høy, A. (2023). “I have never encountered an exercise as confusing as this one”: Mathematical representations and affect in an urban escape booklet. *Proceedings of the Thirteenth Congress of the European Society for Research in Mathematics Education (CERME13*. https://doi.org/10.4135/9781071802755

Turner, E. E., & Drake, C. (2016). A review of research on prospective teachers’ learning about children’s mathematical thinking and cultural funds of knowledge. *Journal of Teacher Education*, *67*(1), 32-46. https://doi.org/10.1177/0022487115597476

Webb, N. M., Gold, K., & Qi, S. (1990). *Mathematical problem-solving processes and performance: Translation among symbolic representations*. UCLA Center for Research on Evaluation. https://files.eric.ed.gov/fulltext/ED344748.pdf

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Wood, L. N. (2000). Communicating mathematics across culture and time. In *Mathematics cross cultures: The history of non-western mathematics* (pp. 1-12). Springer Netherlands. https://doi.org/10.1007/978-94-011-4301-1_1

Zazkis, R., & Liljedahl, P. (2002). Arithmetic sequence as a bridge between conceptual fields. *Canadian Journal of Science, Mathematics and Technology Education, 2*(1), 91–118. https://doi.org/10.1080/14926150209556501

Zulianto, R., & Budiarto, M. T. (2020). Kemampuan translasi representasi matematis siswa kelas VIII SMP dalam menyelesaikan soal kontekstual [The ability to translate mathematical representations of grade VIII junior high school students in solving contextual problems]. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *5*(2), 313–327. http://dx.doi.org/10.30998/jkpm.v5i2.6442