Journal on Mathematics Education
Volume 16, No. 2, 2025, pp. 671-688

Integrating technology, Javanese ethnomathematics, and realistic mathematics education in supporting prospective mathematics teachers' numeracy skills: A learning trajectory

Farida Nursyahidah, Wardono*, Scolastika Mariani, Kristina Wijayanti

Mathematics Education Department, Universitas Negeri Semarang, Semarang, Indonesia
*Correspondence: wardono@mail.unnes.ac.id

Received: 30 November 2024 | Revised: 10 July 2025 | Accepted: 13 July 2025 | Published Online: 17 July 2025

Abstract

In the era of the 21st century and Industrial Revolution 4.0, prospective mathematics teachers (PMTs) are expected not only to possess strong mathematical content knowledge but also to develop pedagogical approaches that promote students' numeracy skills in meaningful and contextually relevant ways. However, despite growing global attention to numeracy, there remains a gap in instructional models that effectively integrate local cultural contexts and technological tools in the preparation of PMTs. Addressing this gap, this study introduces a novel learning trajectory that embeds technology, Javanese ethnomathematics, and Realistic Mathematics Education into a coherent instructional design framework, namely TE-RME aimed at enhancing PMTs' numeracy competencies. The research employed a design research methodology encompassing three iterative stages: preliminary design, design experiments consisting of a pilot and teaching experiment, and retrospective analysis. The participants were 25 fifth-semester PMTs enrolled at a private university in Semarang, Indonesia. The resulting trajectory comprises five learning activities, such as orientation to cultural contexts, exploration and problem-solving of numeracy tasks, task design involving numeracy elements, communication and interpretation of mathematical solutions, and instructional design involving the integration of numeracy tasks. Findings revealed that the TE-RME approach effectively supported PMTs in making meaningful connections between culturally embedded practices and everyday mathematical reasoning. By engaging with authentic local contexts, students demonstrated increased fluency in solving numeracy problems and designing contextually relevant learning activities. This research contributes a culturally responsive instructional model for mathematics teacher education and underscores the pedagogical potential of integrating local wisdom with contemporary mathematics education approaches. Implications point to further research exploring other ethnomathematical contexts to enrich mathematics instruction and promote equitable and culturally grounded mathematics learning.

Keywords: Design Research, Instructional Design, Numeracy, Prospective Mathematics Teacher, Techno-Ethno-Realistic Mathematics Education

How to Cite: Nursyahidah, F., Wardono, Mariani, S., & Wijayanti, K. (2025). Integrating technology, Javanese ethnomathematics, and realistic mathematics education in supporting prospective mathematics teachers' numeracy skills: A learning trajectory. *Journal on Mathematics Education, 16*(2), 671–688. https://doi.org/10.22342/jme.v16i2.pp671-688

Numeracy refers to an individual's capacity to comprehend, utilize, and interpret numbers and mathematical operations across a variety of contexts (Dalim et al., 2023; Kohar et al., 2022; Liljedahl, 2015; OECD, 2016). Beyond basic arithmetic, numeracy encompasses the ability to think mathematically by employing relevant concepts, procedures, facts, and tools to solve real-world problems in meaningful contexts, both as Indonesian citizens and as global participants. This conception aligns closely with the

OECD's definition of mathematical literacy in the Programme for International Student Assessment (PISA), which emphasizes the capacity to reason mathematically, and to formulate, apply, and interpret mathematics in authentic contexts (OECD, 2019). Within Indonesia's curriculum, this is encapsulated in the idea of "thinking," referring to the cognitive processes involved in mathematical reasoning and problem-solving with real-world contexts.

Numeracy is a multidimensional competency encompassing civic, digital, workplace, financial, and health-related domains (Gal et al., 2020). It plays a pivotal role in learners' academic achievement and everyday decision-making (Duckworth, 2009) and contributes to their ability to engage in lifelong learning. A robust understanding of mathematical ideas supports the interpretation of numerical information encountered in daily life and enhances adaptability to technological and scientific advancements (Rosnelli & Ristiana, 2023). Furthermore, numeracy underpins employability in fields such as science, technology, economics, and finance (Straesser, 2015), where analytical and data-driven decision-making is essential (Michael & Lupton, 2016; Singh et al., 2023). It also supports financial autonomy (Grotlüschen et al., 2019) and health literacy (Heilmann, 2020), enabling individuals to make informed decisions regarding budgeting, investing, medication dosages, and interpreting health indicators.

Despite its significance, empirical evidence consistently indicates that Indonesian students exhibit persistently low levels of mathematical literacy. Nationally and internationally, this issue has been documented through various assessments. Since Indonesia's participation in PISA began in 2000, student performance in mathematical literacy has remained below the OECD average. Results from the 2003–2009 PISA cycles consistently placed Indonesian students at or below level 2 on the six-level proficiency scale (Stacey, 2011). In 2015, Indonesia ranked 69th out of 76 countries, with an average score of 375 (level 1), far below the OECD average of 500 (level 3) (OECD, 2016), placing the majority of students at level 1 proficiency.

In response, the Indonesian Ministry of Education introduced the Minimum Competency Assessment (MCA) in 2021, replacing the national examination. However, national data from the 2023 MCA suggest that fewer than 50% of students met the minimum standards for numeracy proficiency. The proportions of students achieving basic numeracy competence were 30.66% in elementary schools, 36.84% in junior high schools, and 35.16% in senior high schools. These outcomes highlight a substantial gap between curricular aspirations and actual student performance in mathematics (OECD, 2019).

One critical factor contributing to this gap is the continued reliance on traditional pedagogical approaches, which prioritize rote learning and procedural fluency over conceptual understanding. Additionally, the limited integration of digital technologies in mathematics instruction further hinders the development of numeracy skills (Vásquez & Martinez, 2019). Although various initiatives have attempted to introduce technology-enhanced learning, many teachers remain underprepared to adopt these tools effectively. As a result, the transformative potential of digital technologies in promoting numeracy remains underutilized.

This situation underscores the need to equip prospective mathematics teachers (PMTs) with pedagogical strategies that integrate technology, cultural relevance, and innovative instructional approaches. PMTs play a pivotal role in shaping future generations' numeracy competencies. To achieve this, teacher education must adopt learning designs that promote deep mathematical understanding through contextualized, student-centered instruction. Designing meaningful mathematical tasks is central to this process, especially tasks grounded in students' real-life experiences and aligned with the stages of mathematical activity and domain-specific knowledge (Ayalon & Even, 2016).

Prior research has highlighted the influence of teacher knowledge and practice on mathematics learning outcomes. Reflection on instructional practice is considered essential for PMTs to enhance core teaching competencies, such as pedagogical reasoning (Solar & Deulofeu, 2016), professional vision (Ivars et al., 2020), and didactic analysis (Groenwald & Llinares, 2019). Reflective practice has also been linked to improved classroom reasoning and more effective task design (Cervantes-Barraza & Araujo, 2023).

One promising pedagogical approach is Techno-Ethno-Realistic Mathematics Education (TE-RME) proposed by Nursyahidah, Wardono et al. (2025), which builds upon the Ethno-RME approach (Prahmana, 2022; Prahmana et al., 2023) by integrating digital technology as a learning medium. TE-RME combines three key elements: ethnomathematics, realistic mathematics education (RME), and educational technology.

Ethnomathematics emphasizes culturally situated mathematical practices, facilitating instruction that resonates with students' cultural backgrounds (D'Ambrosio, 2018; Rosa, 2021). D'Ambrosio (1999) demonstrates that ethnomathematics boosts students' interest, understanding, and creativity by contextualizing mathematics with real-life ideas and practices. It has been shown to enhance learners' engagement, creativity, and mathematical understanding by linking abstract concepts to familiar cultural experiences (Rosa et al., 2016; Rosa & Orey, 2023; Umbara et al., 2023).

Meanwhile, RME promotes the development of conceptual understanding and problem-solving skills by situating mathematics within real-world contexts meaningful to students (Wijaya et al., 2014; Zulkardi & Setiawan, 2020). Contextual learning environments foster literacy and numeracy (Fauzan et al., 2024), as well as higher-order thinking skills (Sutarni et al., 2024). This emphasis has attracted many researchers and policymakers, especially in Indonesia, to create additional curricula and resources that promote the existence and durability of these types of activities in educational classrooms (Rusiyanti et al., 2022). Furthermore, by integrating a focus on ethnomathematics and RME and expanding to include technology as a learning medium, TE-RME offers a holistic approach to creating meaningful, culturally appropriate, and effective learning experiences in mathematics and numeracy instruction (Nursyahidah, Albab, & Mulyaningrum, 2023). TE-RME emphasizes using technology, cultural context, and social reality to facilitate mathematics learning. By leveraging local cultural contexts, TE-RME aims to make mathematics learning more meaningful and relevant for students (Nursyahidah, Wardono et al., 2025). It also can promote a more profound and lasting understanding of mathematical concepts to support numeracy.

Previous research on PMT numeracy instruction has employed various contextual frameworks, such as those based on physical distancing (Kohar et al., 2022) and nutritional content (Sari et al., 2023). These studies indicate that context-rich instruction enhances PMTs' capacity to design meaningful mathematical tasks. Building on these findings, the present study employs multimedia tools—specifically Macromedia Flash and instructional video—to support numeracy learning, capitalizing on their potential to promote interactivity and engagement (Feeley et al., 2023), and also retention (Songkhro et al., 2022).

The novelty of this study lies in its integration of ethnomathematics, RME, and digital technology within the TE-RME framework, applied in the unique cultural context of the Javanese "*syawalan*" tradition—an area previously unexplored in the context of numeracy instruction. Therefore, the study aims to design a learning trajectory grounded in the TE-RME approach to support PMTs' development of numeracy competence, contextual sensitivity, and pedagogical innovation. This design is structured using a Hypothetical Learning Trajectory (HLT) model, guiding the progression of PMTs' learning experiences from initial contextual engagement to formal mathematical understanding of numeracy.

METHODS

This study employed a design research methodology to develop a learning trajectory for teaching numeracy by using TE-RME approach. In particular, it functioned as validation research, focusing on the systematic development and validation of a learning trajectory to enhance theoretical understanding of the learning process and to document the evolution of instructional practices and environments (McKenney & Reeves, 2014).

The specific aim of the research was to develop a HLT grounded in the TE-RME approach to support PMTs' development of numeracy skills. The study was conducted with 25 PMTs enrolled in a private university in Semarang, Indonesia. Following the design research model proposed by Plomp and Nieveen (2007), the research comprised three interconnected phases, namely preliminary design, design experiment (including a pilot experiment and a teaching experiment), and retrospective analysis.

Preliminary Design

During this phase, three key activities were undertaken to construct the initial version of the HLT (Bakker, 2018). Firstly, a numeracy pre-test was administered to the PMTs to identify their baseline competencies. The results revealed that the participants generally required extended time to complete tasks and frequently produced incorrect solutions, indicating limited proficiency in numeracy. Secondly, a comprehensive literature review was conducted to identify effective pedagogical strategies, learning media, and frequently encountered contexts for teaching numeracy (Graven & Jorgensen, 2024; Mahmudin et al., 2024). Lastly, the Javanese cultural tradition of *syawalan* was selected as the ethnomathematical context for the instructional design. Based on this context, a series of learning activities was developed, encompassing the following stages, such as cultural context orientation, numeracy exploration and problem-solving, numeracy task design, communication and interpretation of solutions, and instructional design involving numeracy tasks.

Teaching Experiment

This phase consisted of two primary components: a pilot experiment and a teaching experiment. The pilot experiment involved six PMTs working collaboratively in small groups to evaluate the initial HLT. The primary aim was to assess the clarity and coherence of the student worksheets, including the instructions, tasks, and supporting materials. Feedback was also collected regarding the appropriateness and appeal of the traditional Javanese context in fostering numeracy learning. Based on the insights from this trial, necessary revisions were made to the HLT design. Following the pilot, the revised HLT was implemented in a full teaching experiment involving 25 PMTs.

Data collection during this phase utilized multiple sources and methods, including video recordings of classroom sessions, student worksheet responses, field notes documenting classroom observations, and semi-structured student interviews. These data sources captured the PMTs' engagement in group discussions and classroom presentations. Observations focused on the fidelity of HLT implementation, while interviews ensured alignment between the intended and enacted learning processes. Finally, field notes were used to record students' physical involvement and cognitive engagement during instruction.

Retrospective Analysis

The final phase involved a comparative analysis between the intended HLT, and the actual learning trajectory enacted in the classroom. This process examined how PMTs interacted with the Javanese cultural context, engaged in numeracy tasks, and employed various problem-solving strategies. These included designing mathematical models, reformulating problems to facilitate understanding, applying logical reasoning, solving and creating numeracy tasks, and communicating mathematical ideas.

Data from video recordings, field notes, and interview transcripts provided insights into PMTs' initial understandings of numeracy and the progression of their learning throughout the instructional sequence. The retrospective analysis also revealed how the integration of cultural exploration into the HLT supported PMTs in understanding mathematical problems more deeply, formulating and executing problem-solving plans, evaluating solutions, and designing instruction around numeracy tasks. Overall, the findings demonstrated the effectiveness of the TE-RME-based learning trajectory in enhancing PMTs' numeracy skills and instructional design capabilities.

RESULTS AND DISCUSSION

As a result of this study, the researchers developed a description of a learning trajectory for numeracy learning based on Javanese local wisdom through the TE-RME approach, supported by Macromedia Flash and video. This section presents the results obtained at each stage of the study.

Preliminary Design

At this stage, the researchers collaborated with two lecturers from Michigan State University and several lecturers from universities in Indonesia to complete the planning phase via Zoom meetings. Specifically, a HLT, lesson plan, worksheet for PMTs, and a supporting module were designed to enhance numeracy skills. The numeracy material was contextualized through Javanese local wisdom using the TE-RME approach and was supported by Macromedia Flash and video.

The main focus of the student learning design was the development of the HLT, which was central to the instructional planning. The HLT incorporated Javanese cultural contexts to design numeracy tasks. Its development involved a literature review, field observations, and iterative design cycles specific to numeracy. A curriculum review was also conducted to align selected instructional materials, learning objectives, and indicators with national standards. The resulting HLT comprised five core activities grounded in TE-RME, namely cultural context orientation, numeracy exploration and problem solving, designing numeracy tasks, communicating and interpreting solutions, and designing learning instruction with numeracy tasks.

Each activity was designed to be accessible, engaging, and enjoyable for PMTs. Table 1 presents an overview of these activities and the anticipated responses (conjectures) from PMTs.

Table 1. Outline of the HLT

Activity	Aim	Conjecture of PMTs' Responses
cultural context orientation	PMTs can determine numeracy through Javanese local wisdom using Macromedia Flash media and video.	• PMTs can define numeracy • PMTs can determine the benefit of mastering numeracy
numeracy exploration and solving numeracy problems	PMTs can determine numeracy through the literature from a website and solving numeracy problems.	• PMTs can find the concept of numeracy problems by exploring some literatures. • PMTs can solve numeracy problems

designing numeracy task	PMTs can find another Javanese local wisdom, and design numeracy tasks.	• PMTs can find another Javanese local wisdom that can be used as a context in mathematics learning. • PMTs can design numeracy tasks • Designing numeracy problems can still be challenging for some PMTs
communicating and interpreting the solution	• PMTs can share Javanese local wisdom as a context and numeracy task with others and give comments to each other. • PMTs can solve numeracy problems from another group	• PMTs can communicate Javanese local wisdom as a context • PMTs can communicate numeracy tasks designed • PMTs can give opinions/reasoning to other groups • PMTs can solve numeracy problem • Some PMTs still have difficulty in solving numeracy problem
designing learning instruction with numeracy task	• PMTs can connect the numeracy in several materials • PMTs can do reflection and design HLT for specific mathematics topics including numeracy problems using Javanese TE-RME	• PMTs can connect numeracy to several materials • PMTs can reflect a series of activities • PMTs can design HLT for specific mathematics topics, including numeracy problems using Javanese TE-RME.

Design Experiment

The instructional design followed the five stages described in the HLT presented in Table 1. The sequence of student activities is shown in Figure 1. Each activity is detailed as follows.

Activity 1. Cultural Context Orientation

At the outset, PMTs were prompted with introductory questions:

Researcher : What do you know about ethnomathematics?
PMTs : Mathematics that grows, develops, and is used by a particular culture.
Researcher : Good. What do you understand about numeracy?
PMTs : The ability to calculate, solve everyday problems, and make sound decisions.
Researcher : Excellent. What are the benefits of mastering numeracy?
PMTs : It helps us solve daily problems effectively.

PMTs then studied several articles on ethnomathematics, such as learning design using ethnomathematics (Nursyahidah & Albab, 2021), Ethnomathematics of Pranatamangsa (Prahmana et al., 2021), design of interactive mathematical tasks using ethnomathematics (Cervantes-Barraza & Araujo, 2023), PMTs' lesson planning (Suryadi et al., 2023), Ethnomathematics of Pananrang (Pathuddin, 2021), and mathematics literacy tasks using Bengkulu context (Susanta et al., 2023).

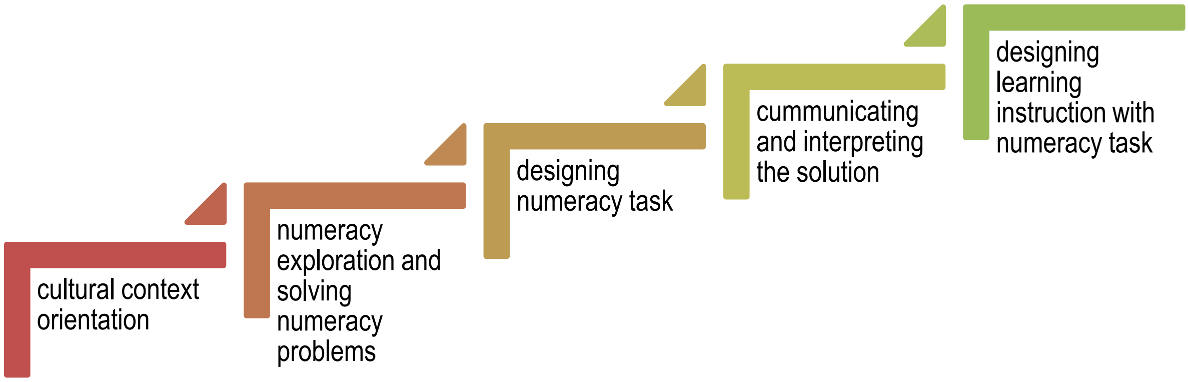


Figure 1. Hypothetical learning trajectory for numeracy learning

Using Macromedia Flash, they were introduced to Javanese traditions such as *syawalan*, *megono gunungan*, fruit *gunungan*, and giant *lopis*. PMTs also watched a video about *megono gunungan*, a traditional event from Pekalongan, Central Java, as shown in Figure 2.

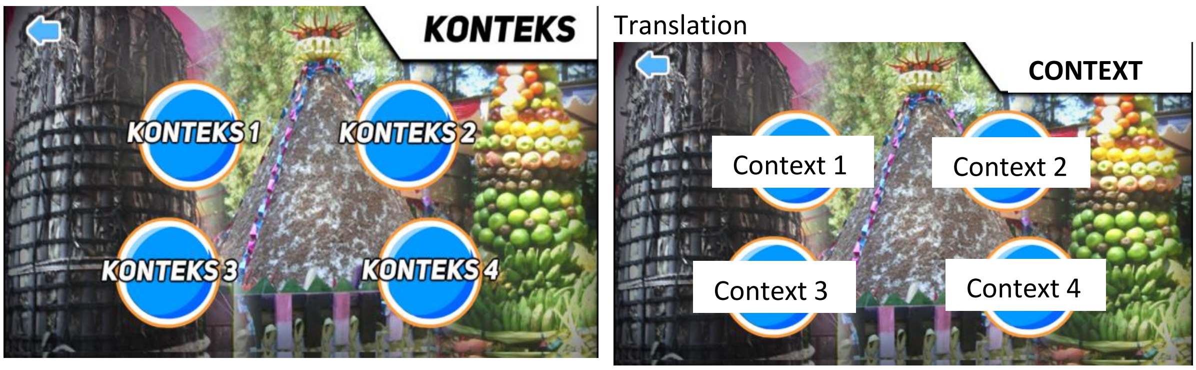
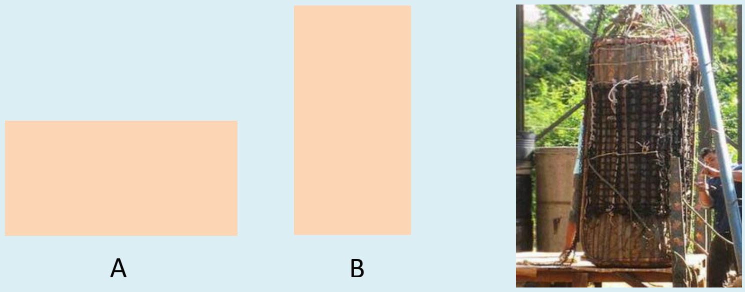


Figure 2. The media technology used to introduce Javanese cultural contexts

PMTs were asked to analyze the tradition by identifying its cultural elements, mathematical relevance, and anthropological aspects, including history, philosophy, and cultural values. This activity supported their ability to recognize ethnomathematics embedded in Javanese traditions and use them as contexts for numeracy tasks.

Activity 2. Numeracy Exploration and Problem Solving

In this phase, PMTs explored concepts of numeracy through various online articles and resources, such as Solving World Problems (https://francesharper.com/category/social-justice-math/), If the World Were a Village (https://nrich.maths.org/7725/note), If the World Were 100 People (https://ed.ted.com/best_of_web/5rhHgDwh), and Kohar et al. (2022) on numeracy and physical distancing. They then worked on the numeracy problem shown in Figure 3, involving two aluminum steamers used in the *syawalan* tradition.

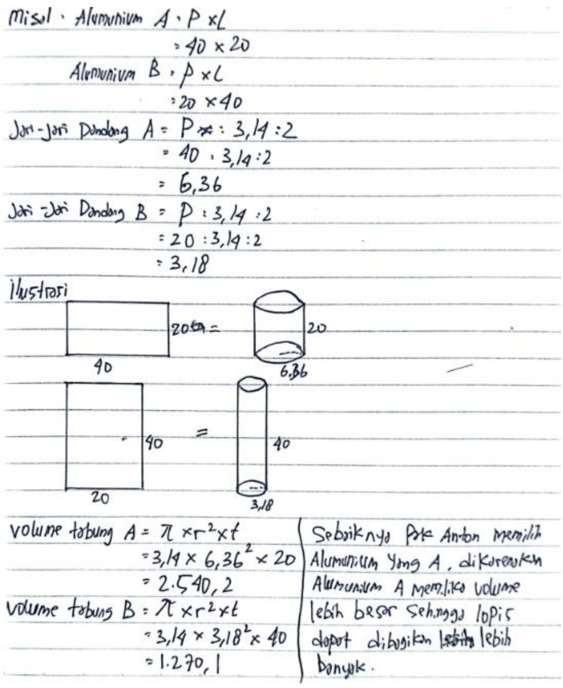


A B

It is known that the aluminum steamer for cooking giant *lopis* in the Pekalongan Syawalan tradition will be made using a sheet of aluminum with the same size but with a different shape as shown in the picture. The two different forms of steamer materials are A and B as shown in the picture. Mr. Anton wants to make giant *lopis* in the Syawalan tradition using the steamer. Which model should Mr. Anton choose so that *lopis* can be distributed to more residents? Explain your answer.

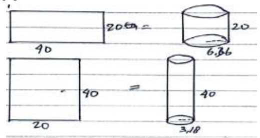
Figure 3. Example of numeracy problem solved by PMTs

An example of a student solution is presented in Figure 4, showing their reasoning using geometric volume calculations.



Translation

For example: Aluminum A = p x l
= 40 x 20
Aluminum B = p x l
= 20 x 40
The radii of boiler A = p : 3,14 : 2
= 40 : 3,14 : 2
= 6,36
The radii of boiler B = p : 3,14 : 2
= 20 : 3,14 : 2
= 3,18
Illustration:



Volume of tube A $= \pi \times r^2 \times t$
$= 3{,}14 \times 6{,}36^2 \times 20$
$= 2.540{,}2$
Volume of tube B $= \pi \times r^2 \times t$
$= 3{,}14 \times 3{,}18^2 \times 40$
$= 1.270{,}1$
Mr. Anton should choose aluminum A because aluminum A has a larger volume and more *lopis* can be distributed.

Figure 4. Example of PMT's response

Based on Figure 4, the PMT approached the numeracy problem by first visualizing the situation described. The PMT began by estimating dimensions for the aluminum sheet—specifically, a length of 40 units and a width of 20 units. Using these dimensions, the PMT calculated the radii of steamers A and B as 6.36 and 3.18 units, respectively. They then illustrated the scenario by drawing both steamer models and proceeded to calculate their respective volumes. The results showed that the volume of steamer A was greater than that of steamer B. Furthermore, the PMT offered a recommendation based on the calculations, suggesting that Mr. Anton should choose steamer A to distribute more *lopis* to the community. This outcome demonstrates that engaging with numeracy problems embedded in the context of Javanese traditions can support PMTs in applying mathematical reasoning to real-life cultural situations.

Activity 3. Designing Numeracy Tasks

In this activity, the PMTs were divided into small groups consisting of 3–5 students. Within these groups, they identified elements of ethnomathematics embedded in the *megono gunungan* tradition, explored additional forms of local wisdom or Javanese ethnomathematics, and designed context-based numeracy tasks. Evidence of the students' active engagement in the learning process includes their participation in group discussions exploring Javanese local wisdom, solving numeracy problems situated in ethnomathematical contexts, and designing numeracy tasks informed by these cultural elements. The students identified several examples of Javanese local wisdom that reflect ethnomathematical ideas, including the *geritan* bamboo, a traditional baby walker originating from Central Java, Indonesia. An example of the results of students' exploration of ethnomathematics in the Javanese local wisdom context is presented in Figure 5.

Figure 5. *Geritan* bamboo (traditional baby walker) as an example of Javanese ethnomathematics

An excerpt of a student-designed numeracy task is presented in Figure 6, exploring proportional reasoning through changes in walking distances. These tasks show that PMTs could independently explore new cultural contexts and design mathematically rich problems rooted in ethnomathematics.

Activity 4. Communicating and Interpreting the Solution

In this activity, PMTs presented their work on Javanese ethnomathematics and shared a numeracy task they had designed with another group. The receiving group provided comments, and the lecturer offered feedback to guide further improvement. The PMTs demonstrated sufficient self-confidence in communicating their work, which supported the development of their mathematical communication skills. They also engaged in discussions of numeracy problems designed by other groups, collaboratively solving them and justifying their reasoning. Through this process, PMTs communicated their solutions, explained their reasoning, and received constructive feedback from both peers and the lecturer.

Activity 5. Designing Learning Instruction with a Numeracy Task

At this stage, PMTs engaged in discussions about the integration of numeracy tasks with broader mathematical content. They explored how numeracy could be meaningfully embedded across different topics using the TE-RME approach. PMTs were asked to reflect on the learning activities by responding to several guiding questions. Based on these reflections, they developed a concrete instructional design or action plan. Specifically, they were required to design a HLT for a selected mathematics topic, incorporating a Javanese ethnomathematics context and embedding numeracy components through the application of the TE-RME framework.

Pada usia 1-2 tahun, tugas perkembangan anak adalah dapat berjalan dengan kedua kaki secara sempurna. Orang Jawa jaman dulu membuatkan alat latihan jalan dari bambu dengan poros dan pegangan sehingga anak dapat berpegangan untuk berjalan berputar. Menurut penuturan, latihan berjalan selama 10 kali putaran sehari dapat membantu anak cepat bisa berjalan. Karena alat hanya berputar di tempat yg. sama, anak sering merasa bosan dan tidak mau berlatih lebih lama.
Bila panjang pegangan ditambah menjadi 2x panjang semula (A titik putar, B tempat pegangan anak, C tempat pegangan anak setelah pegangan diperpanjang 2x), maka dari titik C anak bisa berlatih 5 kali putaran saja karena jarak yang ditempuh sama dengan saat berlatih 10 putaran di titik sebelumnya. Apakah pernyataan tersebut benar? Jelaskan jawabanmu

Translation:
At the age of 1-2 years, the developmental task of a child is to be able to walk perfectly on both feet. Javanese people in the past made walking training tools from bamboo with axles and handles so that children can hold on to walk around. According to the story, practicing walking for 10 times a day can help children learn to walk quickly. Because the tool only rotates in the same place, children often get bored and do not want to practice longer. If the length of the handle is increased to twice the original length (A is the turning point, B is where the child holds, C is where the child holds after the handle is extended twice), then from point C the child can practice only 5 times around because the distance traveled is the same as when practicing 10 rounds at the previous point. Is this statement correct? Explain your answer.

Figure 6. PMTs' work in designing numeracy tasks

Retrospective Analysis

The HLT presented in Table 1 served as both a framework for achieving the intended learning objectives and a tool for identifying and addressing potential challenges that PMTs might face during instruction. The HLT was systematically compared with the collected data to analyze how PMTs understood and applied numeracy concepts within the context of the Javanese *syawalan* tradition through the TE-RME approach. Each activity was deliberately designed to scaffold PMTs' understanding of numeracy task development, grounded in culturally relevant Javanese ethnomathematics contexts.

The data indicated that the PMTs' responses closely aligned with the expectations outlined in the HLT. In Activity 1, PMTs explored a digital representation (Macromedia Flash video) of the *syawalan* tradition and successfully identified mathematical elements embedded in the cultural context. Interviews further revealed their growing understanding of ethnomathematics and numeracy, validating the effectiveness of using a digital-cultural context to support conceptual identification. This activity successfully enhanced PMTs' capacity to explore, recognize, and comprehend cultural contexts in relation to numeracy—a critical component in developing numerate thinking.

In Activity 2, PMTs demonstrated the ability to apply numeracy skills to solve context-based problems. For instance, as shown in Figure 4, PMTs constructed visual representations, made estimations, and interpreted solutions to determine the optimal decision in a culturally relevant scenario. They were able to identify the underlying mathematical concepts, relate them to the problem situation, and demonstrate all key numeracy indicators: understanding, applying, and interpreting. These outcomes confirm that the objectives for Activity 2, as set forth in the HLT, were successfully achieved. Furthermore, Activity 3 required PMTs to design their own numeracy tasks using different forms of Javanese local wisdom. They selected new ethnomathematical contexts and created problems situated in those contexts, as illustrated in Figure 5. This demonstrated their ability not only to apply what they had learned but also to extend it creatively into novel situations.

In Activity 4, PMTs communicated their findings and shared the numeracy tasks they designed with other groups. They engaged in peer evaluation, exchanged feedback, and elaborated on their understanding by solving tasks designed by others. This collaborative learning environment promoted critical thinking and communication skills, while also reinforcing their ability to reason through numeracy tasks situated in unfamiliar contexts. Finally, Activity 5 invited PMTs to reflect on the overall learning process and articulate follow-up actions. As a culminating task, they designed hypothetical learning trajectories incorporating numeracy tasks situated within Javanese ethnomathematics, employing the TE-RME approach. This final activity synthesized prior learning and enabled PMTs to produce instructional plans that aligned with realistic, culturally embedded mathematics learning goals.

Across all five activities, it is evident that PMTs developed a nuanced understanding of numeracy within the framework of Javanese *syawalan* culture, facilitated by the TE-RME approach. The integration of culturally relevant contexts and technology not only enriched the learning experience but also fostered meaningful engagement, problem-solving competence, and numeracy development. The HLT proved effective in guiding instruction and eliciting productive responses from PMTs, thereby affirming its utility in bridging theoretical design and practical classroom implementation.

This study contributes to the field of mathematics education by offering a learning design that supports the development of PMTs' numeracy through culturally contextualized, technology-enhanced pedagogy. By embedding numeracy tasks within the TE-RME framework and utilizing elements of Javanese culture, this research presents a model for creating rich, relevant learning experiences. It is hoped that this approach can empower prospective mathematics teachers to connect mathematical concepts with cultural contexts, thereby enhancing the depth and relevance of mathematics instruction and supporting the cultivation of numerate learners.

In addition, based on Activities 1 through 5, the five characteristics of RME (Gravemeijer & Doorman, 1999; Rusiyanti et al., 2022), which were integrated with ethnomathematics (Prahmana & D'Ambrosio, 2020) in what is known as Ethno-Realistic Mathematics Education (Ethno-RME) (Prahmana, 2022; Prahmana et al., 2023), have been effectively applied throughout the learning process. This integration was further enhanced by incorporating technology as an innovative learning medium (Nursyahidah, Anindya et al., 2025).

The first RME characteristic—the use of context—was addressed in Activity 1, which employed ethnomathematics from Javanese culture, specifically the *megono gunungan* tradition. The use of a Macromedia Flash video provided PMTs with a visual and culturally grounded entry point into numeracy learning. This finding aligns with previous research (Hardiyanto et al., 2024; Nursyahidah, 2020;

Nursyahidah, Albab, & Rubowo, 2023; Nursyahidah, Wardono et al., 2025; Prahmana & Istiandaru, 2021; Putri & Zulkardi, 2018), which has shown that meaningful contexts can help learners visualize abstract mathematical ideas through familiar and concrete representations. Contexts also stimulate a diversity of student responses and solution strategies (Nursyahidah, Albab, & Rubowo, 2023; Nursyahidah & Albab, 2021; Putri & Zulkardi, 2018).

The second characteristic—the use of models—emerged as PMTs constructed visual or symbolic representations of their problem-solving processes. In Activity 2, they employed illustrations to communicate their reasoning. In Activity 3, they designed tasks that required students to use representations such as diagrams, symbols, or written explanations. This finding supports research by Nursyahidah and Albab (2021), who emphasized that the use of models enables learners to externalize their thinking and systematically explore and communicate mathematical ideas. Furthermore, the third characteristic—student contribution—was evident across all activities. PMTs actively participated by expressing their ideas, collaborating in problem-solving, and presenting their solutions. The cultural context of Javanese local wisdom stimulated their engagement and provided a foundation for meaningful discussion. The fourth characteristic—interactivity—was also prominent. PMTs engaged in various forms of interaction: within small groups, between groups during presentations and feedback sessions, and with the lecturer through guidance and commentary. These interactions fostered a collaborative learning environment and supported deeper understanding. Finally, the fifth characteristic—intertwinement—was demonstrated through the integration of numeracy with other domains, such as anthropology, history, and cultural studies. Through project-based learning and group discussions, PMTs explored traditional Javanese artifacts and practices, constructed mathematical meaning from them, and developed interdisciplinary connections grounded in students lived experiences.

Moreover, these findings are consistent with previous studies (Ekawati, 2017; Meryansumayeka et al., 2022; Prahmana & D'Ambrosio, 2020; Putri & Zulkardi, 2018; Zulkardi & Setiawan, 2020), which underscore the importance of aligning instructional approaches with local cultural contexts to enhance the relevance and effectiveness of mathematics learning. This study further confirms the value of an innovative, practice-oriented instructional design in supporting the development of PMTs' numeracy skills.

The strengths of the instructional design lie in its ability to develop PMTs' numeracy across several key dimensions. Through this course, PMTs gained a deeper conceptual understanding of numeracy, demonstrated the ability to solve culturally contextualized problems, and created original numeracy tasks embedded in Javanese ethnomathematics. These activities, supported by group collaboration, reflect the real-world nature of mathematics and strengthen the connection between formal content and students' everyday experiences (Cervantes-Barraza & Araujo, 2023; Nursyahidah & Albab, 2021; Prahmana, 2022). Students can explore local wisdom that exists in everyday life and is already familiar to them. This design promotes the view of mathematics as a human activity tied to reality (Prahmana & D'Ambrosio, 2020; Putri et al., 2015; 2021).

Additionally, the learning design embraces differentiated instruction. It offers content differentiation through diverse learning resources, including scholarly articles and multimedia (Er et al., 2022; Vale & Falloon, 2024), and product differentiation by allowing students to express their understanding in various formats (e.g., video, PowerPoint, handwritten work, or digital documents). The instructional design also fosters deep learning, supporting meaningful, mindful, and joyful experiences. Assignments encouraged students to explore familiar local wisdom and design tasks that reflect their cultural context and personal strengths, thus embodying the core values of the TE-RME approach.

CONCLUSION

This study has successfully developed a well-structured learning trajectory for enhancing numeracy skills by integrating the cultural context of Javanese ethnomathematics within the TE-RME approach. The trajectory consists of five progressive learning activities: cultural context orientation, numeracy exploration and problem-solving, numeracy task design, communication and interpretation of solutions, and instructional design involving numeracy tasks. Contextual digital media, particularly interactive videos developed using Macromedia Flash, were embedded within the learning sequence to support PMTs in understanding and solving numeracy problems in culturally meaningful ways. The findings illustrate how the TE-RME approach facilitated PMTs' conceptual understanding of numeracy by linking mathematical reasoning with local cultural practices, thereby promoting deeper engagement and contextual relevance in mathematics learning.

Despite these promising outcomes, several limitations of the study should be acknowledged. First, the implementation was situated within a specific ethnocultural context—namely, the *syawalan* tradition of Javanese culture—limiting the generalizability of the findings to other sociocultural settings or populations. Second, the focus of the study was restricted to numeracy skills, without extending to other essential components of mathematics education such as critical thinking, collaborative problem-solving, or affective dispositions toward mathematics. Additionally, the relatively small sample size and the short duration of the intervention may have constrained the depth and breadth of observable learning outcomes, thus limiting the potential to assess long-term impacts or broader applicability of the developed trajectory.

Future research should aim to expand the scope and depth of this work by incorporating a wider range of cultural contexts and mathematical domains. Studies that adapt the TE-RME approach to different regions and traditions could contribute to the development of culturally responsive learning trajectories that are inclusive and adaptable across diverse educational settings. Moreover, longitudinal studies with larger and more heterogeneous participant groups are needed to investigate the sustainability and scalability of the approach over time. To further enhance learning engagement and effectiveness, future research might also explore the integration of emerging technologies such as interactive simulations, augmented reality, and virtual learning environments within culturally grounded mathematics instruction. Such advancements could strengthen the pedagogical value of TE-RME and contribute to a more inclusive and innovative framework for mathematics teacher education.

Acknowledgments

The researchers would like to thank the LPDP, which provided the Microcredential PPG grant program in 2023, Tonya Gau Bartell and Nancy Romig as lecturers from Michigan State University, and reviewers for their valuable feedback and support for this research paper.

Declarations

Author Contribution	:	FN: Conceptualization, Writing - Original Draft, Editing and Visualization. W: Editing and Validation. SM: Review and Editing. KW: Formal Analysis and Methodology.
Funding Statement	:	There is no funding for this research.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available for this paper.

REFERENCES

Ayalon, M., & Even, R. (2016). Factors shaping students' opportunities to engage in argumentative activity. *International Journal of Science and Mathematics Education*, *14*(3), 575-601. https://doi.org/10.1007/s10763-014-9584-3

Bakker, A. (2018). *Design research in education: A practical guide for early career researchers*. Routledge.

Cervantes-Barraza, J. A., & Araujo, A. A. (2023). Design of interactive mathematical tasks that make up the reasoning and the Ethnomathematics program. *Journal on Mathematics Education*, *14*(3), 469–482. https://doi.org/10.22342/jme.v14i3.pp469-482

Dalim, S. F., Syed Aris, S. R., Hoon, T. S., Nadzri, F. A., Deni, S. M., Yahya, N., & Si, E. M. (2023). Framework for numeracy and digital skills attributes in higher education. *Research in Social Sciences and Technology*, *8*(3), 16–35. https://doi.org/10.46303/ressat.2023.18

D'Ambrosio, U. (1999). Literacy, matheracy, and technocracy: A trivium for today. *Mathematical Thinking and Learning*, *1*(2), 131–153. https://doi.org/10.1207/s15327833mtl0102_3

D'Ambrosio, U. (2018). Etnomatemática, justiça social e sustentabilidade. *Estudos Avancados*, *32*(94), 189–204. https://doi.org/10.1590/s0103-40142018.3294.0014

Duckworth, E. (2009). Helping students get to where ideas can find them. *The New Educator*, *5*(3), 185–188. https://doi.org/10.1080/1547688X.2009.10399573

Ekawati, R. (2017). Experts' notion and students' responses on context-based mathematics problem. *Journal of Engineering Science and Technology (JESTEC),* *12*(10), 53-64. https://jestec.taylors.edu.my/Special%20Issue%20on%20AASEC%202016/AASEC%202017_paper%206.pdf

Er, S., Toker, Z., & YücelyiĞiT, S. (2022). In-service teachers' opinions about the use of video-based self-reflection for pedagogical development. *Kuramsal Eğitimbilim*, *15*(3), 639–660. https://doi.org/10.30831/akukeg.1039752

Fauzan, A., Harisman, Y., Yerizon, Y., Suherman, S., Tasman, F., Nisa, S., Sumarwati, S., Hafizatunnisa, H., & Syaputra, H. (2024). Realistic mathematics education (RME) to improve literacy and numeracy skills of elementary school students based on teachers' experience. *Infinity Journal*, *13*(2), 301–316. https://doi.org/10.22460/infinity.v13i2.p301-316

Feeley, T. H., Keller, M., & Kayler, L. (2023). Using animated videos to increase patient knowledge: A meta-analytic review. *Health Education & Behavior*, *50*(2), 240–249. https://doi.org/10.1177/10901981221116791

Gal, I., Grotlüschen, A., Tout, D., & Kaiser, G. (2020). Numeracy, adult education, and vulnerable adults: A critical view of a neglected field. *ZDM*, *52*(3), 377–394. https://doi.org/10.1007/s11858-020-01155-9

Gravemeijer, K., & Doorman, M. (1999). Context problems in Realistic Mathematics Education: A calculus course as an example. *Educational Studies in Mathematics*, *39*(1/3), 111–129. https://doi.org/10.1023/A:1003749919816

Graven, M., & Jorgensen, R. (2024). Early numeracy opportunities through number stories with marginalised families. *ZDM – Mathematics Education*, *56*(3), 319–333. https://doi.org/10.1007/s11858-023-01537-9

Groenwald, C. L., & Llinares, S. (2019). Competencia docente de observar con sentido situaciones de enseñanza. *Revista Paradigma*, *40*(1), 29-46. https://doi.org/10.37618/PARADIGMA.1011-2251.2019.p29-46.id740

Grotlüschen, A., Buddeberg, K., Redmer, A., Ansen, H., & Dannath, J. (2019). Vulnerable subgroups and numeracy practices: How poverty, debt, and unemployment relate to everyday numeracy practices. *Adult Education Quarterly*, *69*(4), 251–270. https://doi.org/10.1177/0741713619841132

Hardiyanto, D., Asokawati, I., Majid, P. M., Maesaroh, A. T., & Nursyahidah, F. (2024). Learning reflection using realistic mathematics education assisted by GeoGebra software. *Jurnal Pendidikan Matematika*, *18*(1), 15-26. https://doi.org/10.22342/jpm.v18i1.pp15-26

Heilmann, L. (2020). Health and numeracy: The role of numeracy skills in health satisfaction and health-related behaviour. *ZDM*, *52*(3), 407–418. https://doi.org/10.1007/s11858-019-01106-z

Ivars, P., Fernández, C., & Llinares, S. (2020). A learning trajectory as a scaffold for pre-service teachers' noticing of students' mathematical understanding. *International Journal of Science and Mathematics Education*, *18*(3), 529-548. https://doi.org/10.1007/s10763-019-09973-4

Kohar, A. W., Rahaju, E. B., & Rohim, A. (2022). Prospective teachers' design of numeracy tasks using a physical distancing context. *Journal on Mathematics Education*, *13*(2), 191–210. https://doi.org/10.22342/jme.v13i2.pp191-210

Liljedahl, P. (2015). Numeracy task design: A case of changing mathematics teaching practice. *ZDM*, *47*(4), 625–637. https://doi.org/10.1007/s11858-015-0703-6

Mahmudin, M., Herman, T., Prabawanto, S., Supriyadi, E., & Susilawati, A. (2024). Game design application of trigonometry integrating numeration in daily life using augmented reality. *Journal of Engineering Science and Technology. Special Issue on ISCoE2023, 19*(5), 103-110.

McKenney, S., & Reeves, T. C. (2014). Educational design research. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 131–140). Springer New York. https://doi.org/10.1007/978-1-4614-3185-5_11

Meryansumayeka, Zulkardi, Putri, R. I. I., & Hiltrimartin, C. (2022). Designing geometrical learning activities assisted with ICT media for supporting students' higher order thinking skills. *Journal on Mathematics Education*, *13*(1), 135–148. https://doi.org/10.22342/jme.v13i1.pp135-148

Michael, M., & Lupton, D. (2016). Toward a manifesto for the 'public understanding of big data.' *Public Understanding of Science*, *25*(1), 104–116. https://doi.org/10.1177/0963662515609005

Nursyahidah, F. (2020). Learning reflection through the context of Central Java historical building. *Journal of Physics: Conference Series*, *1567*(2), 022095. https://doi.org/10.1088/1742-6596/1567/2/022095

Nursyahidah, F., & Albab, I. U. (2021). Learning design on surface area and volume of cylinder using Indonesian ethno-mathematics of traditional cookie maker assisted by GeoGebra. *Mathematics Teacher Research Journal. 13*(4), 79-98. https://files.eric.ed.gov/fulltext/EJ1332350.pdf

Nursyahidah, F., Albab, I. U., & Mulyaningrum, E. R. (2023). Learning design of quadrilateral STEM-based through lesson study. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(11), em2352. https://doi.org/10.29333/ejmste/13747

Nursyahidah, F., Albab, I. U., & Rubowo, M. R. (2023). Learning design of sphere using realistic mathematics education assisted by interactive video. *Jurnal Pendidikan Matematika*, *17*(3), 297-312. https://doi.org/10.22342/jpm.v17i3.pp297-312

Nursyahidah, F., Anindya, F. M., Yulianti, M. A., Prisanto, Z. I., & Rosario, M. A. R. (2025). Integrating local wisdom with technology: Designing learning trajectory of cylinder through realistic mathematics education approach. *Jurnal Pendidikan Matematika*, *19*(1), 81-98. https://doi.org/10.22342/jpm.v19i1.pp81-98

Nursyahidah, F., Wardono, W., Mariani, S., & Wijayanti, K. (2025). Integrating technology, ethnomathematics, and realistic mathematics education in learning statistics: A learning trajectory. *Infinity Journal*, *14*(3), 633–654. https://doi.org/10.22460/infinity.v14i3.p633-654

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. OECD. https://doi.org/10.1787/9789264266490-en

OECD. (2019). *Skills Matter: Additional Results from the Survey of Adult Skills*. OECD. https://doi.org/10.1787/1f029d8f-en

Pathuddin, H. (2021). Buginese ethnomathematics: Barongko cake explorations as mathematics learning resources. *Journal on Mathematics Education*, *12*(2), 295–312. https://doi.org/10.22342/jme.12.2.12695.295-312

Plomp, T., & Nieveen, N. (2007). *An Introduction to Educational Design Research*. SLO.

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

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning geometry and values from patterns: Ethnomathematics on the batik patterns of Yogyakarta, Indonesia. *Journal on Mathematics Education*, *11*(3), 439–456. https://doi.org/10.22342/jme.11.3.12949.439-456

Prahmana, R. C. I., & Istiandaru, A. (2021). Learning sets theory using shadow puppet: A study of javanese ethnomathematics. *Mathematics*, *9*(22), 2938. https://doi.org/10.3390/math9222938

Prahmana, R. C. I., Arnal-Palacián, M., Risdiyanti, I., & Ramadhani, R. (2023). Trivium curriculum in Ethno-RME approach: An impactful insight from ethnomathematics and realistic mathematics education. *Jurnal Elemen*, *9*(1), 298–316. https://doi.org/10.29408/jel.v9i1.7262

Prahmana, R. C. I., Yunianto, W., Rosa, M., & Orey, D. C. (2021). Ethnomathematics: Pranatamangsa system and the birth-death ceremonial in Yogyakarta. *Journal on Mathematics Education*, *12*(1), 93–112. https://doi.org/10.22342/jme.12.1.11745.93-112

Putri, R. I. I., & Zulkardi. (2018). Learning fraction through the context of Asian Games 2018. *Journal of Physics: Conference Series*, *1088*(1), 012023. https://doi.org/10.1088/1742-6596/1088/1/012023

Putri, R. I. I., Dolk, M., & Zulkardi. (2015). Professional development of PMRI teachers for introducing social norms. *Journal on Mathematics Education*, *6*(1), 11–19. https://doi.org/10.22342/jme.6.1.1900.11-19

Putri, R. I. I., Zulkardi, Setyorini, N. P., Meitrilova, A., Permatasari, R., Saskiyah, S. A., & Nusantara, D. S. (2021). Designing a healthy menu project for Indonesian junior high school students. *Journal on Mathematics Education*, *12*(1), 133–146. https://doi.org/10.22342/jme.12.1.13239.133-146

Rosa, M. (2021). An ethnomathematical perspective of stem education in a glocalized world. *Bolema—Mathematics Education Bulletin.* 35(70), 840–876. https://doi.org/10.1590/1980-4415v35n70a14

Rosa, M., D'Ambrosio, U., Orey, D. C., Shirley, L., Alangui, W. V., Palhares, P., & Gavarrete, M. E. (2016). *Current and Future Perspectives of Ethnomathematics As a Program*. Springer.

Rosa, M., & Orey, D. C. (2023). Considerations about Ethnomathematics, the culturally relevant Pedagogy and social justice in Mathematical Education. *Educação Matemática Pesquisa Revista Do Programa de Estudos Pós-Graduados Em Educação Matemática*, *25*(2), 145-165. https://doi.org/10.23925/1983-3156.2023v25i2p145-165

Rosnelli, R., & Ristiana, P. A. (2023). Independent curriculum learning management to improve students' literacy and numerical competence in schools. *International Journal of Education in Mathematics, Science and Technology*, *11*(4), 946–963. https://doi.org/10.46328/ijemst.3513

Rusiyanti, R. H., Zulkardi, Putri, R. I. I., & Somakim. (2022). Developing RME-based lesson study for learning community in the learning environment of high school mathematics teachers. *Journal on Mathematics Education*, *13*(3), 499–514. https://doi.org/10.22342/jme.v13i3.pp499-514

Sari, Y. M., Kohar, A. W., El Milla, Y. I., Fiangga, S., & Rahayu, D. S. (2023). Aligning numeracy task design with SDG goals: Nutrition facts as a context for prospective mathematics teachers' problem posing. *Journal on Mathematics Education*, *15*(1), 191–206. https://doi.org/10.22342/jme.v15i1.pp191-206

Singh, D., Chand, S. P., Kumar, K. K., & Ali, R. (2023). Effectiveness of literacy and numeracy in commerce subjects among secondary schools in Fiji. *Journal of Education and Learning (EduLearn)*, *17*(3), 447–454. https://doi.org/10.11591/edulearn.v17i3.20873

Solar, H. S., & Deulofeu, J. (2016). Conditions to promote the development of argumentation competence in the mathematics classroom. *Bolema: Boletim de Educação Matemática*, *30*, 1092-1112. https://doi.org/10.1590/1980-4415v30n56a13

Songkhro, J., Dequiña, Jr., L. S., Dominguez, R. R., & Phanlapa Khathayut, P. (2022). Effectiveness of using animated videos via google sites in enhancing socio-culture of native english-speaking countries. *Education Quarterly Reviews*, *5*(2), 371-380. https://doi.org/10.31014/aior.1993.05.02.497

Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. *Journal on Mathematics Education*, *2*(2), 95–126. https://doi.org/10.22342/jme.2.2.746.95-126

Straesser, R. (2015). "Numeracy at work": A discussion of terms and results from empirical studies. *ZDM*, *47*(4), 665–674. https://doi.org/10.1007/s11858-015-0689-0

Suryadi, D., Itoh, T., & Isnarto. (2023). A prospective mathematics teacher's lesson planning: An in-depth analysis from the anthropological theory of the didactic. *Journal on Mathematics Education*, *14*(4), 723–740. https://doi.org/10.22342/jme.v14i4.pp723-740

Susanta, A., Sumardi, H., Susanto, E., & Retnawati, H. (2023). Mathematics literacy task on number pattern using Bengkulu context for junior high school students. *Journal on Mathematics Education*, *14*(1), 85–102. https://doi.org/10.22342/jme.v14i1.pp85-102

Sutarni, S., Sutama, S., Prayitno, H. J., Sutopo, A., & Laksmiwati, P. A. (2024). The development of realistic mathematics education-based student worksheets to enhance higher-order thinking skills and mathematical ability. *Infinity Journal*, *13*(2), 285–300. https://doi.org/10.22460/infinity.v13i2.p285-300

Umbara, U., Prabawanto, S., & Jatisunda, M. G. (2023). Combination of mathematical literacy with ethnomathematics: How to perspective sundanese culture. *Infinity Journal*, *12*(2), 393–414. https://doi.org/10.22460/infinity.v12i2.p393-414

Vale, E., & Falloon, G. (2024). Using Learning analytics to understand K–12 learner behavior in online video-based learning. *Online Learning Journal*, *28*(1), 44-68. https://doi.org/10.24059/olj.v28i1.3675

Vásquez-Morales, G. R., Martinez-Monterrubio, S. M., Moreno-Ger, P., & Recio-Garcia, J. A. (2019). Explainable prediction of chronic renal disease in the colombian population using neural networks and case-based reasoning. *IEEE Access*, 7, 152900-152910. https://doi.org/10.1109/ACCESS.2019.2948430

Wijaya, A., Van Den Heuvel-Panhuizen, M., Doorman, M., & Robitzsch, A. (2014). Difficulties in solving context-based PISA mathematics tasks: An analysis of students' errors. *The Mathematics Enthusiast*, *11*(3), 555–584. https://doi.org/10.54870/1551-3440.1317

Zulkardi, & Setiawan, M. B. T. (2020). Javanese calendar as context to learn number pattern and least common multiple. *Journal of Physics: Conference Series*, *1470*(1), 012094. https://doi.org/10.1088/1742-6596/1470/1/012094