PLUSMINUS
Jurnal Pendidikan Matematika

Hypothetical Learning Trajectory for Eighth Graders' Understanding of Pythagorean Theorem through Ethno-Realistic Mathematics Education Assisted by Video

Farida Nursyahidah[1*], Muhtarom[2], Irkham Ulil Albab[3], Maya Rini Rubowo[4], Windia Hadi[5]
[1*,2,3,4]Mathematics Education Department, Universitas PGRI Semarang
[1*,2,3]PUI-PT Techno-Ethno-Realistic Mathematics, Universitas PGRI Semarang
Jalan Sidodadi Timur No 24, Dr. Cipto, Semarang, Indonesia
[5]Doctoral school of education, University of Szeged, Hungary
13 Dugonics square, H-6720 Szeged, Hungary
[1*]faridanursyahidah@upgris.ac.id; [2]muhtarom@upgris.ac.id; [3]irkhamulil@upgris.ac.id;
[4]mayarini@upgris.ac.id; [5]windia.hadi@edu.u-szeged.hu

ABSTRAK

Pemahaman konsep geometri, terutama yang berkaitan dengan teorema Pythagoras, seringkali menjadi kendala bagi siswa. Artikel ini bertujuan untuk mengembangkan lintasan belajar hipotetis mengenai materi teorema Pythagoras dengan pendekatan Pendidikan Matematika Etno-Realistik Jawa (E-RME). Penelitian dilakukan dengan menggunakan metode penelitian desain yang meliputi tiga tahap utama, yaitu perancangan awal, pelaksanaan eksperimen pembelajaran, dan analisis retrospektif. Penelitian ini melibatkan siswa kelas VIII di salah satu SMP di Kota Semarang. Fokus artikel ini adalah pada tahap perancangan awal, yaitu dihasilkan hipotesis lintasan belajar yang meliputi tiga kegiatan utama: (1) mengamati konteks video rumah Joglo untuk menentukan jenis segitiga berdasarkan besar sudutnya dan konsep segitiga istimewa; (2) menemukan konsep teorema Pythagoras dan menentukan jenis segitiga berdasarkan panjang sisinya; (3) menerapkan teorema Pythagoras. Hipotesis lintasan pembelajaran ini layak untuk diujicobakan pada tahap eksperimen pembelajaran untuk membantu siswa membangun pemahaman yang lebih mendalam tentang konsep-konsep teorema Pythagoras, sekaligus menumbuhkan apresiasi terhadap budaya lokal dan keragaman dalam berpikir matematika menggunakan E-RME.

Kata Kunci: Penelitian Desain; Etno-Pendidikan Matematika Realistik; Hipotesis Lintasan Pembelajaran; Teorema Pitagoras; Video.

ABSTRACT

Understanding of geometric concepts, especially those related to the Pythagorean theorem, is often an obstacle for students. This study aims to develop a hypothetical learning trajectory for the Pythagorean theorem material using the Javanese Ethno-Realistic Mathematics Education (E-RME) approach. The research was conducted using the design research method, which includes three main stages: initial design, implementation of learning experiments, and retrospective analysis. This research involved grade VIII students in one of the junior high schools in the city of Semarang. The focus of this study is on the initial design stage, resulted a learning trajectory hypothesis which includes three main activities: (1) observing the video context of the Joglo house to determine the type of triangle based on the size of its angles and the concept of special triangles; (2) discovering the concept of the Pythagorean theorem and determining the types of triangles based on the length of their sides; (3) applying the Pythagorean theorem. This learning trajectory hypothesis is worth testing at the experimental stage of learning to help students develop a deeper understanding of the concepts underlying the Pythagorean theorem, while simultaneously fostering an appreciation of local culture and diversity in mathematical thinking through E-RME.

Keywords: Design Research; Ethno-Realistic Mathematics Education; Hypothetical Learning Trajectory; Pythagorean Theorem; Video.

Article Information:

Accepted Article: 9 August 2025, Revised: 3 October 2025, Published: 30 November 2025

How to Cite:

DOI: https://doi.org/10.31980/plusminus.v5i3.3394

Nursyahidah, F., Muhtarom, Albab, I. U., Rubowo, M. R., & Hadi, W. (2025). Hypothetical Learning Trajectory for Eighth Graders' Understanding of Pythagorean Theorem through Ethno-Realistic Mathematics Education Assisted by Video. *Plusminus: Jurnal Pendidikan Matematika, 5*(3), 559-576.

1. INTRODUCTION

Mastery of the Pythagorean theorem is crucial for students as they study their next mathematics topic. This theorem not only introduces students to geometric concepts but also improves problem-solving skills. A study emphasizes that students who understand basic concepts, such as the Pythagorean theorem, are better prepared to tackle complex math problems later in life, leading to improved overall academic performance in mathematics (Ridho, 2023). The Pythagorean theorem has practical applications in fields such as architecture, engineering, and navigation (Ayyaswamy et al., 2025). Understanding this theorem allows students to accurately calculate distances and angles, which is especially important in real-world scenarios. Research shows that students who can effectively apply the Pythagorean theorem show higher levels of critical thinking and practical problem-solving skills (Wulandari et al., 2021).

Engaging with geometric concepts encourages cognitive development among students. Research has shown that learning about the Pythagorean theorem enhances spatial reasoning skills, which are crucial not only in mathematics but also in decision-making and everyday planning (Demirci & Çontay, 2023). This cognitive growth is linked to better overall academic performance across subjects (Afriansyah et al., 2023; Arwadi et al., 2024). Mastering the Pythagorean theorem also facilitates interdisciplinary learning (Zhang, 2025). For example, connections can be drawn between mathematics and physics when discussing concepts such as distance and angle. Recent research has highlighted the benefits of integrating math concepts with other disciplines in improving student engagement and understanding (Deshpande et al., 2021; Efwan et al., 2024). Students who understand and can apply Pythagorean theorems are more likely to participate actively in class discussions and collaborative problem-solving activities. This increase in confidence can lead to positive feedback, enabling students to tackle challenging mathematics problems more effectively (Lutfi et al., 2022; Halini et al., 2023). Moreover, understanding this theorem allows students to apply mathematical concepts to real-world scenarios, enhancing their learning experience and making mathematics more relevant to everyday life (Afriansyah, 2022; Musri'ah et al., 2025).

However, the Pythagorean Theorem, the cornerstone of geometric understanding, is still considered challenging material for many students due to its abstract nature and limited connection to real-world applications (Rahman, 2020; Kaviya & Suryadharani, 2025). Students' difficulties in learning the Pythagorean theorem include students lacking understanding of the mathematical language and concepts involved in the Pythagorean theorem, and implementing their plans effectively, which shows the gap between understanding the theorem conceptually and applying it in problem-solving practices (Wulandari & Riajanto, 2020); misunderstanding the relationship between the sides of a right triangle and failing to recognize when and how to apply the theorem correctly (Cholily & Kusgiarohmah, 2023). Furthermore, anxiety in learning the Pythagorean theorem can inhibit students' interest in engaging with mathematical problems and exploring solutions (Ardhiansah, Muhtadi, & Apiati, 2025).

The causes of these difficulties include the lack of learning design by teachers for Pythagorean material; teachers mainly teach without encouraging active exploration or problem-solving, resulting in a passive learning experience (Maulandani & Afriansyah, 2024). The materials used to prepare the Pythagorean theorem often fail to engage students and connect mathematical concepts to real-life applications, making it difficult for them to see the relevance of what they are learning, which further complicates their understanding (Eviliasani et al., 2022). Additionally, the potential of innovative learning media has not been fully leveraged to support student learning (Tokanov et al., 2023).

Therefore, it is necessary to design learning using the right approach and context, as well as innovative media. One alternative that can be employed is the Ethno-Realistic Mathematics Education (E-RME) approach, which represents a significant advance in mathematics pedagogy by combining ethnomathematical principles with the Realistic Mathematics Education (RME) approach (Prahmana, 2022). Research has shown that students demonstrate better conceptual understanding when mathematical principles are presented in a cultural context familiar to their world (Hardiyanto et al., 2024). This approach has become particularly relevant in teaching the Pythagorean theorem, as various cultures throughout history have developed unique applications and interpretations of this mathematical principle (Agarwal, 2024).

Video-assisted learning designs provide multiple representations of mathematical concepts, supporting a diverse range of learning styles (Yulianto, Sisworo, & Hidayanto, 2022; Kusumaryono et al., 2025). Recent studies show that multimedia learning environments significantly improve students' geometric reasoning abilities and spatial visualization skills (Akayuure et al., 2016; Asiamah & Fletcher, 2023; Bright et al., 2024; Pradana & Sholikhah, 2023). When combined with the principles of E-RME, video can effectively bridge the gap between abstract mathematical concepts and their cultural applications, especially in teaching the Pythagorean theorem. Research by Nursyahidah, Albab, & Rubowo (2023) shows that students who are taught using culturally relevant examples through video-based instruction show better retention and application of geometric concepts compared to those taught through traditional methods. These findings are crucial for the Pythagorean theorem, as video can effectively describe historical and contemporary applications in a variety of cultural contexts.

However, the integration of video-assisted E-RME in the teaching of the Pythagorean theorem presents unique challenges and opportunities. Studies have identified the need for carefully designed learning sequences in the form of learning trajectories that maintain mathematical rigor while incorporating elements of culture and technological support (Dominikus et al., 2023; Haleem et al., 2022; Lyublinskaya et al., 2024). The effectiveness of such integration depends heavily on the alignment of cultural contexts, mathematical content, and appropriate technological capabilities (Mulyadi & Afriansyah, 2022).

Recent studies on technology-enhanced mathematics education highlight the importance of interactive visual representations in developing geometric understanding (Erath et al., 2021; Serin, 2017; Žakelj & Klančar, 2022). Video, when properly implemented within the framework of E-RME, can provide geometric representation and cultural relevance (Prahmana, 2022). This approach has shown opportunities in helping students transition from a concrete to an abstract understanding (Prahmana, 2022) of the Pythagorean theorem.

Additionally, research indicates that student engagement with mathematical concepts increases significantly when teaching incorporates cultural elements and multimedia presentations (Firdaus & Angraini, 2023; Hetmanenko, 2024). The combination of E-RME and video-assisted instruction creates opportunities for students to explore Pythagorean theorems within a familiar cultural context in their daily lives, while benefiting from the visual and interactive capabilities of digital technology.

The research examines the use of culture and technology separately, and few studies have investigated their combined implementation in teaching geometric principles (Serin, 2017; Young, 2023). Previous research on Pythagorean theorem material, conducted by Fitri (2020) using the RME approach, has not integrated ethnomathematics and video. In this study, the context of the Joglo house is used, which is a traditional house of the Central Java Community (Faiziyah et al., 2024). The use of this context is because the process of building a traditional house involves the concept of triangles and the Pythagorean theorem. The novelty of this study lies in the use of the Joglo house context, which has never been employed in the design of Pythagorean learning before, and with the aid of video.

The integration of these three elements combines the E-RME framework, which emphasizes evidence-based reasoning, with video media that facilitates visualization of proof steps and concrete examples. The Joglo context enriches meaning and cultural relevance, enabling students to become more engaged and transfer their learning to real-world situations. Theoretically, this approach aligns with the seamless learning model between cognitive and contextual understanding, where meaningful learning and cognitive engagement increase when material is presented through multimodality and linked to local culture. This is supported by recent findings showing increased engagement and motivation when mathematics material is packaged in a local cultural context and supplemented by technology, such as video, to visualize abstract concepts.

The study uses a design research methodology, which involves three main stages: initial design, experimental teaching (including pilot and teaching experiment), and retrospective analysis. However, current research is limited to the early stages of design. This study aims to develop a Hypothetical Learning Trajectory (HLT) on Pythagoras for eighth graders using the Joglo house as a context, assisted by video.

2. METHOD

This research employs design research as a framework for developing learning theories and educational tools (Bakker, 2018). The subjects of this study were 33 eighth-grade students, comprising 18 females and 15 males, from public junior high schools in Semarang. Data collection was carried out in the 2025/2026 academic year. Data collection involves a variety of methods, including classroom observations, video recordings, student responses to activity sheets, pre-test and post-test administration, and interviews. The data collected aims to capture the learning process and the thinking process of students. Design research, as outlined by Gravemeijer and Cobb (Gravemeijer & Cobb, 2006), consists of three main stages: (1) preliminary design, which includes reviewing relevant literature, assessing students' problem-solving skills, formulating Hypothetical Learning Trajectory, and designing appropriate learning media; (2) experimental design, which consists of pilot and teaching experiments; and (3) retrospective analysis, in which all data collected is examined in relation to HLT to refine and improve future instructional designs.

This study focuses only on the results of the first phase, i.e., the initial design, because this stage is the most crucial conceptual foundation in design research. This phase involves identifying students' basic abilities, determining their needs in learning Pythagorean concepts, and designing HLTs using the context of Joglo's house, supported by videos. The video used in this study is a video of the Joglo house context, which aims to provide students with a visualization of the framework of the Joglo traditional house and its various components that can represent Pythagorean theorem material. The feasibility of student activity sheets and videos was assessed through validation by mathematics and media experts, as well as subject teachers.

3. RESULT AND DISCUSSION

Several activities were conducted in the first stage of design research, including literature reviews, assessments of students' initial abilities, and the development of a Hypothetical Learning Trajectory. The literature review was conducted by gathering information about the Pythagorean theorem, followed by a review of the literature on E-RME and the research design. This is done to develop a preliminary strategy for designing learning. Furthermore, students' talents should be assessed to identify their prerequisites. The approach outlined above is used to create a dynamic hypothetical learning trajectory that can be adjusted during the teaching experiment. In this study, the examination of students' abilities and the formulation of HLT are described as follows.

a. Examine the basic competencies possessed and needed by students in the Pythagorean theorem material

In studying Pythagorean material for grade VIII junior high school, there are several basic competencies that students already have and competencies that students will obtain. Students already have competencies regarding Pythagorean theorem, such as the basic competencies in the first and second grade are: recognizing and mentioning simple 2D shapes (squares, rectangles, triangles, circles), recognizing simple ED shapes (cubes, blocks, tubes, spheres), recognizing length with non-standard units (for example: inches, steps), starting to recognize straight lines, curved lines, and simple angles. The competencies that have been obtained by grade III students include: using standard units for length (cm, m), drawing and recognizing the properties of simple 2D shapes (squares, triangles, rectangles, parallelograms, trapezoids), recognizing folding symmetry and rotational symmetry, and starting to recognize angles as quantities (although the magnitude has not been calculated). Furthermore, the competencies that have been acquired by grade IV students include calculating the circumference and area of squares, rectangles, and triangles, recognizing perpendicular and parallel lines, understanding the concepts of right-angle, obtuse, and acute angles, and understanding the relationships between lines (parallel, intersecting, and perpendicular). The competencies that grade V students have obtained include determining the circumference and area of various 2D shapes (including triangles), using scales on a simple plan, calculating the volume of 3D shapes (such as cubes and blocks), drawing and recognizing right triangles, and solving problems related to the length of the sides. The competencies that grade VI students have obtained include: solving problems about circumference, area, and volume, recognizing the properties of triangles (equilateral, isosceles, right triangles, arbitrariness), understanding the relationships between angles, and determining the length of the sides of a triangle with a simple strategy (e.g., comparing). The competencies that have been obtained by grade VII students include: calculating the area and circumference of more complex triangles and squares, recognizing and using comparisons (ratios) and scales, solving problems related to parallel lines, angles opposite, solving problems with equal comparisons, and reversing values, recognizing the concept of square roots.

Furthermore, the prerequisite material that must be mastered by grade VIII students includes: general triangles and especially right triangles, recognizing perpendicular, parallel, and rightangle lines, mastering number operations (especially squares and simple square roots), determining the circumference and area of triangles, and understanding the concepts of comparison and coherence of triangles.

b. Developing a Hypothetical Learning Trajectory

After conducting a literature review and assessing the students' existing and needed abilities, the next stage is to compile and produce HLT materials for learning the Pythagorean theorem using the context of the *Joglo* house. This HLT offers a set of learning activity procedures comprising four activities designed to help students understand the material being studied, inspire them, and provide a fun and meaningful learning experience with the aid of video media. The four activities can be described as follows.

Activity 1: The purpose of this initial activity is for students to identify the properties of triangles and the concept of special triangles by observing videos that present the context of the *Joglo* house. In this phase, students are first asked to watch the video. After observation, they completed the activity sheet based on what they had seen. This task required them to identify the triangular shapes on the framework of the *Joglo* traditional house and determine the properties of the triangle, as well as the concept of the special triangle. Student activity sheets are systematically compiled to guide students to achieve the desired learning outcomes. During this process, the teacher's role is to facilitate and encourage students to explore the cultural context further, as well as provide additional insights as needed. Figure 1 illustrates the elements of the *Joglo* house that the students investigated during Activity 1.

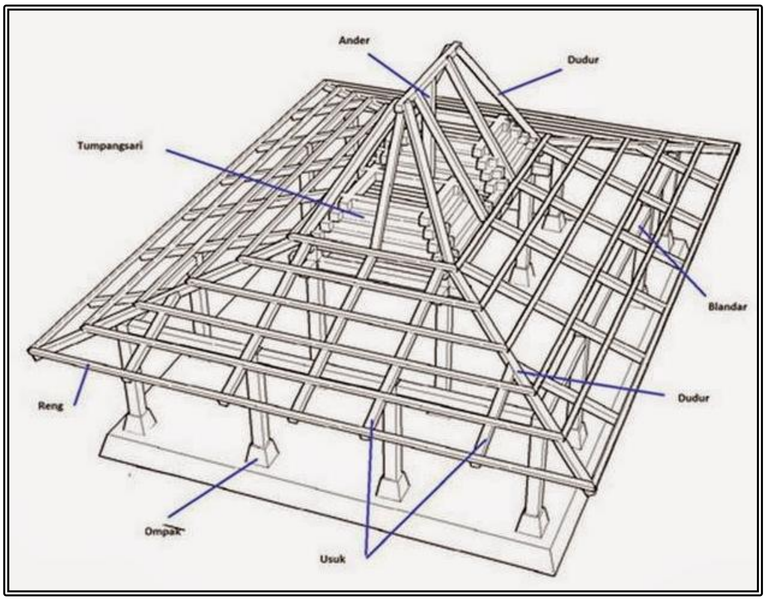

Figure 1. Joglo house as a context

The assumptions of thinking students in activity 1 is illustrated in Table 1.

Table 1. Students' Thoughts in Activity 1

Activity	Conjecture
Engage with *Joglo* house context-based videos	Students can identify the properties of triangles.
Students do activity 1	Students can discover the concept of a special triangle.

Review Activity 1, which identifies the properties of triangles and introduces the concept of Special triangles, is expected to enable students to achieve the formulated learning objectives. Some students tend to have difficulty receiving scaffolding assistance from teachers. The teacher's responsibility is to present students with the findings and information they gain in constructing the concept of a special triangle.

Activity 2: The learning objective in Activity 2 is to find the formula of the Pythagorean Theorem with the help of origami paper and determine the types of triangles based on the length of their sides. Activity 2 began by observing a video of the Joglo house's context and a picture of the *Joglo* house. The purpose of this activity is so that students can find the formula of the Pythagorean Theorem, which states that the length of the square of the hypotenuse side is the result of the sum of the squares of the right sides. Figure 2 illustrates how students discovered or proved the Pythagorean Theorem formula using origami paper.

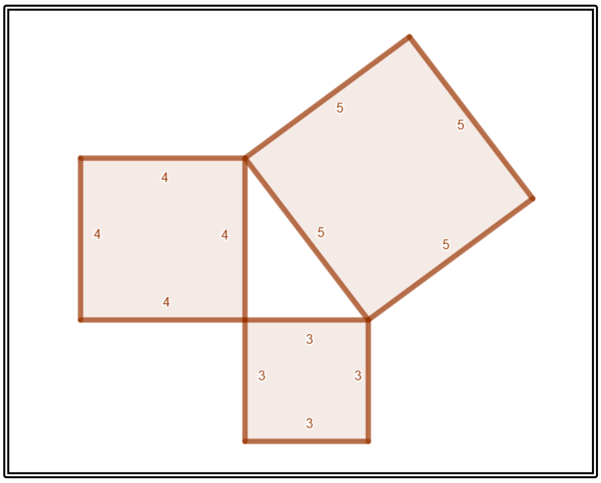

Figure 2. Proof of the Pythagorean Theorem Using Origami

Students are required to discover and prove the Pythagorean Theorem using origami paper. Subsequently, it is relatively easy for students to draw and prove the Pythagorean Theorem, which states that the square of the hypotenuse is equal to the sum of the squares of the other two sides of the right triangle. Through this activity, students are expected to understand the formulas of the Pythagorean Theorem thoroughly. However, if there are still students who have difficulties in this activity, then the role of the teacher is needed as a facilitator, someone who can provide scaffolding so that students can find the concepts being learned.

Throughout the lesson, teachers provide guidance and ask challenging questions to encourage students to think critically and improve their problem-solving abilities related to the Pythagorean theorem. This approach aims to foster active participation and a sense of contribution among students. Table 2 also explains the students' allegations.

Table 2. Student Thoughts in Activity 2

Activity	Conjecture
Observing context-based videos of the *Joglo* house	Students can discover the Pythagorean Theorem
Determining the types of triangles based on the length of their sides	Students can determine the types of triangles based on the length of their sides
Solve problems related to the Pythagorean theorem and the type of triangle based on the length of its sides.	Students can solve contextual problems involving Pythagorean theorems and types of triangles based on the length of their sides.

Upon reflection on Activity 2, where students discover the concept of the Pythagorean theorem and solve problems related to this topic, it is hoped that they can achieve the learning objectives outlined in Activity 2. Some students who are having difficulties will get scaffolding help from teachers. Teachers, as facilitators and motivators, play a crucial role in stimulating students with the findings and information they obtain when building a conceptual understanding of the Pythagorean theorem.

Activity 3: The learning objective in Activity 3 is to solve problems related to the Pythagorean theorem. This activity began with students being given contextual problems related to the Pythagorean theorem, and then discussing them with their group. The goal is to help students apply the Pythagorean theorem through solving problems.

Students can solve contextual problems by applying the Pythagorean theorem that they learn in the previous activity. However, some students may encounter an error in solving the problems, and the teacher can provide scaffolding to help them find the appropriate solution using various possible techniques.

During the learning process, teachers support students by asking thought-provoking questions that aim to improve their high-level thinking skills in solving contextual problems. This approach also encourages students to be more interactive and actively contribute to the learning environment. In addition, the thought processes that students predict are outlined in Table 3.

Table 3. Students' Conjecture in Activity 3

Activity	Conjecture
Applying the Pythagorean theorem concept to solve contextual problems	Students can apply the Pythagorean theorem concept to solve contextual problems

Reflection on Activity 3: By applying the Pythagorean theorem concept to solve contextual problems, it is hoped that students will achieve the learning objectives outlined in Activity 3. Some students who are having difficulties will get scaffolding help from teachers. The role of teachers in this case is to stimulate students to construct the concept of types of triangles.

Based on the findings presented, the initial stage of design research involves preparing for the experiment through three main activities. Some of the activities carried out in the preliminary design stage include conducting a literature review, analyzing the competencies that students currently possess and the competencies they need to acquire, selecting ethnomathematics-based contexts relevant to the Pythagorean theorem material, formulating a Hypothetical Learning Trajectory, and creating innovative instructional media. These activities serve as the basis for developing an initial instructional strategy. The literature review plays an important role in identifying effective initial strategies for formulating HLT (Nursyahidah, Albab, & Rubowo, 2023). This initial design stage is essential for assisting students in understanding Pythagorean Theorem concepts, transitioning from informal to formal mathematical concepts. The use of cultural contexts in the Ethno-RME approach provides a starting point, activities, and meaningful learning resources that facilitate the learning of these concepts more easily and enjoyably. Previous research (Meryansumayeka et al., 2022; Nursyahidah, 2021; Nursyahidah, Albab, & Mulyaningrum, 2023) supports the idea that learning that involves the proper context can increase student engagement (Nursyahidah et al., 2025), conceptual comprehension (Hardiyanto et al., 2024; Nursyahidah et al., 2025), students' problem-solving skills (Andzin et al., 2024; Nursyahidah et al., 2025), and numeracy skills (Nursyahidah et al., 2025).

The instructional design is in line with the five core characteristics of RME outlined by Putri & Zulkardi (2018): 1) Use of context – This study utilizes the ethnomathematical context of Central Java, namely the *Joglo* house. 2) Use of models – Instructional models in constructing the pythagorean theorem help guide students from an informal understanding to formal mathematical concepts. 3) Student contribution – Each activity encourages student input and participation as a pathway to achieving learning goals. 4) Interactivity – Learning involves interaction through discussion, explanation, feedback, collaboration, and evaluation. 5) Intertwinment – Activities integrate related mathematical concepts such as square area, angles, multiplication, division, addition, square roots, and cultural traditions to promote holistic understanding.

Using ethnomathematics as a learning context can stimulate students' understanding and problem-solving skills (Nursyahidah, 2021; Nursyahidah et al., 2025a, 2025 b). Each learning activity is designed to address real-life issues involving Pythagorean theorem concepts, reinforcing the relevance and significance of RME. Students are encouraged to actively participate and apply what they learn in a practical context. Studies by Nursyahidah, Albab, & Rubowo (2023) and Silva et al. (2022) confirm that RME improves the learning experience, while Laurens (2018) highlights its success in improving mathematics achievement.

The HLT design, integrated with E-RME in the Joglo context and video assistance, stands out because it combines local ethnomathematics, concrete object-based reasoning, and dynamic visualization of technology, resulting in a more contextual and multimodal learning trajectory compared to HLT designs based solely on RME learning (Nursyahidah et al., 2025). This design is more innovative, incorporating technological and cultural multimodality to overcome mathematical abstraction (Johar et al., 2025). In contrast, other studies are often limited to static HLT or videos without in-depth evidence of E-RME. The HLT design produced in this study can overcome weaknesses such as a lack of cultural engagement, understanding deficits from 2D images alone, and minimal formal proof reasoning in standard RME. A previous Joglo study (Santoso & Julie, 2024) validated HLT, but without video assistance. Therefore, the HLT design developed in this study can enhance transfer and retention through contextual evidence visualization.

Finally, using Ethno-RME provides a comprehensive method for teaching Pythagorean theorem material. This practice enhances students' conceptual knowledge by incorporating realistic contexts and cultures into daily student life. It can also improve engagement, concept understanding, and problem-solving abilities. These results are supported by previous studies, which have highlighted the effectiveness of E-RME as a forward-thinking and impactful teaching strategy that utilizes technology as a learning medium.

4. CONCLUSION

This research successfully developed a Hypothetical Learning Trajectory for teaching the Pythagorean Theorem through Ethno-Realistic Mathematics Education, utilizing the Joglo house as a cultural context to support students' understanding of concepts related to the Pythagorean Theorem, aided by video. HLTs created during the initial design phase can be implemented in the next phase, the experimental design phase. HLT results include three main activities: (1) observing the context of the Joglo house context video to determine the type of triangle based on its angle and the concept of a special triangle; (2) discovering the concept of the Pythagorean theorem and determining the types of triangles based on the length of their sides; (3) applying the Pythagorean theorem. These findings highlight the potential of integrating local cultural knowledge, as explored through ethnomathematics, with the RME framework to enhance the teaching and learning of the Pythagorean theorem.

Despite these promising results, the study has some limitations. First, it focuses on a specific cultural context, the Joglo house, which may not be directly applicable to students from different regions or cultures. Second, this study only examines the understanding of concepts in Pythagorean theorem material and does not explore other dimensions of learning. Additionally, the limited duration of the intervention and the relatively small sample size may limit the wider application and long-term impact of the findings. Overcoming these limitations in future research could lead to a more in-depth and comprehensive evaluation of the approach.

Based on the results obtained, it is recommended that teachers design learning using an innovative approach that integrates local cultural contexts close to the world of students, RME, and is assisted by technology to help visualize the context used, thereby contextualizing abstract mathematics. Furthermore, future studies are encouraged to build on this research by implementing HLTs developed in a broader context. To develop a varied learning trajectory that takes into account a wide range of cultural and geographical backgrounds, it is necessary to investigate the integration of additional ethnomathematical contexts and expand the range of the E-RME method to include other mathematical subjects and proficiency levels. Through these efforts, researchers and educators can continue to advance mathematics education using instructional strategies that are culturally meaningful and integrated with relevant learning technologies.

ACKNOWLEDGMENT

The authors would like to extend their sincere gratitude to the Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) of Universitas PGRI Semarang for their financial support through the Assignment Research Grant, and the reviewers for their valuable feedback and support for this research paper.

BIBLIOGRAPHY

Afriansyah, E. A. (2022). Peran RME terhadap miskonsepsi siswa MTs pada materi bangun datar segi empat. *Mosharafa: Jurnal Pendidikan Matematika*, *11*(3), 359-368. https://doi.org/10.31980/mosharafa.v11i3.727

Afriansyah, E. A., Permatasari, R. P. D., Hamdani, N. A., & Maulani, G. A. F. (2023, July). How Far is the Mathematical Problem-Solving Ability of Vocational School Students. In *3rd International Conference on Education and Technology (ICETECH 2022)* (pp. 390-403). Atlantis Press.

Agarwal, R. P. (2024). *Mathematics Before and After Pythagoras*. Springer.

Akayuure, P., Asiedu-Addo, S. K., & Alebna, V. (2016). Investigating the Effect of Origami Instruction on Preservice Teachers' Spatial Ability and Geometric Knowledge for Teaching. *International Journal of Education in Mathematics, Science and Technology*, *4*(3), 198-209. https://doi.org/10.18404/ijemst.78424

Andzin, N. S., Sari, P. Y. P., Widodo, R. C., Sukowati, D. I., Indriastuti, S., & Nursyahidah, F. (2024). Arithmetic Sequences and Series Learning Using Realistic Mathematics Education Assisted by Augmented Reality. *Jurnal Pendidikan Matematika*, *18*(1), 139 – 148. https://doi.org/10.22342/jpm.v18i1.pp139-148

Ardhiansah, D., Muhtadi, D., & Apiati, V. (2025). Analysis Of Cognitive Difficulties of Junior High School Students in Solving the Problem of Pythagorean Theorem. *Koordinat Jurnal MIPA*, *6*(1), 25-37.

Arwadi, F., Haris, H., Fudhail, A., Afriansyah, E. A., & Zaki, A. (2024). Kemampuan TPACK Mahasiswa PPL Program Studi PPG Pendidikan Matematika Universitas Negeri Makassar. *Issues in Mathematics Education (IMED)*, *8*(2), 167-172.

Asiamah, O. A., & Fletcher, J. A. (2023). The Effect of Video-Based Pedagogy on Students' Spatial Ability in Solid Geometry. *Asian Journal of Interdisciplinary Research, 6*(4), 26 – 36. https://doi.org/10.54392/ajir2344

Ayyaswamy, K., Raj, A. A., Prathap, S., Madhavakumar, D., Nelson, A., & Kathirvel, N. (2025). An Application of Pythagoras Theorem From Heron's Formula to Derive the Foci of an Ellipse. In *Educational AI Humanoid Computing Devices for Cyber Nomads* (pp. 73-98). IGI Global Scientific Publishing.

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

Bright, A., Welcome, N. B., & Arthur, Y. D. (2024). The effect of using technology in teaching and learning mathematics on student's mathematics performance: The mediation effect of students' mathematics interest. *Journal of Mathematics and Science Teacher*, *4*(2), em059. https://doi.org/10.29333/mathsciteacher/14309

Cholily, Y. M., & Kusgiarohmah, P. A. (2023). Learning Module Analysis of Pythagorean Theorem Based on Scientific Approach. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(3), 3286. https://doi.org/10.24127/ajpm.v12i3.6108

Demirci, S., & Çontay, E. G. (2023). Reaching Pythagorean Theorem by Folding Patty Paper. *Journal of Inquiry Based Activities.* 13(2), 119-131

Deshpande, D. S., Riccomini, P. J., Hughes, E. M., & Raulston, T. J. (2021). Problem Solving with the Pythagorean Theorem: A Think Aloud Analysis of Secondary Students with Learning Disabilities. *Learning Disabilities. Learning Disabilities: A Contemporary Journal*, *19*(1), 23-47.

Dominikus, W. S., Madu, A., Sabon, Z. A. K. W., & Jalo, P. L. (2023). Ethno Mathematics at the Traditional House of Mbaru Niang Wae Rebo, Manggarai. *Journal of Law and Sustainable Development*, *11*(12), e1875. https://doi.org/10.55908/sdgs.v11i12.1875

Efwan, N. S., Afriansyah, E. A., Luritawaty, I. P., Arwadi, F., & Yadav, D. K. (2024). The Level of students' mathematical creative thinking skills as measured by their self-confidence. *International Journal of Didactic Mathematics in Distance Education*, *1*(2), 125-136.

Erath, K., Ingram, J., Moschkovich, J., & Prediger, S. (2021). Designing and enacting instruction that enhances language for mathematics learning: A review of the state of development and research. *ZDM – Mathematics Education*, *53*(2), 245–262. https://doi.org/10.1007/s11858-020-01213-2

Eviliasani, K., Sabandar, J., & Fitriani, N. (2022). Problem-Based Learning Assisted by GeoGebra to Improve Students' Mathematical Understanding. *AL-ISHLAH: Jurnal Pendidikan*, *14*(1), 85–98. https://doi.org/10.35445/alishlah.v14i1.1092

Faiziyah, N., Khoirunnisa', M., Kholid, M. N., Sari, C. K., Nurcahyo, A., Alfiana, T. P., & Nurmeidina, R. (2024, January). Ethnomathematics: An exploration of mathematical concepts in the Joglo traditional house. In *AIP Conference Proceedings* (Vol. 2926, No. 1, p. 020058). AIP Publishing LLC.

Firdaus, D. F., & Angraini, L. M. (2023). Development of Animated Video-based Mathematics Learning on The Three-dimensional Material of Class XII SMA to Improve Mathematical Literacy. *Kreano: Jurnal Matematika Kreatif Inovatif*, *14*(2), https://doi.org/10.15294/kreano.v14i2.39628

Fitri, K. A. (2020). Student strategy in solving PISA problem through realistic mathematics education approach. *Journal of Physics: Conference Series*, *1460*(1). https://doi.org/10.1088/1742-6596/1460/1/012032

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. *In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), Educational design research* (pp. 45-85). Routledge.

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Halini, R, Z., Pasaribu, R. L., Mirza, A., & Afriansyah, E. A. (2023). Students' Scientific Attitudes and Creative Thinking Skills. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(2), 315–326. https://doi.org/10.31980/mosharafa.v12i2.786

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.

Hetmanenko, L. (2024). The role of interactive learning in mathematics education: Fostering student engagement and interest. *Multidisciplinary Science Journal*, *6*, 2024ss0733. https://doi.org/10.31893/multiscience.2024ss0733

Kaviya, M. D., & Suryadharani, M. P. (2025). Connecting Mathematics to Real-World Applications: A Review of Practical Teaching Approaches. *Contemporary Techniques in Math Education*.

Kusumaryono, S., Santosa, A., Rahayu, A. P., & Sumartini, T. S. (2025). Comparing the Effectiveness of Learning Video Media and the Imitation Model in Enhancing Mathematical Learning Outcomes and Student Motivation. *Mosharafa: Jurnal Pendidikan Matematika*, *14*(2), 405 – 412. https://doi.org/10.31980/mosharafa.v14i2.2712

Mulyadi, R., & Afriansyah, E. A. (2022). Pengaruh literasi digital terhadap kemandirian belajar matematika siswa. *Math Didactic: Jurnal Pendidikan Matematika*, *8*(2), 183-191.

Musri'ah, I, Aziz, A., Sulistyaningsih, D. (2025). Implementasi Model Connecting, Organizing, Reflecting, Extending terhadap Kemampuan Penalaran Matematis Materi Teorema Pythagoras Kelas VIII. *Pendas: Jurnal Ilmiah Pendidikan Dasar*. 10(4), 522-539.

Laurens, T. (2018). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569 – 578. https://doi.org/10.12973/ejmste/76959

Lutfi, A., Indria Sari, A. A., Stiadi, E., & Lestary, R. (2022). Meningkatkan Kepercayaan Diri Siswa Menggunakan Problem Solving dan Problem Posing Berbasis Pendekatan Scientific. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, *6*(3), 308 – 315. https://doi.org/10.33369/jp2ms.6.3.308-315

Lyublinskaya, I., Okita, S., Walker, E., & Yan, X. (Kitty). (2024). Developing teachers' cultural competencies through co-design of robot-coding mathematics activities for Latinx and Black elementary school students. *London Review of Education*, *22*(1). 1-14. https://doi.org/10.14324/LRE.22.1.11

Maulandani, S., & Afriansyah, E. A. (2024). Mathematical Reasoning Skills Review of Student Self-Regulated Learning in Number Pattern. *Plusminus: Jurnal Pendidikan Matematika*, *4*(1), 27-46. https://doi.org/10.31980/plusminus.v4i1.1685

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

Nursyahidah, F. (2021). Learning Design on Surface Area and Volume of Cylinder Using Indonesian Ethno-mathematics of Traditional Cookie maker Assisted by GeoGebra. In *Mathematics Teaching-Research Journal, 13*(4), 79 – 98.

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.17.3.20040

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

Nursyahidah, F., Wardono, W., Mariani, S., & Wijayanti, K. (2025a). 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

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

Pradana, L. N., & Sholikhah, O. H. (2023). Spatial Reasoning Construction: The Way to Use It to Solve Geometric Problems. *Jurnal Pendidikan Matematika*, *17*(2).

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. (2022). Ethno-realistic mathematics education: The promising learning approach in the city of culture. *SN Social Sciences*, *2*(12), 257.

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

Rahman, A. A. (2020). The feasibility of pbl-reathnomath model to train hots of elementary school students. *Advances in Mathematics: Scientific Journal*, *9*(11), 9887 – 9908. https://doi.org/10.37418/amsj.9.11.99

Ridho, M. H., Mulyaning, E.C.A., Dahlan, J.A. (2023). Analysis of Students' Mathematical Representation Ability on Pythagoras Theorem in Junior High School. *International Conference on Studies in Education and Social Sciences*. Oct. 20-23, Antalya, Turkey.

Santosa, F. D. W., & Julie, H. (2024). Realistic mathematics learning in Joglo traditional house culture to teach the concept of surface area constructing space. *Proceedings of the International Conference on Mathematics and Mathematics Education* (pp. 123-135). Atlantis Press.

Serin, H. (2017). Technology-integrated Mathematics Education: A Facilitating Factor to Enrich Learning. *International Journal of Learning and Development*, *7*(4), 60-67. https://doi.org/10.5296/ijld.v7i4.12082

Silva, R. A. (2022). Ethnomathematics Approach as a Tool for Cultural Valuation and Social Representativity: Possibilities in a Quilombola Community in the State of Amap á —Brazil. In *Mathematics Enthusiast, 19*(2), 370 – 393. https://doi.org/10.54870/1551-3440.1557

Tokanov, M., Damekova, S., Kuttykozhayeva, S., Abdoldinova, G., & Smagulov, Y. (2023). Information and communication technology integration and teaching mathematics in higher education. *Journal on Mathematics Education*, *13*(4), 739 – 752. https://doi.org/10.22342/jme.v13i4.pp739-752

Wulandari, L., & Riajanto, M. L. E. J. (2020). Analisis Kesulitan Siswa SMP dalam Menyelesaikan Soal Materi Teorema Pythagoras. *Jurnal Riset Pendidikan dan Inovasi Pembelajaran Matematika (JRPIPM)*, *3*(2), 61-67. https://doi.org/10.26740/jrpipm.v3n2.p61-67

Wulandari, S., Syahbana, A., Tanzimah, T., Shang, Y., Weinhandl, R., & Sharma, R. (2021). Analysis of students' thinking level in solving Pythagoras' theorem problems based on Van hiele's theory. *Malikussaleh Journal of Mathematics Learning (MJML)*, *4*(2), 124-130. https://doi.org/10.29103/mjml.v4i2.3905

Young, J. R. (2023). The Role of Technology in Enhancing Urban Mathematics Education. *Journal of Urban Mathematics Education*, *16*(2), 1 – 13. https://doi.org/10.21423/jume-v16i2a589

Yulianto, A., Sisworo, S., & Hidayanto, E. (2022). Pembelajaran matematika berbantuan video pembelajaran untuk meningkatkan motivasi dan hasil belajar peserta didik. *Mosharafa: Jurnal Pendidikan Matematika*, *11*(3), 403-414. https://doi.org/10.31980/mosharafa.v11i3.731

Žakelj, A., & Klančar, A. (2022). The Role of Visual Representations in Geometry Learning. *European Journal of Educational Research*, *11*(3), 1393 – 1411. https://doi.org/10.12973/eu-jer.11.3.1393

Zhang, Y. (2025). The exploration of the interdisciplinary education of mathematics in universities: a case study of mathematics and finance. *Frontiers in Interdisciplinary Educational Methodology*, *2*(2), 74-80.

AUTHOR BIOGRAPHY

	**Farida Nursyahidah, S.Pd., M.Pd.** Faculty member at Universitas Persatuan Guru Republik Indonesia Semarang. Completed undergraduate studies in Mathematics Education at Universitas Negeri Semarang, Semarang, in 2010; Completed graduate studies in Mathematics Education at Universitas Sriwijaya, Palembang, in 2013.
	**Dr. Muhtarom, S.Pd., M.Pd.** Faculty member at Universitas Persatuan Guru Republik Indonesia Semarang. Completed undergraduate studies in Mathematics Education at IKIP PGRI Semarang, Semarang, in 2009; Completed graduate studies in Mathematics Education at Universitas Sebelas Maret Surakarta, and doctoral studies in Mathematics Education at Universitas Negeri Surabaya, in 2019.
	**Irkham Ulil Albab, S.Pd., M.Pd.** Faculty member at Universitas Persatuan Guru Republik Indonesia Semarang. Completed undergraduate studies in Mathematics Education at IKIP PGRI Semarang, Semarang, in 2011; Completed graduate studies in Mathematics Education at Universitas Sriwijaya, Palembang, in 2014.
	**Maya Rini Rubowo, S.Pd., M.Si.** Faculty member at Universitas Persatuan Guru Republik Indonesia Semarang. Completed undergraduate studies in Mathematics Education at IKIP Semarang, Semarang, in 1997; Completed graduate studies in Mathematics at Universitas Gajah Mada, Yogyakarta, in 2003.
	**Windia Hadi, S.Pd., M.Pd.** Faculty member at Universitas Muhammadiyah Prof. DR. HAMKA. Completed undergraduate studies in Mathematics Education at Universitas Muhammadiyah Prof. DR. HAMKA, in 2013; Completed graduate studies in Mathematics Education at Universitas Pendidikan Indonesia, in 2015; and now as a doctoral student at the Doctoral school of education, University of Szeged, Hungary.