UJME 14 (2) 2025: 167-178
UNNES JOURNAL OF MATHEMATICS EDUCATION
https://journal.unnes.ac.id/journals/ujme
ISSN: 2252-6927 (print); 2460-5840 (online)

Development of Digital Puzzle Based on Indonesian Traditional Houses as Virtual Manipulative Learning Media for Plane Geometry

Kufita Rachman[a,*], Azza Ilvana Mas'ud[a], Siti Raihani Vesya[a], Ade Putri Arbiyanti[a] , Ilham Rasyid[a]

[a] *Department of Elementary School Education, Yogyakarta State University, Yogyakarta, 55281, Indonesia*

** E-mail address: kufitarachman.2021@student.uny.ac.id*

ARTICLEINFO

Article history:
Received 9 July 2025
Received in revised form 30 August 2025
Accepted 31 August 2025

Keywords:
Digital Puzzles; Elementary School; Mathematics; Plane Geometry; Virtual Manipulation Media

Abstract

The gap between the theory of plane geometry and real-life contexts occurs because the media often used only teach procedurally, resulting in weak conceptual understanding among students. Based on this, this research aims to develop a digital puzzle based on traditional houses that is suitable and practical for use as a virtual manipulative medium to bridge contextual understanding toward conceptual understanding. This research used a Research and Development (R&D) design and the 4-D model (define, design, develop, and disseminate) with interview guidelines and feasibility and practicality questionnaires as instruments, which were administered to 25 fourth-grade elementary school students. The results of validation by content and media experts indicate a very feasible category with feasibility percentages of 88% and 97.5%. This media is considered very practical to use, with a practicality percentage of 81.7%. These findings show that Digital Puzzle Media based on Traditional Houses is well-suited for teaching plane geometry in elementary school.

1. Introduction

In ordinary life, mathematical concepts become tangible through various shapes and structures in the surrounding environment. One of the initial mathematical concepts that helps understand shapes and the relationships between parts in geometric structures, both visually and analytically, is plane figures. The research by Tay & Preciado Babb (2023) discusses that plane figures are an important foundation for the development of advanced geometric thinking in mathematics among elementary school students. This aligns with research that highlights the role of plane figures in building visual logic and spatial reasoning in elementary school students, thereby explicitly enabling students to understand the properties and shapes of objects around them (Gambini, 2022; Jablonski & Ludwig, 2023). However, there is a gap between the urgency of understanding flat geometry and the reality on the ground, where some students still face difficulties in comprehending it.

The difficulties in understanding and applying the concept of flat shapes experienced by students include difficulties in recognizing sides, distinguishing between regular and irregular polygons, and determining the names of the flat shapes that have been stied (Herawati et al., 2022). The factors behind this problem were explored by the research of Samsudin & Nugraha (2024), which found that the learning media commonly used, such as textbooks and formulas, were too procedural, failing to builstudents' conceptual understanding of flat shapes. In line with Makhdum et al. (2023), some students experience difficulties in learning mathematics, which can be influenced by the instructional techniques used by the teacher. Additionally, a study using an onto-semiotic approach was conducted to identify the constraints faced by elementary school students in understanding flat shapes and found three main types of constraints:

To cite this article:
Rachman, K., Mas'ud, A. I., Vesya, S. R., Arbiyanti, A. P., & Rasyid, I. (2025). Development of Digital Puzzle Based on Indonesian Traditional Houses as Virtual Manipulative Learning Media for Plane Geometry. *Unnes Journal of Mathematics Education*, *14*(2), 167-178. https://doi.org/10.15294/ujme.v14i2.29951

cognitive maturity, understanding of mathematical situations, and teaching strategies used by teachers (Milinia & Amir, 2022). Referring to Piaget's theory, elementary school students are generally at the concrete operational stage cognitively, which allows them to begin understanding mathematical logic and relationships. However, learning media that can be visualized well is needed to support their understanding (Oogarah-Pratap et al., 2025). The exposure indicates that there is a need for learning media that aligns with the concrete operational cognitive development to support the understanding of flat shapes.

One of the efforts to bridge concrete cognition with conceptual abstraction at the concrete operational stage of elementary school students can be done through manipulative media that support mathematical thinking, problem-solving, direct learning, and deep understanding of the material (Makhdum et al., 2023; Tjandra, 2023). According to Horan & Carr (2018), manipulation is a physical object that gives students firsthand experiences and actively involves them in the learning process. Virtual manipulatives are the result of the advancement of digital technology over time. Virtual manipulation refers to interactive digital representations of objects that can be accessed through various electronic devices and are designed to represent mathematical concepts, allowing students to interact directly with objects on the screen (Bouck & Park, 2018; Yakubova et al., 2024). Virtual manipulation can be tailored to students' needs to be more interactive, for example, by providing additional instructions or assistance, making it easier for students who struggle to understand mathematical concepts (Ismail et al., 2023; Long et al., 2022). Studies show that interactive learning media, particularly digital-based, have proven effective in increasing motivation and accelerating the understanding of two-dimensional geometry and the abstraction of flat shape concepts in elementary schools (Chusna et al., 2024; Ng et al., 2020; Purnama, 2024). Among various digital manipulative media, puzzles stand out as a simple yet flexible form, consisting of flat geometric pieces and allowing students to assemble a variety of meaningful shapes. The effective use of puzzle media can encourage the improvement of understanding and learning outcomes of flat shapes among elementary school students (Hasni et al., 2024). The advantages of interactive virtual manipulatives like this puzzle can support mathematical understanding by opening up opportunities for integrating local culture through an ethnomathematics approach to create more meaningful learning.

The ethnomathematics approach can enrich the learning experience by connecting mathematical ideas with students' cultural backgrounds, creating more meaningful learning (Payadnya et al., 2024). Research by Sudrajat et al. (2024) proves that the ethnomathematics approach can enhance students' understanding of flat shapes through cultural exploration. In line with these findings, the ethnomathematics approach is also capable of connecting mathematical abstractions through everyday cultural contexts such as weaving patterns, traditional architecture, and economic activities, thereby facilitating students' mastery of various mathematical concepts (Fatimah et al., 2024; Rosa & Orey, 2021). Moreover, the ethnomathematics approach also promotes inclusive learning by respecting students' cultural identities, thereby building engagement and confidence during mathematics instruction (Fouze & Amit, 2021). Research by Rachman et al. (2025) has developed interactive digital learning media with an ethnomathematics approach based on the culture of the Kaliurang area, which has been proven valid for supporting geometry learning for elementary school students. In the context of ethnomathematics related to plane geometry, one of the local cultural representations rich in geometric elements and potential for integration into mathematics education is the traditional Indonesian house shape. Shapes such as triangles, rectangles, trapezoids, as well as symmetry and repetition patterns, are commonly found in the design of traditional house constructions. Research by Anwar et al. (2024) proves that structures such as the traditional houses of the Tengger Tribe contain mathematical concepts that can be utilized in geometry learning through an ethnomathematics approach. Based on that study, the integration of ethnomathematics of traditional houses in the development of learning media not only enriches the local cultural context but also supports the development of meaningful digital manipulative media that aligns with the cognitive characteristics of elementary school students.

Recent research shows that virtual manipulative media and interactive digital tools effectively enhance students' understanding of geometry and learning motivation (Altiparmak & Ercan, 2025; Chusna et al., 2024; Purnama, 2024; Rahayu & Suarjana, 2024), while the ethnomathematics approach through local cultural contexts such as traditional houses has proven to strengthen the understanding of flat shapes, including through puzzles in the form of traditional games (Suryaningsih & Munahefi, 2021), local wisdom-based flat shape cutouts (Wulansari et al., 2022), and the concrete assembly of Joglo house shapes (Wasono et al., 2024). However, there is still a research gap in integrating the ethnomathematics of traditional houses

in Indonesia from every island into a single learning medium in the form of a Digital Puzzle. This study offers novelty through the development of a Digital Puzzle media based on Indonesian traditional houses that combines virtual manipulative principles and ethnomathematics approaches simultaneously. Unlike previous studies that tend to separate digitalization and cultural context, this media is designed to strengthen students' visual-spatial engagement and understanding of flat shapes through the contextual exploration of geometric forms in traditional architecture, tailored to the cognitive stages of elementary school students.

The urgency of this research lies in the understanding of elementary school students regarding flat shapes, which remains a challenge, especially because the learning media used tend to be procedural and do not support interactive visual or spatial exploration. On the other hand, students at the concrete operational stage require concrete or visual media to understand abstract concepts. Meanwhile, there is potential in approaches that combine cultural contexts, such as ethnomathematics, which have proven capable of making learning more meaningful and relevant. Based on this, this research aims to develop digital puzzle learning media based on traditional houses that integrates visual manipulatives in virtual form and ethnomathematics to support contextual, interactive flat shape learning that aligns with the cognitive characteristics of elementary school students. This research provides a theoretical contribution by enriching the study of digital manipulative-based mathematics learning media integrated with ethnomathematics, in line with students' cognitive development stages. This research provides a theoretical contribution by enriching the study of digital manipulative-based mathematics learning media integrated with ethnomathematics, in line with the cognitive development stages of students. Practically, the digital puzzle based on traditional houses developed can be used as an interactive medium to enhance the understanding of flat shapes while fostering appreciation for local culture in mathematics learning at the elementary school level.

2. Methods

This study employed a mixed method, combining a qualitative and quantitative approach with an R&D design. The aim of research and development (R&D) was to create goods that were valid through study and evaluation. In order to create a contextual and inventive Digital Puzzle Media Based on Traditional Houses, this study applied the 4-D model R&D design (defined, designed, developed, and disseminated). The define stage determined the demand for educational materials based on the cognitive growth of fourth-grade students in the concrete operational stage. The design stage included the selection of media in the form of a Digital Puzzle based on Traditional Houses and the initial design in the form of determining learning outcomes and objectives. The development stage produced media using PowerPoint and image elements from Pinterest, which were then validated by subject matter and media experts before being tested on students. The dissemination stage involved distributing the product to elementary schools. This model was chosen because it could identify the real needs of students, develop theory-based products, and test the feasibility and practicality of the media before implementation.

The research instruments in the form of interview guidelines and questionnaires were adapted from previous studies that had been tested for validity and reliability. Interviews were conducted with the 4th-grade teachers of SD Negeri 1 Tambi for needs analysis. Additionally, lecturers at Yogyakarta State University's Elementary School Teacher Education program with a focus on mathematics and learning media used questionnaire tools to evaluate the feasibility of the materials and learning media. Additionally, students' answers to a questionnaire were used to gauge the practicality of the media it represented.

This research used the random sampling technique involving 25 fourth-grade students from SD Negeri 1 Tambi as the sample. The inclusion criteria in this study included, among others, 4th-grade students during the academic year of the study, who participated in mathematics learning specifically on flat shapes, and who obtained permission from responsible parties, such as parents and the school, to participate. Meanwhile, exclusion criteria were set for students who did not fully participate in the learning process during the research period and students who refused consent to be involved in the research process.

Qualitative data analysis from interviews was conducted descriptively through condensation, presentation, and conclusion drawing. Meanwhile, the quantitative data from the questionnaire were statistically analyzed using Microsoft Excel. The acquisition of questionnaire scores to assess feasibility, according to Arikunto (2014), used the following formula.

$$\text{Feasibility} = \frac{\text{Total score accomplished}}{\text{Total maximum score}} \text{ x } 100\%$$

After conducting the feasibility assessment process, the results were described based on the feasibility categories according to Arikunto (2014), as shown in Table 1.

Table 1. Feasibility Criteria

Score	Category
0% − 20%	Not Feasible
21% − 40%	Less Feasible
41% − 60%	Feasible Enough
61% − 80%	Feasible
81% − 100%	Very Feasible

Based on the feasibility criteria in the table above, the development of the Digital Puzzle Media Based on Traditional Houses was at least within the score range of 61%–80%. Furthermore, to calculate the practicality response data from students' questionnaires, the following formula was used..

$$\text{Practicability} = \frac{\text{Total score accomplished}}{\text{Total maximum score}} \times 100\%$$

After calculating practicality, the Digital Puzzle Media Based on Traditional Houses was categorized according to the criteria in Table 2.

Table 2. Practicality Criteria

Score	Category
0% − 20%	Not Practical
21% − 40%	Less Practical
41% − 60%	Practical Enough
61% − 80%	Practical
81% − 100%	Very Practical

3. Results & Discussions

This research develops digital puzzle learning media based on traditional houses for flat shape learning in elementary schools. The research design uses research and development with the 4-D model, which includes four stages: the define stage, the design stage, the develop stage, and the disseminate stage as follows..

3.1 Define stage

The purpose of the define stage is to determine and define the needs related to learning media, in accordance with the cognitive development of elementary school students. The results of the interview conducted with the 4th-grade teacher at SD Negeri 1 Tambi revealed that the learning tools, such as the media used for flat shapes material, still consist of textbooks and formulas that are too procedural in nature. This does not adequately support the conceptual understanding of elementary school students, whose cognitive development isat the concrete operational stage, thus requiring media that can help visualize flat shape concepts. Based on the problems identified in the field, the development of virtual manipulation media is needed to help students understand the concept of flat shapes according to their developmental stage. In addition, at this stage, information is also being collected to support the development of Digital Puzzle Media Based on Traditional Houses, such as design tools, content materials, cultural references, and relevant pedagogical resources.

3.2 Design stage

At the design stage, content mapping planning is also carried out at this stage, flat shape materials are selected and mapped according to the curriculum used, namely the independent curriculum. The learning

outcomes used are that students can identify the characteristics of various flat shapes (sides and angles) in terms of quantity, compose (composition), and decompose (decomposition) various flat shapes in more than one way.

Next, planning was carried out to integrate local culture into the traditional house forms, such as roof shapes, windows, and shapes containing geometric elements, which were adapted into puzzle pieces to enable students to learn about flat shapes while also building knowledge of culture. The design planning also considers the appeal in terms of elements, layout, and colors, as well as navigation to ensure it is user-friendly for elementary school students. The Digital Puzzle Media Based on Traditional Houses is designed using the HTML format because it is lightweight, can be opened on various devices, and is easy to integrate with interactive elements such as drag-and-drop, shape animations, and audiovisuals. When the Digital Puzzle Media based on the Traditional House is run, a display like that in Figure 1 will appear. If you want to start learning, students can click "Start".

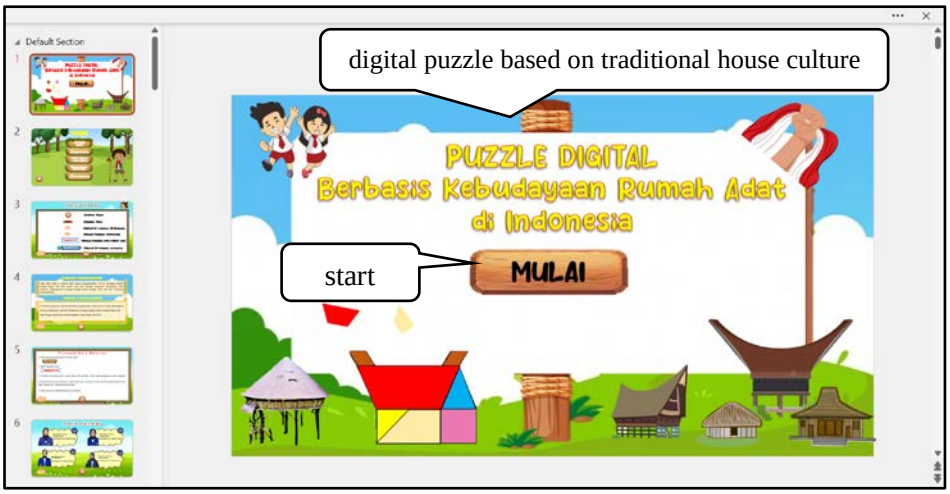

Figure 1. The Home Page of the Puzzle Digital Media based on Traditional Houses
Source: Compilation Team, 2025

Next, the main menu will appear, consisting of three sections: usage instructions, learning objectives and achievements, and playing the Digital Traditional House Puzzle. The instructions menu provides technical guidance, while the learning objectives and achievements explain the competencies to be achieved. The main menu "Playing Traditional House Puzzle" presents an interactive activity of assembling the shape of a traditional house from flat geometric pieces digitally. The main menu display is presented in Figure 2.

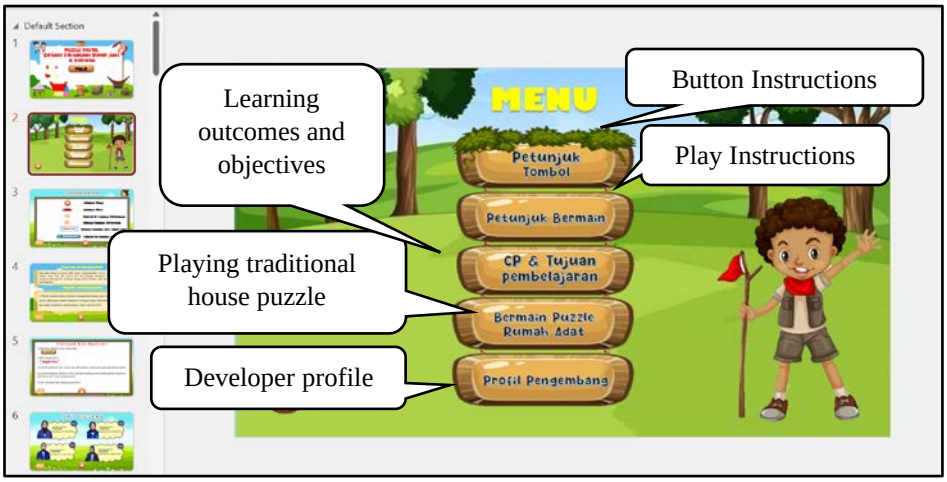

Figure 2. Digital Puzzle Media Menu Page based on Traditional House
Source: Compilation Team, 2025

The user instruction menu interface is designed to make it easier for students to operate the Digital Puzzle Media Based on Traditional Houses, with intuitive and easy-to-understand icons and buttons. This feature aims to provide a step-by-step guide before students start the puzzle assembly activity to facilitate their use of the Digital Puzzle Media Based on Traditional Houses, as shown in Figure 3.

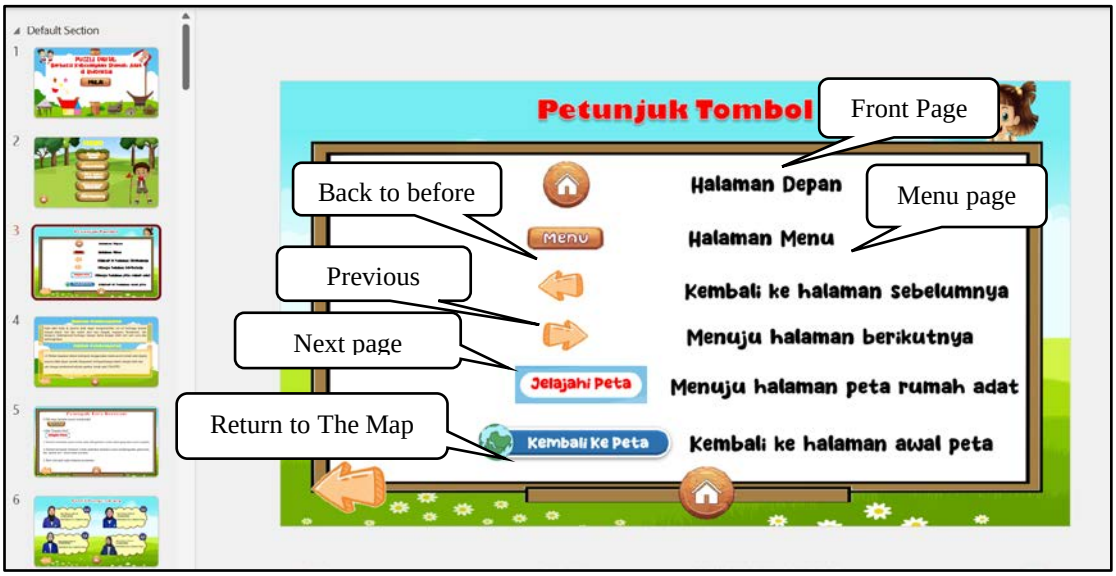

Figure 3. Instruction Page for Puzzle Digital Media Button based on Traditional House
Source: CompilationTeam, 2025

The appearance of the achievement and learning objectives menu is designed to provide information to students regarding the competencies to be achieved. This menu helps students understand the direction and benefits of the learning activities to be undertaken. The appearance of the achievement and learning objectives menu can be seen in Figure 4.

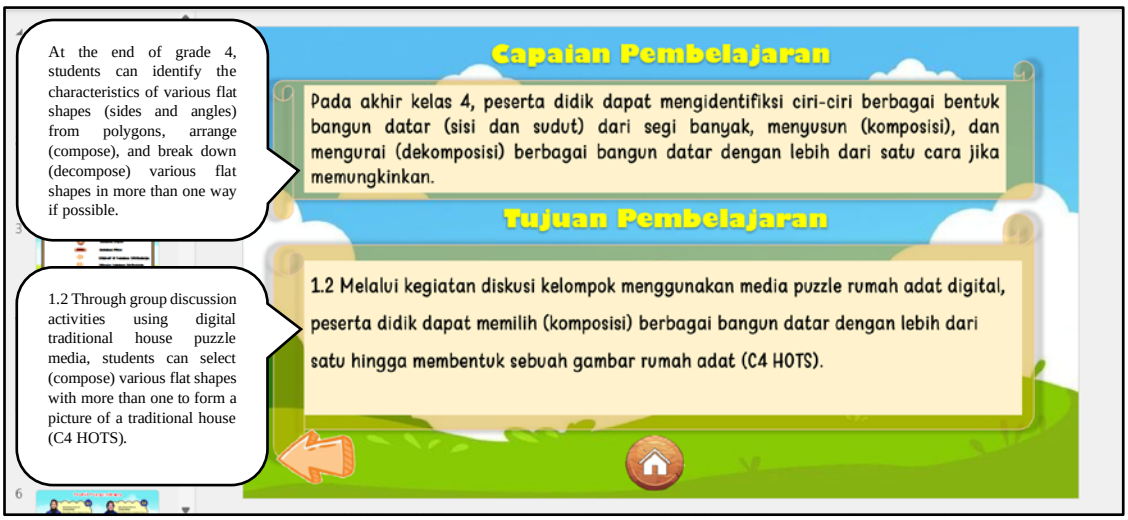

Figure 4. Menu of Learning Outcomes and Objectives
Source: Compilation Team, 2025

The Digital Puzzle Game Menu Based on Traditional Houses presents interactive activities that can be played by students. In this menu, students are asked to arrange flat geometric pieces into meaningful traditional house shapes. Students can arrange the flat geometric pieces into the shapes of the Honai, Bolon, Tongkonan, Bidayuh, and Joglo traditional houses. The appearance of this menu can be seen in Figure 5.

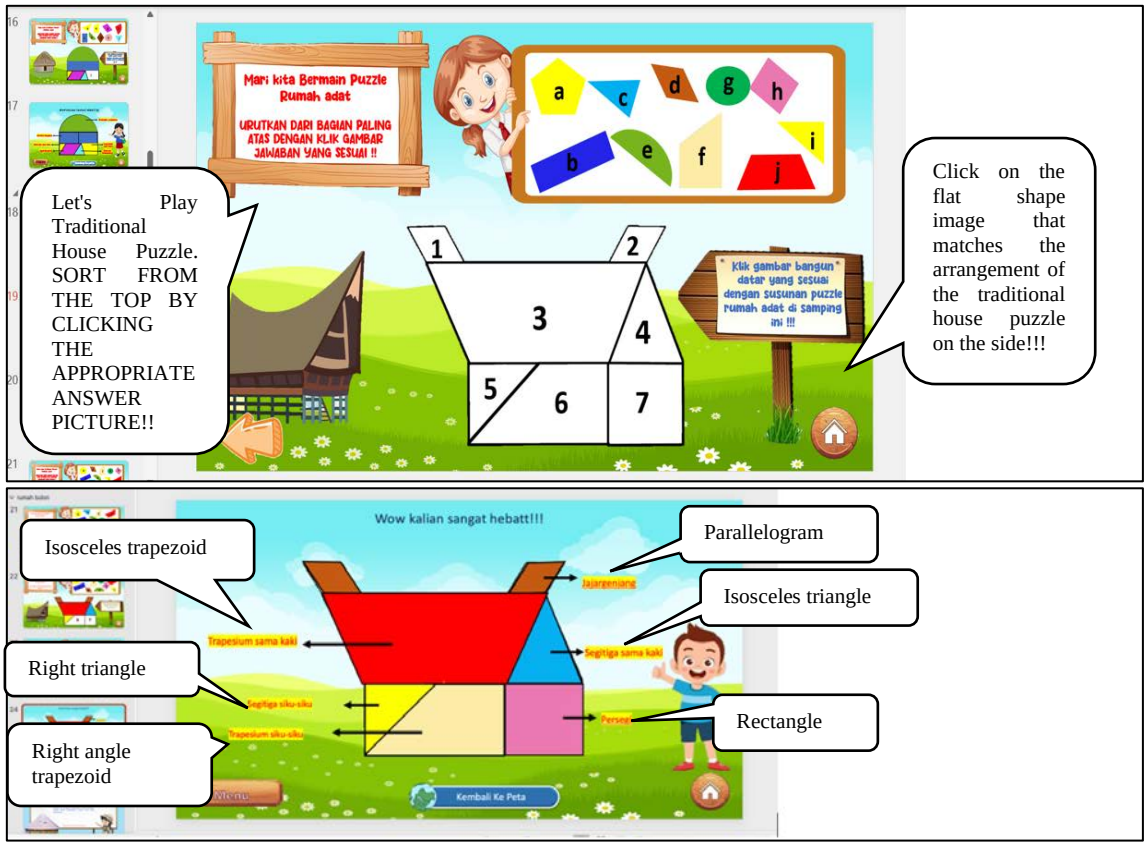

Figure 5. Digital Puzzle Game based on Traditional House
Source: Compilation Team, 2025

The use of Digital Puzzles Based on Traditional Houses by 4th-grade students during lessons aims to help students understand flat shapes. Additionally, this media can provide an interactive learning experience, as students are directly involved in assembling various types of flat shapes until they can form a traditional house. Digital Puzzles Based on Traditional Houses can be used as a reference and teaching resource for teachers on flat shapes for 4th-grade students.

3.3 Development stage (develop)

At this stage, a Digital Puzzle Media Based on Traditional Houses is produced and converted into HTML format to be validated by subject matter experts and media experts for revision so that the media is suitable for use before being tested on students in the field. The subject matter expert in this study is a lecturer from the Department of Elementary School Teacher Education at Yogyakarta State University, specializing in mathematics, with a total of one person. The media expert in this study is a lecturer from the Department of Elementary School Teacher Education at Yogyakarta State University, specializing in educational technology, with a total of one person. The evaluation results of the subject matter expert on the Digital Puzzle Media Based on Traditional House that has been developed are presented in Table 3.

Table 3. Results of the Expert Material Feasibility Assessment

Aspect	Average Score Achievement	Percentage	Category
Relevance of the Material	3.4	85%	Very Feasible
Organizing Material	3.5	87.5%	Very Feasible
Strategies for Learning	3.7	92%	Very Feasible
Total Score	**35**	**88%**	**Very Feasible**

Based on the results of the material expert assessment, the material relevance aspect received an average score of 3.4 or 85 % so that it was in the "Very Feasible" category. The material organization aspect gets an average score of 3.5 or 87.5 % so that it falls into the "Very Feasible" category. The aspect of strategies for learning received an average score of 3.7, so it was in the "Very Feasible" category. The average final score of the material expert is 3.5 or 88 % so it is included in the "Very Feasible" category. Material experts provide input to make minor improvements according to suggestions regarding the relevance of the material contained in the Indigenous House-Based Digital Puzzle media to the selected learning outcomes. The material expert gave a conclusion based on the assessment score that the material in the media was "Suitable for testing with revisions according to suggestions".

In line with the findings of Apriyus et al. (2020) who developed digital learning media with similar material assessment aspects and demonstrated product feasibility. Interactive learning media such as this Digital Puzzle Based on Traditional Houses, then need to be assessed for material feasibility to be tested in the field by students (Ananda et al., 2022). According to Warsita (2019), if any material inconsistencies are found in the developed media, revisions and improvements need to be made to ensure that the media truly supports the achievement of learning objectives, as was done in this development. The findings of the development of the Digital Puzzle Based on Traditional Houses, with the material concluded to meet feasibility, aim to support the learning of flat shapes. In line with Schroth (2019), who developed visual manipulation media conceptually by assembling flat geometric pieces into a shape known as a tangram puzzle, paying attention to appropriate content that can enhance the understanding of flat shapes and students' ability to recognize shapes and patterns.

After the feasibility of the material was assessed, an expert media evaluation was conducted on the Digital Puzzle Media Based on Traditional Houses that was developed. The final results of the feasibility assessment are presented in detail in Table 4.

Table 4. Results of Media Expert Assessment

Aspect	Average Score Achievement	Percentage	Category
Design Appearance Aspects	3.7	92%	Very Feasible
Aspect of Letters	4	100%	Very Feasible
Language Aspect	4	100%	Very Feasible
Total Score	**3.9**	**97.5%**	**Very Feasible**

Based on the assessment of media experts, the letter display aspect received an average score of 3.7 or 92% including the "Very Feasible" category. The font aspect gets an average score of 4 or 100% including the "Very Feasible" category. The language aspect received an average score of 4 or 100% including the "Very Feasible" category. The average final score from media experts is 3.9 or 97.5% so it is included in the "Very Feasible" category. Media experts provide input to make slight improvements according to suggestions regarding the color contrast of the elements of the media display design of the Indigenous House-Based Digital Puzzle. The media expert gave a conclusion based on the assessment score that the media was "Suitable for testing with revisions according to suggestions".

These findings are in line with the findings of Primasatya & Mukmin (2020), where learning media products with high validity will be field-tested after minor revisions. Although the media received a very feasible final score, the expert's suggestion for improvement regarding color contrast is not merely aesthetic but important to ensure interest, readability, and understanding effectiveness for elementary school students. Referring to related research, the selection of relevant, contrasting, and cognitively appropriate colors can guide attention, motivate students, support cognitive and affective processes, and reduce cognitive load to enhance retention in multimedia learning (Désiron & Schneider, 2024). These findings align with the effectiveness of digital puzzles in enhancing the quality of learning, which is also influenced by appropriate visual design. This is supported by Ariyanti & Ahsani (2022) who found that digital puzzle media effectively improves the learning outcomes of elementary school students.

Then, the Digital Puzzle Media Based on Traditional Houses, which had its material and media feasibility validated, was tested on 25 fourth-grade students at SD Negeri 1 Tambi during flat shape learning. Students conducted an assessment using a practicality questionnaire to refine the developed

media. Details of student assessments related to the practicality of the Digital Puzzle Media Based on Traditional Houses are presented in Table 5.

Table 5. Practicality Assessment Results

Aspect	Average Score Achievement	Percentage	Category
Ease of Use	3	75%	Practical
Learning Time Efficiency	3.3	82.5%	Very Practical
Meaningfulness in Learning	3.5	87.5%	Very Practical
Total Score	**3.2**	**81.7%**	**Very Practical**

Based on student assessment, the ease of use aspect received an average score of 3 or 75% including the "Practical" category. The learning time efficiency aspect received an average score of 3.3 or 82.5% including the "Very Practical" category. The aspect of meaningfulness in learning received an average score of 3.5 or 87.5% including the "Very Practical" category. The average final score of practicality in the trial conducted by students as a whole was 3.2 or 81% so that it included "Very Practical". Students commented that the Indigenous House-Based Digital Puzzle media was fun to use and helped them understand flat building materials during learning. It can be concluded that the Indigenous House-Based Digital Puzzle media can be used to support flat building learning in the classroom.

The findings of this evaluation of media practicality are consistent with the findings of Himmah et al. (2022) study, which discovered that interactive media in HTML format is highly useful for educational purposes. If learning materials are enjoyable to use and may boost students' motivation while they are learning, they are deemed practical. This finding is consistent with related research that indicates that because learning media are varied and aligned with the content, their use may impact students' motivation to study (Panggabean & Shaleha, 2022). Moreover, the findings of this research are also in line with the study by Rachman et al. (2025) which developed interactive digital media with a cultural context to support the mathematics learning process and proved to be effective. Based on the research findings, the development of Indigenous House-Based Digital Puzzle media has been able to fulfill the development objectives, namely feasibility and practicality.

3.4 Disseminate stage

At the dissemination stage, the packaging and distribution of the developed learning media are carried out as the final process of this development. The product is a Digital Tangram media based on traditional houses, which has been evaluated and tested and declared valid and practical. This traditional house-based digital Tangram media was then given to the teachers with the aim of being used as an innovative learning medium and supporting the learning of flat shapes in the classroom. In addition, this media was also distributed via a drive link so that it could be accessed more widely.

The implementation of the development process for the Digital Puzzle based on Traditional Houses encountered obstacles such as the integration of local culture into digital elements, which required additional review to remain relevant to learning outcomes while not losing cultural significance. These obstacles were addressed through feasibility assessments by experts, ensuring that the media remained relevant and contextual to the needs of the students. The limitation of this study lies in the trials being conducted only on feasibility and practicality, without yet testing effectiveness on specific variables. The follow-up that can be done is to test the effectiveness of this media on spatial abilities as well as other related abilities. Theoretically, this research reinforces Piaget's theory of cognitive development at the concrete operational stage, where elementary school students are able to better understand the concept of flat shapes through visual and manipulative learning experiences based on local culture, such as the shape of traditional houses. Methodologically, the use of the 4-D model for the development of Digital Puzzle media based on traditional houses demonstrates effectiveness with a systematic approach based on expert validation and direct student involvement to create relevant and tested learning media. Practically, it provides an innovation that can be used by teachers in teaching to understand the concept of flat shapes, enhance student interaction, and build knowledge of local culture.

4. Conclusion

The results of this study indicate that the ethnomathematics-integrated digital puzzle on plane geometry is both feasible and practical for classroom use. The study contributes theoretically by introducing a digital puzzle medium that integrates ethnomathematical elements aligned with students' cognitive development. This is supported by validation results from content and media experts, which showed high feasibility ratings of 88% and 97.5%, respectively. Practically, the traditional-house-based digital puzzle serves as an alternative interactive medium that enhances students' understanding while promoting appreciation of local culture embedded within Grade 4 plane geometry concepts. This is evidenced by a student-rated practicality score of 81.7%, categorized as highly practical. Based on these findings, it can be concluded that the Indonesian traditional house-based puzzle is a feasible and practical culturally responsive learning medium that can help improve the quality of mathematics instruction in primary schools.

Elementary school teachers are advised to utilize Digital Puzzle Media based on Traditional Houses as a manipulative tool on an engaging and meaningful virtual platform, especially for plane geometry materials. Schools are expected to support the use of this interactive digital media based on local wisdom by providing adequate technological facilities. Researchers are subsequently advised to test the long-term impact of using this media on a student's competency, adapt it to other mathematics subjects, or implement it in school environments with different characteristics to broaden the scope of application and development of ethnomathematics-based learning media.

References

Altiparmak, K., & Ercan, O. (2025). The impact of virtual manipulatives in online learning on 4th grade students' learning. *Journal of Online Learning Research, 11*(1), 9–33. https://www.learntechlib.org/p/225241/

Ananda, S. R., Mappalotteng, A. M., & Bakri, H. (2022). Pengembangan Media Pembelajaran Interaktif Pada Mata Pelajaran Teknologi Informasi dan Komunikasi Berbasis Articulate Storyline. *Jurnal MediaTIK, 5*(1), 58–64. https://doi.org/10.59562/mediatik.v5i1.1383

Anwar, L., Sa'dijah, C., Fauzan, A., Johar, R., & Cahyani, S. D. (2024). Exploring Ethnomathematics in the Traditional House of Suku Tengger: Bridging Structures and Classrooms. *Journal of Ecohumanism, 3*(6), 1872–1882. https://doi.org/10.62754/joe.v3i6.4143

Apriyus, A., Syahputra, E., & Marlina, L. (2020). Validation of media interactive learning in vocational high school. *Jurnal Pendidikan Teknologi Kejuruan, 3*(1), 64–67. https://doi.org/10.24036/jptk.v3i1.4423

Arikunto, S. (2014). Prosedur penelitian: Suatu pendekatan praktik. Rineka Cipta.

Ariyanti, M. Y., & Ahsani, E. L. F. (2022). Penerapan media pembelajaran puzzle bangun datar untuk meningkatkan hasil beajar pada mata pelajaran matematika siswa kelas IV. *ALPEN: Jurnal Pendidikan Dasar, 6*(2), 60-69. https://doi.org/10.24929/alpen.v6i2.151

Bouck, E. C., & Park, J. (2018). A systematic review of the literature on mathematics manipulatives to support students with disabilities. *Education and Treatment of Children, 41*(1), 65–106. https://doi.org/10.1353/etc.2018.0003

Chusna, N. L. U., Khasanah, U., & Najikhah, F. (2024). Interactive Digital Media for Learning in Primary Schools. *Asian Pendidikan, 4*(2), 72–78. https://doi.org/10.53797/aspen.v4i2.10.2024

Désiron, J. C., & Schneider, S. (2024). Exploring the interplay of information relevance and colorfulness in multimedia learning. *Frontiers in Psychology, 15*, Article 1393113. https://doi.org/10.3389/fpsyg.2024.1393113

Fatimah, N., Setiawati, E., & Suharto, T. H. (2024). Integrasi Etnomatematika Budaya Banjar dalam Pembelajaran Bangun Datar untuk Siswa Kelas 2 SD. *Jurnal Pendidikan Indonesia: Teori, Penelitian, dan Inovasi, 4*(6), 1–6. https://doi.org/10.59818/jpi.v4i6.1004

Fouze, A. Q., & Amit, M. (2021). Teaching geometry by integrating ethnomathematics of bedouin values. *Creative Education, 12*(02), 402. https://doi.org/10.4236/ce.2021.122029

Gambini, A. (2021). Five years of comparison between euclidian plane geometry and spherical geometry in primary schools: An experimental study. *European Journal of Science and Mathematics Education, 9*(4), 230–243. https://doi.org/10.30935/scimath/11250

Hasni, Z. M., Puspani, U., Jannah, D. N., & Juhji, J. (2024). Optimization of Visual Puzzle Media Utilization to Enhance Geometry Understanding in Elementary Schools: An Analytical Study. *Tarunateach: Journal of Elementary School, 2*(1), 43-51. https://journal.staitaruna.ac.id/index.php/jes/article/view/193

Herawati, H., Herman, T., Suryadi, D., & Prabawanto, S. (2022). Concept of Polygon: Case Study of Elementary Students' Difficulties. *Mathematics Teaching Research Journal, 14*(5), 36–49. https://eric.ed.gov/?id=EJ1382281

Himmah, E. F., Astutik, S., & Aristya, P. D. (2024). Development of HTML5-Based Mobile Learning Media to Enhance Critical Thinking Skills of Elementary School Students in IPAS Learning. *Jurnal Paedagogy, 11*(4), 836–846. https://doi.org/10.33394/jp.v11i4.13065

Horan, E., & Carr, M. (2018). How much guidance do students need? An intervention study on kindergarten mathematics with manipulatives. *International Journal of Educational Psychology, 7*(3), 286–316. https://dialnet.unirioja.es/servlet/articulo?codigo=6642642

Ismail, N. F. H., Shahrill, M., & Asamoah, D. (2021). Learning through virtual manipulatives: Investigating the impact of Gizmos-based lessons on students' performance in integers. *Contemporary Mathematics and Science Education, 4*(1), 23009. https://doi.org/10.30935/conmaths/12857

Jablonski, S., & Ludwig, M. (2023). Teaching and Learning of Geometry—A Literature Review on Current Developments in Theory and Practice. *Education Sciences, 13*(7), 682. https://doi.org/10.3390/educsci13070682

Long, H. M., Bouck, E. C., & Kelly, H. (2022). An evidence-based practice synthesis of virtual manipulatives for students with ASD and IDD. *Focus on Autism and Other Developmental Disabilities, 38*(3), 147–157. https://doi.org/10.1177/10883576221121654

Makhdum, F. N., Sandhu, H. R., Batool, T., Khan, S., Faisal, F., & Younas, A. (2023). Effect of using Symbolab calculator in teaching simultaneous equations on students' conceptual understanding at the elementary level in pakistan: Mathematics attitude in technological corners. Journal of Positive School Psychology, 117–124. https://mail.journalppw.com/index.php/jpsp/article/view/15022

Milinia, R., & Amir, M. F. (2022). The analysis of primary students' learning obstacles on plane figures' perimeter and area using onto-semiotic approach. *Al Ibtida: Jurnal Pendidikan Guru, 9*(1), 19–33. https://doi.org/10.24235/al.ibtida.snj.v9i1.9958

Ng, O.-L., Shi, L., & Ting, F. (2020). Exploring differences in primary students' geometry learning outcomes in two technology-enhanced environments: dynamic geometry and 3D printing. *International Journal of STEM Education, 7*(1), 50. https://doi.org/10.1186/s40594-020-00244-1

Oogarah-Pratap, B., Bholoa, A., & Ramma, Y. (2025). Stage theory of cognitive development—Jean Piaget. In Science education in theory and practice: An introductory guide to learning theory (pp. 125–142). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-81351-1_8

Panggabean, D., & Shaleha, K. (2022). Pengaruh Media Pembelajaran terhadap Motivasi Belajar pada Siswa Kelas IV SD Siburbur Kecamatan Halongonan Kabupaten Tapanuli Selatan dengan Mata Pelajaran Bahasa Indonesian. *Edumaniora : Journal of Education and Humanities, 1*(01), 23–34. https://journal.cdfpublisher.org/Index.Php/Edumaniora/Article/Download/9/8

Payadnya, I. P. A. A., Wulandari, I. G. A. P. A., Puspadewi, K. R., & Saelee, S. (2024). The significance of ethnomathematics learning: A cross cultural perspectives between Indonesian and Thailand educators. *Journal for Multicultural Education, 18*(4), 508–522. https://doi.org/10.1108/JME-05-2024-0049

Primasatya, N., & Mukmin, B. A. (2020). Validitas multimedia interaktif K13 pada materi pecahan sebagai inovasi pembelajaran tematik bagi siswa kelas IV. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika, 6*(1), 84–93. https://doi.org/10.29407/jmen.v6i1.14195

Purnama, R. (2024). A Systematic Review: Interactive Media in Mathematics Learning—What Do We Get?. *International Journal of Humanities Education and Social Sciences, 3*(6), 3261–3275. https://doi.org/10.55227/ijhess.v3i6.1043

Rachman, K., Pangestika, C., Vesya, S. R., & Arbiyanti, A. P. (2025). Development of Android-based applications integrated with Tari Piring culture as ethnomathematics learning media for elementary school students. *Union: Jurnal Ilmiah Pendidikan Matematika*, *13*(1), 200–212. https://doi.org/10.30738/union.v13i1.19217

Rachman, K., Rasyid, I., Arbiyanti, A. P., & Vesya, S. R. (2025). Integration of Kaliurang Local Culture into Augmented Reality for Spatial Geometry Learning Media Development. *SAKAGURU: Journal of Pedagogy and Creative Teacher*, *2*(1), 55-70. https://doi.org/10.70211/sakaguru.v2i1.203

Rahayu, D., & Suarjana, I. M. (2024). Virtual manipulatives: A pathway to enhancing numeracy skills in inclusive classrooms. *International Journal of Elementary Education (IJEE)*, *8*(3), 503–510. https://doi.org/10.23887/ijee.v8i3.89805

Rosa, M., & Orey, D. C. (2021). An Ethnomathematical Perspective of STEM Education in a Glocalized World. *Bolema: Boletim de Educação Matemática, 35(*70), 840–876. https://doi.org/10.1590/1980-4415v35n70a14

Samsudin, A., & Nugraha, B. (2024). Elementary School Students' Obstacles in Understanding t*he Concept of Area and Perimeter*. Indonesian Journal of Educational Research and Review, 7(1), 15–25. https://doi.org/10.2991/978-2-38476-206-4_16

Schroth, S., Tang, H., Carr Chellman, A., & AlQahtani, M. (2019). An exploratory study of Osmo Tangram and tangram manipulative in an elementary mathematics classroom. *Journal of Educational Technology Development and Exchange, 11*(1), 1 17. https://doi.org/10.18785/jetde.1101.01

Sudrajat, S., Winarto, A., & Wicaksono, B. (2019). Ethnomathematics of Kalimantan Batik in Field Geometry Learning in Elementary School. *International Journal of Trends in Mathematics Education Research, 6*(1), 26–32. https://doi.org/10.33122/ijtmer.v6i1.172

Suryaningsih, C., & Munahefi, D. (2021). Penerapan puzzle bernuansa etnomatematika melalui permainan engklek pada materi bangun datar. *PRISMA: Prosiding Seminar Nasional Matematika, 4*, 111–118. https://journal.unnes.ac.id/sju/prisma/article/view/45008

Tay, M. K., & Preciado Babb, A. P. (2023). Enhancing spatial reasoning through geometry transformation instruction in Ghana. *Proceedings of PME 46*, 4, 259–266. https://www.researchgate.net/publication/373142344_ENHANCING_SPATIAL_REASONING_THROUGH_GEOMETRY_TRANSFORMATION_INSTRUCTION_IN_GHANA

Tjandra, C. (2023). Effectiveness of using manipulatives in mathematics teaching in inclusive education programs in an elementary school. *Dharmas Education Journal (DE_Journal)*, *4*(1), 168–178. https://doi.org/10.56667/dejournal.v4i1.944

Warsita, B. (2019). Evaluasi media pembelajaran sebagai pengendalian kualitas. *Jurnal Teknodik*, *17*(4), 92. https://doi.org/10.32550/teknodik.v17i4.581

Wasono, E., Miluwati, M., & Susanto, M. R. (2024). Pengembangan media puzzle rumah adat joglo berbasis pbl pada pembelajaran geometri matematika kelas V SDN 1 Kaloran Temanggung. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 9*(03), 868-879. https://doi.org/10.23969/jp.v9i03.16118

Wulansari, S., Pangestika, R. R., & Ratnaningsih, A. (2022). Pengembangan media puzzle matematika berbasis kearifan lokal pada materi bangun datar di kelas IV SDN Ketangi. *Jurnal Pendidikan Dasar, 3*(2), 44-50. http://jurnal.umpwr.ac.id/index.php/jpd/article/view/2236

Yakubova, G., Chen, B. B., Al-Dubayan, M. N., & Gupta, S. (2024). Virtual instruction in teaching mathematics to Autistic students: Effects of video modeling, virtual manipulatives, and mathematical games. *Journal of Special Education Technology*, *39*(1), 51–66. https://doi.org/10.1177/01626434231177875