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Development of an Ethnomathematics-Based Pop-Up Book Oriented Toward Elementary Students' Conceptual Understanding of Mathematics

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ABSTRACT

Low levels of students' conceptual understanding of mathematics pose a significant barrier to mastering subsequent topics and developing other essential mathematical skills. One contributing factor frequently associated with this issue is the limited variety and contextual relevance of instructional media used in the classroom. This study aims to develop an ethnomathematics-based pop-up book to enhance elementary students' conceptual understanding of three-dimensional geometric shapes, evaluated in terms of its validity, practicality, and effectiveness. The research employs a development methodology following the ADDIE model, which consists of five key stages: Analysis, Design, Development, Implementation, and Evaluation. The participants in this study were 25 sixth-grade students at SDN 1 Bayan. Data were collected through tests and questionnaires and analyzed using qualitative and quantitative approaches. The findings revealed that: (1) the media expert validation yielded a score of 70, categorized as "highly valid"; (2) the content expert validation resulted in a score of 69, also rated "highly valid"; (3) small group trials conducted by teachers and students obtained scores of 53 and 56.8 respectively, both categorized as "highly practical"; (4) the large group trial yielded a score of 54.4, also falling within the "highly practical" category; and (5) the effectiveness test using the Wilcoxon Signed Rank Test produced a significance value of 0.000 ($p < 0.05$), indicating a significant difference between pretest and posttest results. These results confirm that the ethnomathematics-based pop-up book is valid, practical, and effective in improving sixth-grade students' conceptual understanding of three-dimensional geometry. Integrating ethnomathematical elements is designed to assist teachers in delivering more engaging and interactive instruction, thus enabling students to comprehend geometric concepts better through cultural contexts.

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1. INTRODUCTION

Conceptual understanding is a fundamental skill that students must possess in learning mathematics. It refers not only to the ability to recall or recognize mathematical concepts but also to the ability to express those concepts in one's own words, interpret their meaning, and apply them appropriately [1]. Students with strong conceptual understanding are more likely to easily learn subsequent topics and develop other mathematical skills, as this form of understanding serves as a foundation or prerequisite for mastering more advanced materials [2]. Indicators of conceptual understanding include (1) the ability to restate a concept; (2) to classify objects based on their properties in relation to the concept; (3) to provide examples and non-examples; (4) to represent the concept in various mathematical forms; (5) to select and use appropriate procedures or operations; and (6) to apply the concept to problem-solving situations [3].

However, a preliminary study conducted through tests and interviews with sixth-grade students and teachers at SDN 1 Bayan revealed that most students demonstrated a low level of conceptual understanding in geometry, particularly in three-dimensional shapes. This was evident in their test results on the properties of cubes and rectangular prisms—content previously taught in fifth grade. Many students exhibited misunderstandings related to these shapes. One possible cause is the limited variety and contextual relevance of instructional media. Teachers primarily relied on outdated visual aids and standard textbooks, which may not adequately support students' conceptual development.

It is necessary to incorporate engaging and relevant instructional media in the learning process to address this issue. Instructional media play a crucial role in supporting teachers' delivery of content and enhancing students' motivation and comprehension [4]. Media that are visually appealing, appropriate, and aligned with the characteristics of the subject matter can significantly improve learning outcomes and foster students' conceptual understanding, especially in the topic of three-dimensional geometry. Therefore, this study proposes the development of a Pop-Up Book as an instructional medium specifically designed to support conceptual understanding in this domain.

A Pop-Up Book is an innovative form of printed material that presents information using three-dimensional designs created through folding, pulling, and rotating mechanisms [5]. Using Pop-Up Books in mathematics education helps students visualize spatial relationships and better understand geometric forms. One of the key advantages of Pop-Up Books is their ability to enhance students' cognitive engagement by providing tactile and visual representations of abstract objects.

In this study, the Pop-Up Book is developed by integrating geometric concepts with cultural elements, a pedagogical approach known as ethnomathematics. Ethnomathematics is a method of teaching mathematics that connects mathematical ideas with cultural practices, enabling students to use familiar cultural artifacts as learning tools [6]. Previous studies rarely combined ethnomathematics with pop-up book media oriented toward conceptual understanding. Integrating cultural contexts is expected to improve students' grasp of abstract concepts by relating mathematical content to everyday experiences.

Ethnomathematics allows students to construct meaning through tangible, real-world connections, making abstract ideas more accessible [7]. Moreover, culturally contextualized mathematics instruction empowers students to apply their prior knowledge and social environment as part of their learning process [8].

Based on this rationale, the research question addressed in this study is: How can an ethnomathematics-based Pop-Up Book be developed to ensure its validity, practicality, and effectiveness in supporting sixth-grade students' conceptual understanding of three-dimensional geometry? Accordingly, this study aims to describe the development of an ethnomathematics-based pop-up book focused on improving conceptual understanding, which is assessed through validity, practicality, and effectiveness. This instructional medium is expected to provide students with more concrete representations of geometric content, enhancing their conceptual learning.

2. METHOD

This study employed a Research and Development (R&D) approach. R&D is a research method aimed at producing a specific product and evaluating its feasibility and effectiveness [9]. The development model implemented in this study was the ADDIE model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation [10].

The research was conducted from August 2024 to May 2025, with the participants comprising 25 sixth-grade students from SDN 1 Bayan. The object of the study was an ethnomathematics-based Pop-Up Book designed to enhance students' conceptual understanding of three-dimensional geometry.

2.1 Data Collection Techniques

In this study, data regarding the validity and practicality of the instructional media were collected using questionnaires based on a five-point Likert scale (1–5). The validity questionnaire comprised 15 statement items, while the practicality questionnaire contained 12 items. Meanwhile, data related to the effectiveness of the media were obtained through a mathematical conceptual understanding test developed based on predetermined conceptual understanding indicators.

2.2 Data Analysis Techniques

The scores obtained from the questionnaires were converted into qualitative data based on a standard classification table for levels of validity and practicality. These standard classifications were calculated by considering the score range and the number of statements on each questionnaire to ensure a more accurate and valid interpretation of the data [11]. The standard criteria used to assess validity and practicality levels are presented in the following table.

Based on Table 1, the Pop-Up Book media is considered valid if it receives a score higher than 51. Furthermore, the media is deemed practical if it obtains a score above 40.8, as presented in Table 2.

Table 1. Standard Qualification for Media Validity

Formula	Score Interval	Category
$X > \bar{X}_i + 1{,}8 \times Sb_i$	> 63	Very valid
$\bar{X}_i + 0{,}6 \times Sb_i < X \leq \bar{X}_i + 1{,}8 \times Sb_i$	$51 < X \leq 63$	Valid
$\bar{X}_i - 0{,}6 \times Sb_i < X \leq \bar{X}_i + 0{,}6 \times Sb_i$	$39 < X \leq 51$	Moderately valid
$\bar{X}_i - 1{,}8 \times Sb_i < X \leq \bar{X}_i - 0{,}6 \times Sb_i$	$27 < X \leq 39$	Less valid
$X \leq \bar{X}_i - 1{,}8 \times Sb_i$	≤ 27	Not valid

Table 2. Standard Qualification for Media Practicality

Formula	Score Interval	Category
$X > \bar{X}_i + 1{,}8 \times Sb_i$	$> 50{,}4$	Very practical
$\bar{X}_i + 0{,}6 \times Sb_i < X \leq \bar{X}_i + 1{,}8 \times Sb_i$	$40{,}8 < X \leq 50{,}4$	Practical
$\bar{X}_i - 0{,}6 \times Sb_i < X \leq \bar{X}_i + 0{,}6 \times Sb_i$	$31{,}2 < X \leq 40{,}8$	Moderately practical
$\bar{X}_i - 1{,}8 \times Sb_i < X \leq \bar{X}_i - 0{,}6 \times Sb_i$	$21{,}6 < X \leq 31{,}2$	Less practical
$X \leq \bar{X}_i - 1{,}8 \times Sb_i$	$\leq 21{,}6$	Not practical

Subsequently, the effectiveness data were analyzed using a normality test with the Shapiro–Wilk method, as the sample size was fewer than 50 participants. A non-parametric statistical analysis was employed using the Wilcoxon Signed Rank Test for the hypothesis testing.

3. RESULTS AND DISCUSSION

This development research results in an ethnomathematics-based Pop-Up Book designed to enhance students' conceptual understanding of three-dimensional geometry. The development of this instructional media followed a series of systematic procedures based on the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation.

3.1 Result

The outcome of this development research is an ethnomathematics-based Pop-Up Book proven valid, practical, and effective in enhancing sixth-grade students' conceptual understanding of mathematics, particularly in three-dimensional geometry at SDN 1 Bayan. The development process followed the ADDIE model, which consists of five main stages.

3.1.1 Analysis

The analysis stage is the initial phase in the development research process, aimed at identifying instructional problems and their potential causes [12]. This study analyzed four aspects: needs, students, subject content, and elements of local cultural wisdom.

The needs analysis revealed that during mathematics instruction in grade VI at SDN 1 Bayan, the teacher relied solely on the teacher's guidebook and student textbook, which presented only 2D visual representations—insufficient for teaching the characteristics of

three-dimensional shapes. The lack of relevant instructional media contributed to students' difficulties understanding the material.

The student analysis showed that many students had a low level of conceptual understanding regarding three-dimensional shapes. Several students were still unable to identify basic three-dimensional figures correctly. This limited conceptual understanding challenges future learning, becoming an obstacle to grasping more complex geometry topics. Conceptual understanding serves as the foundation for students to master subsequent mathematical concepts.

The content analysis focused on the learning objectives in Geometry Element, Phase C, which state: "Students can construct and decompose three-dimensional shapes (cubes, rectangular prisms, and their combinations), recognize spatial visualization (front, top, and side views), and compare the characteristics of plane and solid shapes." The specific three-dimensional shapes covered in the sixth-grade curriculum at SDN 1 Bayan include cube, rectangular prism, square pyramid, triangular prism, cylinder, cone, and sphere.

Table 3. Analysis of Local Cultural Products

Local Cultural Product	Product Image	Geometric Concept
Besek Bambu		Cube
Ceraken		Rectangular Prism
Jaje Iwel/Abug		Square Pyramid
Atap *Bale Mengina*		Triangular Prism
Gendang Beleq		Cylinder
Jaje Cerorot		Cone
Jaje Tigapo		Sphere

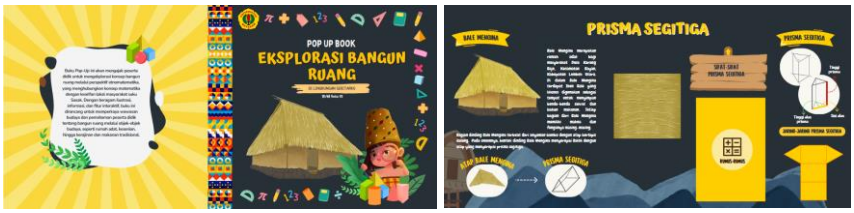
The cultural product analysis explored traditional objects from the Sasak ethnic community that could be integrated as ethnomathematical elements in the Pop-Up Book to support the delivery of three-dimensional geometry content. The selected cultural products and their corresponding geometric concepts are presented in Table 3 above.

3.1.2 Design

The design stage of the Pop-Up Book was carried out based on the results of the previous analysis. At this stage, the instructional media and research instruments were designed.

a. Pop-Up Book Design

The design of the Pop-Up Book involved organizing instructional content on three-dimensional geometry and integrating narratives related to local cultural wisdom. This stage also included creating illustrations, layout, and draft pages. The Pop-Up Book was designed with attention to the proportions, placement, and composition of elements such as color, font, and illustrations—notably those representing cultural products of the Sasak community. The design process was tailored to the characteristics of elementary school students and was developed using Sketchbook and Canva applications. Figure 1 presents several draft pages of the Pop-Up Book ready for printing.



(a) (b)

Figure 1. Draft of the Pop-Up Book Media: (a) Cover Page, (b) Content Page

b. Development of Research Instruments

The instruments used in this study included an expert validation questionnaire, teacher and student response questionnaires, and a mathematical conceptual understanding test. The expert validation and teacher-student response questionnaires were developed by adapting relevant instruments from previous studies. Meanwhile, the conceptual understanding test was constructed based on six indicators of mathematical conceptual understanding and was subsequently subjected to validity and reliability testing.

3.1.3 Development

This stage involved the realization of the media design, validation of the instructional media, and validation and reliability testing of the conceptual understanding instrument.

a. Media Realization

The Pop-Up Book design was printed in a 21 cm × 21 cm format using board paper for the cover and 260 gsm art paper for the content pages. The printed components were assembled to form the final product's three-dimensional elements and interactive features.

b. Media Validation Test

The media validation test was conducted to determine the level of validity and to obtain expert feedback and suggestions from specialists in instructional media and subject matter (mathematics). The media expert validation yielded a total score of 70 out of a

maximum of 75, categorized as “very valid,” with no revision required. The detailed results of the media validation are presented in the following table:

Table 4. Media Validation Results

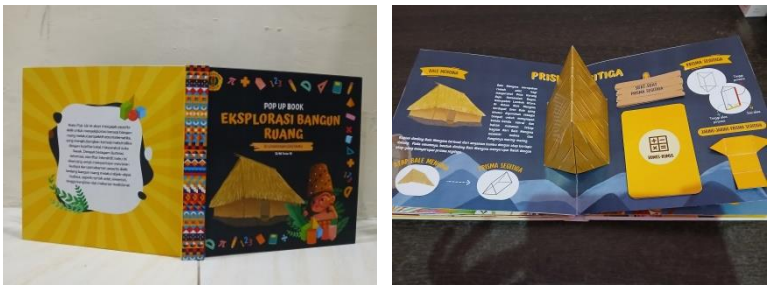
Evaluation Aspect	Component Score	Total Score	Maximum Score	Category
Visual Appearance	29	70	75	Very Valid
Media Presentation	17			
Ease of Use	9			
Material Quality	15			

Subsequently, the content expert validation produced a score of 69 out of 75, also categorized as “very valid,” though accompanied by several recommendations for improvement. The detailed results of the material validation are shown below:

Table 5. Content Validation Results

Evaluation Aspect	Component Score	Total Score	Maximum Score	Category
Alignment with the Curriculum	9	69	75	Very Valid
Content Feasibility	22			
Cultural Relevance and Student Experience	10			
Language Use	20			
Student-Centered Orientation	8			

At this stage, revisions were made to the Pop-Up Book based on feedback from the content expert. The suggestions for improvement focused on several key areas, including the sequence of material presentation, the accuracy of formulas, and the clarity and shape of three-dimensional elements. The finalized version of the Pop-Up Book can be seen in Figure 2.



(a) (b)

Figure 2. Final Version of the Pop-Up Book Media: (a) Cover Page, (b) Content Page

c. Instrument Validity and Reliability Test

In instrument development, the higher the validity and reliability values obtained, the more accurate and trustworthy the data generated by the research will be [13]. In this study, instrument validation consisted of content and construct validity tests.

Content validity was assessed by involving two expert lecturers with expertise in mathematics education. The evaluation data were analyzed using Aiken's V formula, and the results are presented in the following table:

Table 6. Aiken's V Result for Conceptual Understanding Test Instrument

Item Numbers	Evaluators		S_1	S_2	Σs	n(c-1)	V	Category
	I	II						
1-11	44	50	33	39	88	88	0,818	Very Valid

Based on Table 6, Aiken's V index value was 0.818, indicating a very high level of validity, with minor suggestions for improvement related to using illustrations in some test items.

Construct validity testing was conducted through empirical testing of 12 previously deemed valid items. The instrument was tested on 27 students not part of the main research sample. The empirical test results showed that 1 out of 12 items was invalid, with a significance value of 0.112 ($p > 0.05$).

Reliability testing was then performed on the 11 valid mathematical conceptual understanding test items. The results showed a Cronbach's Alpha score of 0.835, which exceeds the threshold of 0.70, indicating that the instrument is reliable.

3.1.4 Implementation

The implementation stage aims to gather feedback on the product after its application in the learning environment [14]. The implementation of the Pop-Up Book media was carried out from April 19 to April 26, 2025. Before the trial began, all students completed a pretest as part of the evaluation process. The implementation was conducted in two phases: a small-group trial and a large-group trial.

a. Small-Group Trial

This trial involved six students and one classroom teacher who observed using the Pop-Up Book during a small-scale learning session. This phase aimed to identify initial issues with the product before its broader application [15]. During this stage, both the teacher and students completed response questionnaires to evaluate the practicality of the Pop-Up Book media before it was fully implemented in the classroom. The results of the teacher and student responses are presented in the following tables.

Based on Table 7, the teacher's response yielded a score of 53, categorized as "very practical," along with a suggestion to optimize the use of the Pop-Up Book during instruction. As shown in Table 8, the students' average response score was 56.8, also falling into the "very practical" category. A suggestion for improvement was to enhance the adhesion of the 3D cylinder element to ensure durability and clarity.

Table 7. Teacher Response Questionnaire Results

Evaluation Aspect	Component Score	Total Score	Maximum Score	Category
Lesson Delivery	13	53		Very Practical
Content	13			
Media	9			
Language	8			
Media Usability	10			

Table 8. Student Response Questionnaire – Small-Group Trial

Evaluation Aspect	Component Scorer	Total Score	Average Score	Maximum Score	Category
Motivation	84	341	56,8	60	Very Practical
Content	21				
Media	86				
Language	29				
Ease of Use	58				
Cultural Relevance and Student Experience	57				

b. Large-Group Trial

The large-group trial was conducted with the sixth-grade class at SDN 1 Bayan, consisting of 25 students. The Pop-Up Book was implemented using a contextual learning model by applying ethnomathematics. One of the key benefits of contextual learning is that the knowledge acquired by students tends to be more long-lasting, as it is constructed through meaningful application activities [16]. This method encourages students to develop deeper conceptual understanding rather than relying solely on memorization. After the learning session, students were instructed to complete a posttest and fill out a response questionnaire as feedback for further analysis during the evaluation phase.

Evaluation

The evaluation stage is the final phase of this research. In the ADDIE model, evaluation is conducted to assess the quality of the development process and to measure students' competencies before and after the implementation stage [17]. In this study, the evaluation aimed to determine the practicality and effectiveness of the ethnomathematics-based Pop-Up Book. The evaluation was based on the results of the student response questionnaire and the mathematical, conceptual understanding test administered during the large-group trial.

The level of practicality of the Pop-Up Book, as assessed through a questionnaire completed by 25 students, is presented in Table 9. Based on Table 9, the average total score obtained from the student response questionnaire was 54.4, which falls into the "Very Practical" category.

Table 9. Student Response Questionnaire Results – Large-Group Trial

Evaluation Aspect	Component Score	Total Score	Average Score	Maximum Score	Category
Motivation	337	1361	54,4	60	Very Practical
Content	106				
Media	341				
Language	115				
Ease of Use	236				
Cultural Relevance and Student Experience	226				

Next, the effectiveness of the Pop-Up Book was determined using the results of the student's mathematical conceptual understanding test focused on the topic of three-dimensional geometry in Grade VI. The descriptive statistics of the pretest and posttest scores are shown in the following table:

Table 10. Descriptive Analysis of Pretest and Posttest Scores

Description	**Pretest**	**Posttest**
Minimum Score	0	5
Maximum Score	41	77
Mean	10	36,91
Median	9	36
Mode	14	32

As shown in Table 10, there was an improvement in all aspects of the posttest scores, including the minimum, maximum, mean, median, and mode. The analysis of media effectiveness was continued through normality testing and hypothesis testing.

a. Normality Test

A normality test was conducted as a prerequisite for applying parametric statistical analysis to determine the effectiveness of the Pop-Up Book media. The Shapiro–Wilk test was employed in this study due to the small sample size of 25 students ($N < 50$).

Table 11. Results of the Shapiro–Wilk Normality Test

	Shapiro-Wilk		
	Statistic	df	Sig. (p-value)
Pretest	,844	25	,001
Posttest	,975	25	,763

Based on Table 11, the pretest data were not normally distributed, with a significance value of 0.001 ($p = 0.001 < 0.05$). Meanwhile, the posttest data followed a normal distribution, with a significance value of 0.763 ($p = 0.763 > 0.05$). Since one of the data sets violated the normality assumption, the effectiveness analysis was carried out using the non-parametric Wilcoxon Signed Rank Test.

b. Hypothesis Testing

The Wilcoxon Signed Rank Test was used to evaluate the effectiveness of the ethnomathematics-based Pop-Up Book by determining whether there was a significant difference between the pretest and posttest scores. This test is an alternative for analyzing differences between paired data when one or both sets are not normally distributed [18]. The results of the Wilcoxon Signed Rank Test in this study are presented in the following table:

Table 12. Wilcoxon Signed Rank Test Results

	Posttest-Pretest
Z	-4,375
Asymp.Sig. (2-tailed)	,000

Based on Table 12, the Z-value of –4.375 indicates a significant difference between the pretest and posttest scores, reflecting student performance improvement. Furthermore, the Asymp. Sig. (2-tailed) value is 0.000, which is less than the significance threshold of 0.05, indicating that the difference is statistically significant. According to the decision rule for hypothesis testing used in this study—if the significance value is less than 0.05, H_0 is rejected, and H_1 is accepted. Therefore, it can be concluded that the ethnomathematics-based Pop-Up Book effectively improves the mathematical conceptual understanding of sixth-grade students at SDN 1 Bayan, specifically on three-dimensional geometry.

3.2 Discussion

This study produced an ethnomathematics-based Pop-Up Book that is valid, practical, and effective in improving sixth-grade students' mathematical and conceptual understanding at SDN 1 Bayan, specifically on three-dimensional geometry. The development process followed the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation.

Based on the analysis, it was found that the students demonstrated a low level of conceptual understanding of three-dimensional geometry. This deficiency hindered their comprehension of more complex topics, as mathematical concepts are interconnected and require a solid foundation [19]. Learning geometry, particularly spatial figures, demands students' ability to visualize and interpret abstract structures. As geometry involves abstract representations, students need learning media to concretize abstract mathematical ideas [20]. At the elementary level, students' cognitive development is mostly limited to concrete objects or familiar events [21]. Thus, instructional media should provide tangible representations using real-life and culturally familiar references.

Observations during mathematics instruction revealed that the teacher primarily used simple teaching aids and standard textbooks. This issue is common and reflects a broader problem in elementary education—a lack of diverse and contextually relevant instructional media, which limits students' comprehension. This is consistent with the findings of Nursyamsiah, who stated that students' poor performance in geometry was due to teachers' reliance on conventional, memorization-based methods with minimal media innovation [22].

In response to these challenges, this study developed a Pop-Up Book to improve the quality of mathematics instruction. One of the strengths of Pop-Up Books is their ability to enhance student understanding through visual and tactile 3D elements, which are highly relevant to the core characteristics of three-dimensional geometry [23], [24]. To maximize the effectiveness of the media, ethnomathematics was applied as the foundational design approach. Previous research has shown that integrating ethnomathematics into learning media can improve students' conceptual understanding [25]. In this study, elements of local cultural wisdom from the Sasak ethnic group were analyzed and incorporated into the Pop-Up Book based on their relevance to spatial geometry concepts. Prior ethnomathematical research has indicated that Sasak cultural products are rich in mathematical content, making them a suitable foundation for elementary-level geometry instruction [26].

The Pop-Up Book was designed with careful attention to proportions, layout, color schemes, fonts, and illustrations, particularly of Sasak cultural objects, in ways that align with the developmental characteristics of elementary students. Using vibrant colors, appealing visuals, and creative layouts was intended to make learning more enjoyable [27]. Additionally, using distinct colors for symbols and mathematical terms helps students easily identify and internalize key concepts [28]. All design elements were organized within a layout that ensured clarity, effectiveness, and visual engagement [29].

Development of the Pop-Up Book was informed by media and content expert validations, followed by improvements based on their feedback. Suggestions included adjustments to content sequencing, formula accuracy, and refinement of 3D illustrations. The order of content presentation plays a critical role in information retention, thus requiring well-structured sequencing to optimize student comprehension [30]. Improvements were also made by simplifying formulas and enhancing visual representations. These revisions contributed to the practicality and instructional clarity of the product [31].

Following validation, the Pop-Up Book was tested to determine its practicality and effectiveness using a contextual learning model integrated with ethnomathematics. Meta-analytic evidence supports the effectiveness of contextual learning in improving elementary students' mathematical achievement [32]. The trial results confirmed that the Pop-Up Book was both practical and effective, as measured by students' conceptual understanding gains. These findings align with Lestari et al., who found that Pop-Up Book media positively impacted students' understanding of mathematical concepts [33]. Similarly, Pradiani et al. reported improvements in student learning outcomes in geometry following the use of Pop-Up Books [34]. These findings suggest that this ethnomathematics-based Pop-Up Book is a promising tool for optimizing conceptual understanding in geometry instruction.

Despite its success, this study has several limitations in both media and content aspects. In terms of media, the 3D representation of the sphere was not proportionally accurate, which may lead to student misconceptions; therefore, additional supporting media are recommended. In terms of content, the Pop-Up Book lacked features for

developing students' problem-solving skills and thus should be supplemented with quizzes or problem-based tasks during instructional use.

4. CONCLUSION

The ethnomathematics-based Pop-Up Book, developed using the ADDIE model, has proven valid, practical, and effective in improving sixth-grade students' mathematical and conceptual understanding at SDN 1 Bayan, particularly in three-dimensional geometry. This conclusion is supported by the results of the validation tests, which indicated that the Pop-Up Book was highly valid, receiving a score of 70 from the media expert and 69 from the content expert, along with minor revision suggestions.

Furthermore, responses from teachers and students demonstrated that the Pop-Up Book was very practical, with scores of 53 from the teacher, 56.8 from students in the small-group trial, and 54.4 from students in the large-group trial. In addition, the student's mathematical and conceptual understanding test results showed that the Pop-Up Book was effective, with a significance value of 0.000 ($p < 0.05$) according to the Wilcoxon Signed Rank Test.

This instructional media is suitable for use by elementary school teachers when teaching three-dimensional geometry in both lower and upper grades. The content was designed by considering the material's complexity level, thereby helping teachers deliver lessons in alignment with instructional goals and curricular needs.

Based on the findings of this study, several limitations of the developed media were identified. Future research focusing on Pop-Up Book development is encouraged to address these limitations. Integrating technology, such as QR codes and Augmented Reality (AR), is strongly recommended to overcome the limitations of 3D element representation. Additionally, incorporating interactive features such as games or quizzes—manually or digitally via QR codes—could enhance student engagement and conceptual understanding of spatial geometry topics.

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REFERENCES

[1] E. Gee and D. Harefa, "Analysis of Students' Mathematic Analisis Kemampuan Koneksi dan Pemahaman Konsep Matematis Siswa," *Musamus Journal of Primary Education*, vol. 4, no. 1, pp. 1–11, 2021.

[2] D. A. Apriliyana, S. Masfu'ah, and L. A. Riswari, "Analisis Pemahaman Konsep Matematika Siswa Kelas V pada Materi Bangun Ruang," *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, vol. 6, no. 6, pp. 4166–4173, 2023.

[3] A. Febriyani, A. R. Hakim, and N. Hakim, "Peran Disposisi Matematis terhadap Kemampuan Pemahaman Konsep Matematika," *Plusminus: Jurnal Pendidikan Matematika*, vol. 2, no. 1, pp. 87–100, 2022.

[4] S. Nurfadhillah, *MEDIA PEMBELAJARAN: Pengertian Media Pembelajaran, Landasan, Fungsi, Manfaat, Jenis-Jenis Media Pembelajaran, dan Cara Penggunaan Kedudukan Media Pembelajaran*. Sukabumi: CV Jejak (Jejak Publisher), 2021.
[5] N. K. Umam, A. M. Bakhtiar, and H. Iskandar, "Pengembangan Pop Up Book Bahasa Indonesia Berbasis Budaya Slempitan," *Trapsila: Jurnal Pendidikan Dasar*, vol. 1, no. 2, pp. 1–11, 2019.
[6] A. Fauzi and H. Setiawan, "Etnomatematika: Konsep Geometri Pada Kerajinan Tradisional Sasak Dalam Pembelajaran Matematika Di Sekolah Dasar," *Didaktis: Jurnal Pendidikan Dan Ilmu Pengetahuan*, vol. 20, no. 2, pp. 118–128, 2020.
[7] A. Fauzi and U. Lu'luilmaknun, "Etnomatematika Pada Permainan Dengklaq Sebagai Media Pembelajaran Matematika," *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, vol. 8, no. 3, pp. 408–419, 2019.
[8] S. W. Dari and J. Jatmiko, "Analisis Peran Etnomatematika dalam Pembelajaran Matematika," *Prosiding Seminar Nasional Kesehatan, Sains dan Pembelajaran*, vol. 3, no. 1, pp. 269–278, 2024.
[9] F. A. Slamet, *Model Penelitian Pengembangan (RnD)*. Malang: Institut Agama Islam Sunan Kalijogo Malang, 2022.
[10] M. Molenda, "In search of the elusive ADDIE model," *Performance Improvement*, vol. 54, no. 2, pp. 40–42, 2015.
[11] E. P. Widoyoko, *Evaluasi Program Pembelajaran: Panduan Praktis Bagi Pendidik dan Calon Pendidik*. Yogyakarta: Pustaka Pelajar, 2009.
[12] F. Hidayat and N. Muhamad, "Model Addie (Analysis, Design, Development, Implementation and Evaluation) Dalam Pembelajaran Pendidikan Agama Islam," J. *Inov. Pendidik. Agama Islam*, vol. 1, no. 1, pp. 28–37, 2021.
[13] E. F. Tarigan, S. Nilmarito, K. Islamiyah, A. Darmana, and R. D. Suyanti, "Analisis instrumen tes menggunakan rasch model dan software SPSS 22.0," *Jurnal Inovasi Pendidikan Kimia*, vol. 16, no. 2, pp. 92–96, 2022.
[14] N. Indriana, I. F. Nisa, and D. E. Diantika, "Pengembangan Model Pembelajaran Bahasa Indonesia dengan Pendekatan Komunikatif Berbasis Keunggulan Lokal," *Jurnal Onoma: Pendidikan, Bahasa, Dan Sastra*, vol. 10, no. 1, pp. 1–15, 2024.
[15] L. A. M. Parera et al., "Pengembangan video pembelajaran kimia berbantuan Kinemaster pada materi sistem koloid untuk kelas XI SMA/MA," *Jurnal Beta Kimia**, vol. 2, no. 1, pp. 23–32, 2022.
[16] D. Nababan and C. A. Sipayung, "Pemahaman Model Pembelajaran Kontekstual Dalam Model Pembelajaran (CTL)," *Jurnal Pendidikan Sosial Dan Humaniora**, vol. 2, no. 2, pp. 825–837, 2023.
[17] H. H. Batubara, *Media pembelajaran efektif*. Semarang: Fatawa Publishing, 2020.
[18] Y. D. Astuti and V. Karolina, "Pengaruh Media Pembelajaran Kalkulator Bilangan Terhadap Hasil Belajar Siswa dalam Mata Pelajaran Matematika di Sekolah Dasar," *Jurnal Dunia Pendidikan*, vol. 5, no. 5, pp. 1887–1897, 2025.
[19] P. Indiati, W. D. Puspitasari, and B. Febrianto, "Pentingnya Media Tangram Terhadap Kemampuan Pemahaman Konsep Bangun Datar," in *Prosiding Seminar Nasional Pendidikan*, vol. 3, pp. 290–294, Oct. 2021.
[20] C. D. Karisma and E. Ahdhianto, "Analisis Kebutuhan Media Pembelajaran Matematika Bangun Ruang Pada Siswa Kelas V Sekolah Dasar," *Jurnal Pemikiran Dan Pengembangan Sekolah Dasar (JP2SD)*, vol. 11, no. 2, pp. 265–276, 2023.
[21] A. H. Witono, I. P. Artayasa, Y. A. S. Anwar, A. Fauzi, M. Erfan, and I. Nurmawanti, *Perkembangan Peserta Didik*, Mataram: Sanabil, 2020.
[22] G. Nursyamsiah et al., "Analisis Kesulitan Siswa SMP Kelas VIII dalam Menyelesaikan Soal Materi Bangun Ruang Sisi Datar," *Maju*, vol. 7, no. 1, pp. 98–102, 2020.
[23] R. Setiyanigrum, "Media Pop-Up Book Sebagai Media Pembelajaran Pascapandemi Covid-19," *Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS)*, vol. 3, no. 1, pp. 216–220, 2020.
[24] I. P. Sari, I. H. Batubara, and M. Basri, "Pengenalan bangun ruang menggunakan augmented reality sebagai media pembelajaran," *Hello World Jurnal Ilmu Komputer*, vol. 1, no. 4, pp. 209–215, 2023.
[25] S. G. Jabali, S. Supriyono, and P. Nugraheni, "Pengembangan media game visual novel berbasis etnomatematika untuk meningkatkan pemahaman konsep pada materi aljabar," *Alifmatika: Jurnal Pendidikan Dan Pembelajaran Matematika*, vol. 2, no. 2, pp. 185–198, 2020.
[26] L. M. Alditia and I. Nurmawanti, "Etnomatematika: Eksplorasi Konsep Geometri dalam Kearifan Lokal Suku Sasak," *Indiktika: Jurnal Inovasi Pendidikan Matematika*, vol. 5, no. 2, pp. 160–169, 2023.
[27] N. Vega, "Analisis Peran Visual Media Cetak dalam Meningkatkan Minat Konsumsi Sayuran pada Anak," *DIVAGATRA - Jurnal Penelitian Mahasiswa Desain*, vol. 4, no. 1, pp. 100–111, 2024.

[28] M. Erfan, A. Widodo, U. Umar, R. Radiusman, and T. Ratu, "Pengembangan Game Edukasi 'Kata Fisika' Berbasis Android untuk Anak Sekolah Dasar pada Materi Konsep Gaya," *Lectura: Jurnal Pendidikan*, vol. 11, no. 1, pp. 31–46, 2020.
[29] D. Nurdiansyah, **Desain Grafis Gen Z**, Banyumas: Wawasan Ilmu, 2024.
[30] I. Suciati, "Penggunaan Metode 'Perang Mental Matematika' Dengan Menggunakan Media Kartu Pecahan Pada Materi Penjumlahan Bilangan Pecahan," *Jurnal Pendidikan dan Pembelajaran*, vol. 3, no. 1, pp. 35–42, 2020.
[31] B. Cahyanto and M. Afifulloh, "Electronic Module (E-Module) Berbasis Component Display Theory (CDT) Untuk Matakuliah Pembelajaran Terpadu," *JINOTEP (Jurnal Inovasi Dan Teknologi Pembelajaran)*, vol. 7, no. 1, pp. 49–56, 2020.
[32] Y. P. Parhusip and A. T. A. Hardini, "Meta Analisis Efektivitas Pembelajaran Kontekstual Terhadap Kemampuan Pemahaman Matematika Bagi Siswa Sekolah Dasar," *Mimbar Ilmu*, vol. 25, no. 3, pp. 319–326, 2020.
[33] D. Lestari, I. D. S. Mahendra, and W. Anggriani, "Pengaruh Media Pembelajaran Pop Up Book Pada Materi Statistika Terhadap Pemahaman Konsep," *PRISMA, Prosiding Seminar Nasional Matematika*, pp. 7–15, 2024.
[34] N. P. W. Y. Pradiani, M. Turmuzi, and A. Fauzi, "Pengembangan media pembelajaran pop-up book materi bangun ruang pada muatan pembelajaran matematika kelas V sekolah dasar," *Jurnal Ilmiah Profesi Pendidikan*, vol. 8, no. 3, pp. 1456–1469, 2023.

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