Quality of an Ethnomathematics Based Pop-Up Book Media on Fractions for Primary School

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ABSTRACT

This research is driven by the urgency of comprehending the basic concepts of fractions found in grade II students. These problems indicate the requirement for enhancing interactive and contextual learning media such as ethnomathematics-based fraction pop-up book media. So, this research aims to see the quality of ethnomathematics-based fraction pop-up book media that is feasible in terms of validity and practicality. This research was performed at SD Negeri 1 Salakan Bantul, with the research subjects being grade II students totalling 22 students. This study uses R&D research using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation. The data collection techniques used were observation, interview, and questionnaire. The data analysis technique used qualitative and quantitative analysis. The outcomes showed that the ethnomathematics-based fraction pop-up book media met the valid and practical criteria. This can be found in the validation result by media experts and material experts who show "Very Valid" criteria, with a percentage value of media experts of 97.33% and material experts of 93.33%. The assessment was also undertaken regarding the practicality of utilizing the product that showed the criteria "Very Practical" by acquiring teacher response scores of 98.67% and students of 98.63%. Based on the data fulfilled, it can be concluded that the ethnomathematics-based fraction pop-up book media is feasible in terms use as an alternative learning media in learning mathematics fraction material in grade II elementary school. Fraction pop-up book media based on ethnomathematics can strengthen comprehension of fraction material by integrating local culture.

Keywords: Elementary School, Ethnomathematics, Fractions, Pop-up Book Media

Introduction

The concept of fractions is introduced in elementary schools during Phase A, specifically in second grade. This aligns with the decision of the Head of the Curriculum and Assessment Standards Education Agency issued by the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2022), which classifies fractions under the number element. The learning outcomes emphasize students'

ability to understand fractions as parts of a whole through contexts involving the equal division of an object or group of objects, introducing halves and quarters.

Fractions represent a challenging mathematics topic for students due to their abstract nature and students' limited grasp of basic numerator and denominator concepts (Anggreini & Priyojadmiko, 2022; Novidayanti et al., 2024). This difficulty is particularly pronounced among second-grade elementary students, typically aged 7–8 years. According to Piaget's cognitive development theory, students in this age range operate in the concrete operational stage, making them more receptive to concepts through direct experiences and tangible objects (Marinda, 2020). Meanwhile, mathematics instruction's abstract characteristics hinder elementary students' learning without appropriate media (Putri et al., 2024). This issue worsens with monotonous teaching methods, leading students to memorize content without deep conceptual understanding (Rahimah, 2023).

Similar challenges in fraction instruction occur at SD Negeri 1 Salakan. Observations and interviews with second-grade teachers reveal suboptimal mathematics learning. Students perceive mathematics as difficult, resulting in low conceptual understanding, particularly in fractions. Manifestations include inability to identify numerators and denominators, leading to confusion in reading, writing, interpreting fractions, and relating them to real-life situations.

These conditions indicate that second-grade students require instruction that concretizes abstract fraction concepts. Instructional media are essential for this process, especially visuals suited to elementary students' preference for images over text. Contextual media aligned with student characteristics can optimize knowledge transfer (Rahma et al., 2024; Hani et al., 2024). Elementary school students, especially low-grade students, have characteristics that tend to prefer lots of pictures compared to full text (Syaputra et al., 2023). Thus, visual media are ideal for fraction instruction.

One promising visual medium is the pop-up book, a three-dimensional book that provides concrete visualizations to clarify objects and concepts (Rianti et al., 2023). Its strengths lie in concretizing abstract ideas through engaging images, boosting student activity and interest (Sentarik & Kusmariyatni, 2020; Sinta & Harlinda Syofyan, 2021). Pop-up books can innovate fraction instruction by presenting concrete, contextual visuals drawn from students' daily lives, including local cultural elements. Such innovation enhances relevance by integrating fractions into local culture. Observations at SD Negeri 1 Salakan show that mathematics instruction has not yet utilized media linking concepts to local culture familiar to students. Local culture offers meaningful, experience-based learning contexts. Therefore, developing an ethnomathematics-based pop-up book tailored to second-grade characteristics is necessary.

Ethnomathematics explores the interplay between culture and mathematics. The term was coined by D'Ambrosio from Brazil in 1977 (Rawani & Fitra, 2022). It examines the transmission, dissemination,

and institutionalization of mathematical knowledge (concepts, procedures, practices) rooted in historical-cultural contexts (Wulandari et al., 2024). Thus, ethnomathematics underpins pop-up book development for fractions, incorporating 3D images of Javanese cultural objects to introduce concepts. Selecting Javanese culture as context is apt, as Nursanti et al., (2024) demonstrate that Javanese traditions embed mathematical thinking exploitable for instruction. According to Zulaekhoh & Hakim (2021), note that Java's provinces feature culturally reasoned patterns interpretable mathematically.

Although prior studies show ethnomathematics integration strengthens conceptual understanding, research specifically developing ethnomathematics-based pop-up books for second-grade fractions remains scarce. Previous work targets upper elementary or secondary levels, focusing on geometry or game-based media. Moreover, validating pop-up book feasibility for fractions via the ADDIE model emphasizing validity and practicality has received limited attention. This study addresses these gaps by developing an ethnomathematics-based pop-up book for second-grade fractions, aligned with Phase A outcomes, Javanese cultural contexts, and cognitive characteristics, while testing validity and practicality through expert validation and teacher-student trials.

This research centers is focus on quality of an ethnomathematics-based pop-up book for second-grade fraction instruction per Phase A outcomes. The medium aims to enhance fraction understanding while enriching learning via local wisdom. This aligns with Una et al. (2024), who emphasize local integration in media development to bolster mathematical comprehension. The objectives are to produce a valid and practical ethnomathematics-based pop-up book for fractions.

Methods

This study employed a Research and Development (R&D) method aimed at producing a specific product and testing its feasibility (Sugiyono, 2015). The following outlines the stages:

1. Development Design

This research adopted the ADDIE model (Branch in Sugiyono, 2015) due to its systematic, logical, and flexible workflow, making it suitable for visual learning media development. The model aligns with the research objectives of producing usable learning media, focusing solely on validity and practicality testing without measuring effects on student learning outcomes due to time constraints and research scope.

The research design followed five ADDIE stages. The analysis stage involved needs assessment through data collection via observations and interviews with second-grade teachers. The design stage included creating a media prototype by structuring content, determining media components, selecting images, designing interactive features, and planning the learning media layout. During development,

the designed pop-up book media ethnomathematics-based fractions was validated by media and content experts to obtain revisions. Implementation involved field-testing with 22 second-grade students and their classroom teacher to assess practicality through response questionnaires. Evaluation occurred twice: post-expert validation and post-teacher-student practicality trials.

2. **Research Participants**

Research subjects comprised 22 second-grade students from SD Negeri 1 Salakan, Bantul, and one second-grade teacher as media users. Validators included media and content experts lecturers in primary school teacher education at Universitas Sarjanawiyata Tamansiswa with expertise in learning media development and elementary mathematics instruction. Participant selection aligned with research goals: testing practicality from users' perspectives and validity from experts' viewpoints.

3. **Data Collection Procedures**

Data collection techniques included observation, interviews, and questionnaires to obtain comprehensive data. Observation and interview instruments were internally developed for this context to identify initial mathematics learning conditions, student characteristics, media usage, student difficulties, and teacher-identified media needs. Questionnaire instruments were adapted from previous studies by Nafoura, 2021; Ata, 2020; and Amaliah, 2022 and modified to suit the ethnomathematics-based pop-up book characteristics. Questionnaires assessed media validity by media and content experts, and practicality by teachers and students. All instruments were consulted with the academic advisor prior to use.

4. **Data Analysis**

Data were analyzed using qualitative and quantitative techniques. Qualitative analysis described the media development process and examined validator feedback. Quantitative analysis processed validity and practicality questionnaire results.

Expert validation and teacher response questionnaires employed a 1–5 Likert scale, while student response questionnaires used a Guttman scale with yes or no options (Sugiyono, 2015). Quantitative data were analyzed using the percentage formula as follows:

$$P = \frac{\sum x}{\sum x_1} \times 100\ \%$$

Details:

P   = Percentage of validity/practicality score

$\sum x$ = Total score obtained

$\sum x_1$ = Maximum possible score

The percentage results of the feasibility scores in terms of validity or practicality were analyzed and interpreted based on the following criteria very valid or very practical ($80\% < PP \leq 100\%$), valid or valuable ($60\% < PP \leq 80\%$), quite valid or reasonably practical ($40\% < PP \leq 60\%$), not valid or not practical ($20\% < PP \leq 40\%$), and very not valid or very not practical ($0\% \leq PP \leq 20\%$). Based on these criteria, the ethnomathematics-based fraction pop-up book media can be declared feasible in terms of validity and practicality if it meets the minimum percentage criteria of more than 60%.

Results and Discussion

The results of this study are aligned with the R&D research procedure using the ADDIE development model, which consists of five stages: analysis, design, development, implementation, and evaluation. The data obtained from each stage of the procedure carried out in this research and development can be described as follows.

The analysis stage involved pre-research data collection identifying teacher-centered mathematics instruction and lack of concrete media, causing second-grade students at SD Negeri 1 Salakan to struggle with fraction concepts and lose focus. Teacher interviews confirmed students understand fractions better with appropriate media, highlighting the need for interactive, contextual learning tools. Thus, an ethnomathematics-based fraction pop-up book was developed, integrating Javanese culture to reinforce basic fraction concepts before advancing to complex topics, serving as the foundation for subsequent product design.

Product design is undertaken by making a *prototype of* ethnomathematics-based fraction *pop-up book* media utilizing the *Adobe Illustrator* application. The design-making process is undertaken in several stages, namely

1. Determination of learning media components, which will include media *cover*, preface, table of contents, instructions for use, learning outcomes, learning objectives, learning materials, *QR code for YouTube* video of fraction songs, *QR code for* Quizizz evaluation questions, bibliography, author profile, and blurb on the back of the *pop-up book*.

2. The material's structure begins with introducing fraction material through the general comprehension of fractions, followed by learning the concept of fractions according to the learning outcomes of half and quarter, to illustrations of their application in everyday life through Javanese cultural elements. Illustrations in this media include traditional fabrics, houses, and cakes equipped with related cultural information that will increase students' knowledge of the cultural context. In addition, evaluation questions are created to measure student comprehension.

3. The selection of images used are woven cloth by Banten Province, Kebaya House by DKI Jakarta Province, cubit cake by West Java Province, batik cloth by *ceplok kawung* motif by Central Java Province, Joglo House by Yogyakarta Province, and Surabaya layer cake by East Java Province. In addition, there are also supporting illustrations, such as pictures of girls and boys wearing traditional Javanese clothes and a map of the island of Java on each page display. The images are made digitally using *vector art* applied to *Adobe Illustrator software.* The outcomes of the selected picture illustrations can be found in Figure 1.
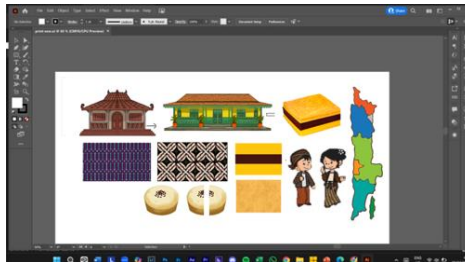

Figure 1. *Pop Up Book Content Picture Element*

4. The creation of interactive features, consisting of practical activities and links to fraction songs by the YouTube *platform* and evaluation questions by the Quizizz *platform* through *QR codes*. In addition, there are practical activities designed to invite students to do hands-on activities, such as pulling or opening pictures that represent fractions. This will be related to the *pop-up book* techniques used, namely *v-fold, pull tabs,* and *box and cylinder*.

5. Format selection was modified to be as interesting as possible for elementary school students, especially grade II students. The *background* on the *cover* and content pages combines blue, the main colour, and a little cloud element. Meanwhile, the bottom of the *background* is equipped with grass elements. Then, the fonts used are Nunito for the content, Letters For Learners for the *cover*, Hug Me Tight for the *cover* and content, and Happy School for the *cover*. The *font* size used ranges from 18 pt to 48 pt so that it is easy for grade II students to read.

6. Learning media design planning is undertaken by combining the process of determining learning media components, compiling materials, selecting images, creating interactive features, and selecting formats. The pre-designed design plan will be developed utilizing Adobe Illustrator.
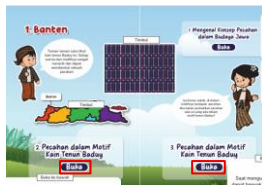
The design by *prototyping* learning media products produces an ethnomathematics-based fraction *pop-up book* media design that is arranged beginning with the cover, preface, table of contents, instructions for use, learning outcomes and objectives, introduction to fraction material $\frac{1}{2}$ and fractions $\frac{1}{4}$; ethnomathematical learning of fraction concepts $\frac{1}{2}$ on Baduy woven fabric by Banten Province, Betawi traditional house by DKI Jakarta Province, and cubit cake by West Java Province; ethnomathematical

learning of fraction concepts $\frac{1}{4}$ on batik ceplok kawung motif by Central Java Province, Joglo traditional house by Yogyakarta Province, and Surabaya layer cake by East Java; evaluation questions; bibliography; and the author's profile. The design that has been made will be consulted by the supervisor before going to the product enhancement stage.

At the product development stage, the design results that have been consulted with the supervising lecturer were submitted to experts. These experts included both media specialists and content experts who are competent in their respective fields. This was intended to obtain suggestions and comments as a reference for revisions before conducting a feasibility assessment in terms of validity. Revisions were provided by the media and content experts as evaluation materials to develop a product suitable for use by second-grade elementary school students.

The suggestions and comments from the media expert included adding arrow instructions on each command to open or pull. These arrows are used to assist students by providing directional guidance for opening or pulling the paper upwards, downwards, to the right, or to the left. Meanwhile, the content expert suggested improving several difficult-to-understand words. Some words marked with a yellow background were changed, such as replacing "opened" with "open," writing "1/2" as "half," and adding the conjunction "so that." The results of the revisions from both the media and content experts can be seen in Table 1

Table 1. Revision Results from Media Expert and Content Expert

Validator	Revision	Before revision	After revision
Media Expert Validation	Arrow Instructions		
Material Expert Validation	Word Improvement		

The product design has been revised per the recommendations and comments by the experts, and then an assessment of the feasibility of the learning media product in terms of validity through a validation questionnaire is undertaken. The media expert filled out the validation questionnaire on Tuesday, April 22, 2025, using an assessment that included aspects of technical feasibility, which received a score of 63

out of a maximum score of 65, and practical feasibility, which fulfilled a maximum score of 10. Validation was also undertaken by material experts on Thursday, April 17, 2025, by an assessment including aspects of curriculum suitability that received a score of 15 out of a maximum score of 15, the feasibility of material content as much as 43 out of 45, and language feasibility as much as 12 out of 15. The final results of the validation questionnaire by both media and material experts received the criteria "Very Valid", which can be found in Table 2.

Table 2. *Results of Media Expert and Material Expert Validation*

Category	Value fulfilled $(\sum x)$	Maximum score $(\sum x_1)$	Percentage (%)	Criteria
Media Expert Validation	73	75	97,33 %	Very valid
Material Expert Validation	70	75	93,33 %	Very valid

The validated product design was developed into a printed product and tested on May 2, 2025, with the class teacher and 22 second-grade students at SD Negeri 1 Salakan. Both teacher and student response questionnaires yielded "Very Practical" criteria: teacher responses scored 73/75 (98.67%) across curriculum suitability, attractiveness, convenience, and usefulness; student responses scored 326/330 (98.63%) across attractiveness, convenience, and usefulness in Table 3.

Table 3. *Results of Teacher and Student Response Questionnaires*

Category	Value fulfilled $(\sum x)$	Maximum score $(\sum x_1)$	Percentage (%)	Criteria
Teacher Response	73	75	98, 67 %	Very practical
Student Response	217	220	98,63 %	Very practical

The final evaluation was conducted once after expert validation (as described in the development stage), while product implementation required no further evaluation since response questionnaires met practicality criteria. The ethnomathematics-based fraction pop-up book, validated as both valid and practical, uses A4 portrait paper (210×297 mm) with Ivory 350 gsm glossy hardcover cover and Ivory 260 gsm interior pages. Titled "Pop Up Book Fraction Math: Recognizing Fraction Concepts in Javanese Culture," the 14-sheet (22-page) book includes preface, contents, usage instructions, learning outcomes and objectives, fraction introduction, ethnomathematical fraction concepts, evaluation questions, bibliography, and author profile.

Figure 2. *Results of The Ethnomathematics-Based Fraction Pop-Up Book Media*

In the ethnomathematics-based fraction *pop-up book* media, the introduction of fraction material $\frac{1}{2}$ and fractions $\frac{1}{4}$ is presented briefly about something whole (equal) on the left side of the media or an entire (equal) on the right side of the media related to each fraction. In addition, there are also QR *barcode* fraction songs and evaluation questions as one of the applications of technology in learning media. Then, to comprehend the concept of fraction material is done ethnomathematically. Ethnomathematical learning in the *pop-up book* fraction media, utilizing the culture in each province on the island of Java, is as follows.

1. Traditional Fabrics

   The traditional cloth in the *pop-up book* fraction media based on ethnomathematics is taken from the culture of Banten Province in the form of Baduy woven cloth and Central Java Province in the form of batik ceplok kawung motif. Both were chosen because they can represent fractions $\frac{1}{2}$ and fractions $\frac{1}{4}$. In Banten Province, the traditional fabric is Baduy woven fabric that is associated with the concept of fractions $\frac{1}{2}$ that can be found in Figure 3.
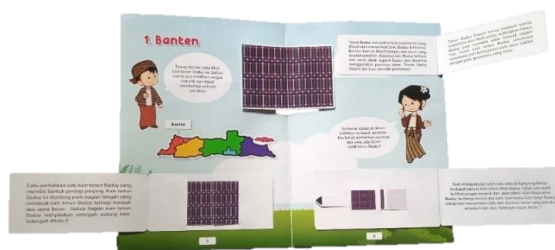

Figure 3. *Ethnomathematical Learning of Fraction$\frac{1}{2}$ On Traditional Fabric*

On the concept of fractions$\frac{1}{4}$ is associated with traditional fabrics in Central Java Province, namely batik ceplok kawung, as shown in Figure 4.

Figure 4. *Ethnomathematical Learning of Fractions$\frac{1}{4}$ on Traditional Fabrics*

The two cultural displays of traditional fabrics in Figure 3 and Figure 4 contain equal and equal fraction material that illustrates students' daily activities by involving parts of the two traditional fabrics, namely Baduy woven fabric and batik ceplok kawung motif fabric in everyday life. Both displays are also equipped with brief information about each conventional cloth. The display is also

modified to increase visual appeal by interactive features. This interactive feature includes illustrations of Baduy woven fabric and batik ceplok kawung motifs that are embossed, as well as commands to be pulled and opened down, right or left. The use of colour in the image and writing is arranged as interestingly as possible to attract students' attention.

2. Traditional House

The traditional house in the ethnomathematics-based fraction *pop-up book* media is taken by one of the cultures by DKI Jakarta Province in the form of Kebaya Traditional House and DI Yogyakarta Province in the form of Joglo Traditional House. Both were chosen because they can represent fractions $\frac{1}{2}$ and fractions $\frac{1}{4}$. The traditional house in DKI Jakarta Province is the Betawi traditional house, commonly found as the kebaya house, which is associated with fractions $\frac{1}{2}$ that can be found in Figure5.

Figure 5. *Fraction Design* $\frac{1}{2}$ *In the Traditional House*

The concept of fractions $\frac{1}{4}$ is associated with a traditional house in DI Yogyakarta Province, namely the Joglo traditional house, which can be found in Figure *6*.

Figure 6. *Design Fractions* $\frac{1}{4}$ *In a Traditional House*

The second display, in Figure 5 and Figure 6, contains learning material on equal and equal fractions that illustrate students' daily activities by involving parts of the two traditional houses, namely the Betawi traditional house and the Joglo traditional house in everyday life. The display is also equipped with brief information about each conventional house. Both design views are modified to be attractive by creating interactive features with illustrations of Betawi traditional houses and Joglo conventional houses that will move when the page is opened because it uses the *v-fold* technique and

commands to be pulled and opened down, right or left. The use of colour is also made as enjoyable as possible in the image and writing to attract students' attention.

3. Traditional Cake

The traditional cakes in the ethnomathematics-based fraction *pop-up book* media are taken by one of the cultures of West Java Province in the form of kue cubit and East Java Province in the form of layer cakes Surabaya. Both were chosen because they can represent fractions $\frac{1}{2}$ and fractions $\frac{1}{4}$. In West Java Province, the traditional cake in kue cubit is associated with fraction $\frac{1}{2}$ which can be found in Figure 7.

Figure 7. Fraction Design $\frac{1}{2}$ in Traditional Cake

The concept of fraction $\frac{1}{4}$ is associated by a traditional cake in East Java Province, namely the Surabaya layer cake. The outcomes of the design design can be found in Figure 8.

Figure 8. Fraction Design $\frac{1}{4}$ in Traditional Cake

The two concepts of fractions in traditional cakes found in Figure 7 and Figure 8 contain equal and equal fractions material that illustrates students' daily activities by involving parts of the two traditional cakes, namely kue cubit and kue lapis Surabaya in everyday life. The display of each conventional cake is also equipped with brief information as an introduction.

All design elements were modified to increase visual appeal by interactive features. These interactive features include illustrations of cubit cakes and Surabaya layer cakes that are *box and*

cylinder and a command to open down or to the left. The colours in the images and text are made as attractive as possible to increase students' interest in fractions.

The ethnomathematics-based fraction pop-up book integrates interactive 3D visualization techniques v-fold, pull tabs, and box and cylinder with the concepts of $\frac{1}{2}$ and $\frac{1}{4}$ fractions alongside ethnomathematical approaches. This aligns with Sintia et al (2024) who state that 3D visualization not only enhances learning engagement but also deepens students' understanding of $\frac{1}{2}$ and $\frac{1}{4}$ fraction concepts. The ethnomathematics approach also facilitates comprehension of basic fraction mathematics through local cultural contexts (Dwi Masithoh et al., 2023). The book's content and techniques conform to the Merdeka Curriculum learning outcomes and have been validated as "highly valid" by media and material experts (Table 2).

The pop-up book enhances second-grade students' understanding of $\frac{1}{2}$ and $\frac{1}{4}$ fraction concepts, particularly numerator and denominator comprehension, through concrete representations of daily Javanese culture. Implementation on May 2, 2025 at SD Negeri 1 Salakan with 22 students and teachers yielded highly practical responses (Table 3). Thus, the media effectively reduces students' math anxiety and negative perceptions toward mathematics learning (Hakim dalam Zulaekhoh & Hakim, 2021).

Conclusion

This study identified fraction concept comprehension problems among second-grade students. Product development followed the ADDIE R&D model through needs analysis, prototype design, validated print production, implementation with students and teachers, and implementation evaluation. The validity and practicality results each showed the requirements of "Very Valid" and "Very Practical." The results from the validation and response questionnaires were 97.33% from the media expert validation questionnaire, 93.33% from the material expert validation questionnaire, 98.67% from the teacher response questionnaire, and 98.63% from the student response questionnaire. Thus, this media is feasible for teaching $\frac{1}{2}$ and $\frac{1}{4}$ fractions with Javanese cultural integration.

Limitations include Javanese cultural scope restriction, basic $\frac{1}{2}$ and $\frac{1}{4}$ fraction content only, lack of pre-post effectiveness testing, and 22-student sample limitation at SD Negeri 1 Salakan. Future research should expand Indonesian cultural contexts, develop advanced fraction topics and other mathematics content, and test effectiveness to measure second-grade students' fraction comprehension empirically.

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