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Development of a Fractions Flipbook to Improve Fourth-Grade Students' Mathematical Representation Skills

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Abstract

This research developed a mathematics flipbook on fractions with like denominators to improve fourth-grade students' mathematical representation skills. Using a research and development design based on the ADDIE model, the study involved 52 students: 26 in the experimental class and 26 in the control class. Data were collected through expert validation, teacher and student response questionnaires, and pretests and posttests. The flipbook received validity scores of 86% from media experts and 98% from material experts, while its practicality score was 98%. The experimental class achieved an average N-gain of 0.75, compared with 0.34 in the control class. An independent-samples t-test indicated no significant pretest difference ($p = 0.148$), but a significant posttest difference ($p < 0.001$). The effect size was very large (Cohen's $d = 3.067$). These findings indicate that the flipbook is valid, practical, and effective in supporting students' mathematical representation skills.

Keywords: *Flipbook Teaching Materials, Mathematical Representation Skills*

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INTRODUCTION

Mathematical representation skills are one of the key competencies in mathematics education because they help students understand and communicate mathematical ideas through various forms of representation. The National Council of Teachers of Mathematics identifies representation as one of the process standards in mathematics education (National Council of Teachers of Mathematics, 2000). These skills encompass visual representations in the form of pictures or diagrams, symbolic representations in the form of mathematical symbols and notation, and verbal representations in the form of explanations using words. These three forms of representation are interrelated in helping students understand mathematical concepts, particularly abstract ones. Norairi et al. (2022) discuss the importance of mathematical representations in solving word problems involving fractions in elementary school. Therefore, mathematics instruction needs to provide students with opportunities to connect various forms of representation so that their understanding is not limited to computational skills but also includes the ability to present and explain mathematical ideas.

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The issue of Indonesian students' mathematical achievement remains a concern, as reflected in the results of international and national assessments. According to the Programme for International Student Assessment (PISA), which assesses the mathematical literacy of 15-year-old students, Indonesia obtained a mathematics score of 366 in 2022, compared with 379 in 2018 (OECD, 2023). At the national level, the 2026 Academic Competency Test (Tes Kemampuan Akademik/TKA) reported an average mathematics score of 43.41 out of 100 for elementary school (SD/MI) student (Uly, 2026). The PISA result provides a broader indication of students' mathematical literacy, within which mathematical representation is addressed as part of the mathematical processes. In contrast, the 2026 TKA Mathematics explicitly includes mathematical representation among the competencies assessed. Because the two assessments differ in their frameworks and target populations, their scores should not be directly compared. Nevertheless, they provide complementary context for understanding mathematics achievement and the importance of strengthening students' mathematical understanding from the elementary level. One topic that requires attention is fractions, which involves understanding the relationship between parts and the whole and connecting visual representations with fraction symbols. Gampu and Ambarita (2025) revealed that elementary school students face difficulties in understanding the meaning of fractions and solving problems related to this topic. Arianto and Supardi (2024) demonstrated that visualization can help students understand the concept of fractions.

This issue was also observed in mathematics instruction at the Kebonsari 3 Tuban Public Elementary School (UPT SD Negeri Kebonsari 3 Tuban). Based on initial observations of 52 fourth-grade students, 23 students or approximately 45% had not achieved learning mastery, while 29 students, or about 55%, had achieved mastery. The observation results indicated that students who had not achieved mastery still struggled when solving problems presented as pictures or concrete models, connecting visual representations with fraction symbols, and explaining the meaning of fractions verbally. These findings suggest that students still require instructional support to help them understand the concept of fractions through various forms of representation. Difficulties in connecting symbolic representations with visual or concrete forms were also discussed by (Unaenah et al., 2024). This situation highlights the need for instructional materials that not only present content and example problems but also facilitate students' ability to observe, connect, and explain the concept of fractions.

One alternative that can be used to support this learning is a mathematics flipbook. A flipbook is a digital instructional resource that presents material in a structured manner through a combination of text, images, and multimedia elements. These features can be utilized to present fraction concepts through illustrations while also providing students with the opportunity to study the material and complete exercises in a more interactive way. Vikiantika et al. (2022) demonstrated the potential of using flipbooks in mathematics instruction to support student learning outcomes. Zuhro et al. (2024) also developed a flipbook-based mathematics e-module on fractions, which was found to be suitable and effective for learning. Meanwhile, Susiliastini and Sujana (2022) developed an ethnomathematics-based flipbook that links mathematical concepts to cultural contexts. These studies indicate that flipbooks can be utilized to support mathematics learning with diverse presentation styles and objectives. However, their development must still be tailored to students' needs and the specific mathematical skills intended for improvement.

Previous studies have developed various learning media and instructional materials to support students' mathematical abilities, including mathematical representation. Firdaus et al. (2022), for example, developed Articulate Storyline-based learning media on cubes and blocks nets to improve fifth-grade students' mathematical representation skills. Their

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findings indicated that the media supported an improvement in students' mathematical representation abilities. In addition, several studies have developed flipbooks for different mathematical learning objectives. Andara et al. (2022) focused on improving mathematical problem-solving skills, while Rahma and Rhomdani (2025) addressed mathematical communication skills. Susiliastini and Sujana (2022) integrated ethnomathematics contexts into flipbook-based learning, whereas A'inulkholifah and Sari (2025) focused on interactive flipbook development to support conceptual understanding. These studies demonstrate the potential of various learning media and flipbooks to support mathematics learning. However, differences remain in the learning content, instructional activities, and mathematical skills addressed. The study by Firdaus et al. (2022), for instance, focused on geometric material and Articulate Storyline-based media, while the previous flipbook studies addressed problem-solving, communication, ethnomathematics, and conceptual understanding. Therefore, the present study develops a mathematics flipbook specifically for fourth-grade students learning fractions with the same denominator, with an emphasis on visual, symbolic, and verbal representation skills. Its distinguishing features include illustrated fraction materials, activities for observing, discussing, and drawing conclusions, exercises for recognizing, comparing, and ordering fractions, a fraction song, and interactive exploration using Polypad. These activities are designed to help students interpret fraction illustrations, connect them with mathematical symbols, and explain their understanding in written form.

Based on this need, this study developed a mathematics flipbook teaching material on fractions with the same denominator for fourth-grade elementary school students. The novelty of the product lies in the integration of content and learning activities designed to develop visual, symbolic, and verbal representations. This flipbook contains illustrations of fractions, activities for observing, discussing, and drawing conclusions, as well as exercises for recognizing, comparing, and ordering fractions with the same denominator. Additionally, the product includes a fraction song as a learning interlude, a "Skill Builder" section to reinforce students' understanding, and Polypad as a tool for interactive exploration. The integration of visual, symbolic, and verbal activities is supported by Liu and Jacobson (2022), who reported that fourth-grade students used these three forms of representation when solving fraction-ordering tasks. Thus, this development is not only oriented toward presenting material in a digital format but also toward integrating learning activities that support the development of students' mathematical representation skills.

Based on this description, this study aims to describe the process of developing a mathematics flipbook teaching material on fractions with the same denominator to improve the mathematical representation skills of fourth-grade elementary school students. Additionally, this study aims to determine the validity, practicality, and effectiveness of the developed teaching material. The research results are expected to provide an alternative digital teaching material that supports the learning of fractions in a more visual and interactive way and to serve as a reference for the development of mathematics teaching materials oriented toward students' mathematical representation skills.

METHODS

Type and Design

This study employed the research and development (R&D) method to produce mathematics flipbook teaching materials on fractions with like denominators and to examine their validity, practicality, and effectiveness. Sugiyono (2019) explains that research and development aims to produce a specific product while simultaneously assessing its feasibility. The development process followed the ADDIE model, consisting of five phases: Analysis, Design, Development, Implementation, and Evaluation.

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According to Oktavia and Rahmawati (2021), formative evaluation can be conducted at each stage to provide a basis for product improvement. In this study, the Analysis phase involved identifying students' learning difficulties and instructional needs, while the Design phase focused on preparing the instructional content and flipbook structure. The Development phase involved producing the flipbook, conducting expert validation, and revising the product based on expert feedback. During the Implementation phase, the developed flipbook was used in classroom instruction to assess its practicality and effectiveness. Evaluation was conducted formatively throughout the development process, including the assessment of expert validation results, teacher and student responses, and students' pretest and posttest performance. These evaluation findings informed product refinement and provided evidence for assessing the feasibility of the developed instructional material.

The study was conducted at a public elementary school in Tuban, East Java, Indonesia, during the first semester of the 2026/2027 academic year. The study involved 52 fourth-grade students from two classes, with 26 students in each class. Class 4-A was purposively selected as the experimental group based on the availability of facilities to support the use of the flipbook, variations in students' abilities and learning styles, access to learning devices, and the suitability of the instructional schedule. Class 4-B served as the control group. The development process followed the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. Each stage was carried out systematically to identify students' learning needs, design the instructional material, develop and validate the flipbook, implement the product in classroom learning, and evaluate its validity, practicality, and effectiveness.

Data and Data Sources

The research data consisted of quantitative and qualitative data. Quantitative data included validation scores from subject matter experts and media experts to measure the validity of the flipbook; questionnaire scores from teachers and students in Class 4-A (the experimental group) to assess its practicality; and the pretest and posttest results of students in Classes 4-A and 4-B to evaluate the effectiveness of the flipbook. Qualitative data consists of the validators' critiques and suggestions, which were used as the basis for product improvements. Data sources included subject matter experts, media experts, the fourth-grade teacher, and students from both participating fourth-grade classes.

Data Collection Techniques

Data were collected through observation, interviews, validation, questionnaires, and tests. Validation sheets were used to assess the suitability of the content and media. Content aspects included the appropriateness of the subject matter, presentation, mathematical representation, and language. Media aspects included visual and audio presentation, interactivity, suitability for student characteristics, and usefulness. Validation assessments used a four-point Likert scale: 4 = very good, 3 = good, 2 = not very good, and 1 = very poor, based on (Rahayu & Anwar, 2024).

Teacher and student response questionnaires were used to determine reactions to the use of the flipbook instructional material. The assessment used a four-point Likert scale, where 4 = strongly agree, 3 = agree, 2 = disagree, and 1 = strongly disagree, as described by (Prasetyo & Purwihartuti, 2025). The use of four response options without a neutral category helps reveal the respondents' response tendencies. During the implementation stage of the ADDIE model, the experimental group received instruction using the developed flipbook, whereas the control group received conventional instruction without the flipbook.

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Pretest and posttest assessments were administered to measure students' mathematical representation skills before and after instruction. The test items were developed based on the mathematical representation standards established by the National Council of Teachers of Mathematics (NCTM, 2000), which encompass three indicators: visual, symbolic, and verbal representation. Visual representation involved students' ability to use diagrams or illustrations to model and interpret mathematical problems. Symbolic representation involved students' ability to express and translate mathematical ideas using mathematical symbols and notation. Verbal representation involved students' ability to organize, communicate, and explain mathematical ideas in written form. The instruments consisted of 10 test items covering these three indicators and were reviewed by experts to assess their content suitability, clarity, and alignment with the intended learning objectives and mathematical representation indicators. The same assessment indicators were used in both the pretest and posttest to measure changes in students' mathematical representation skills following instruction.

Table 1. Mathematical Representation Indicators and Test Item Distribution

Indicator	Description	Test Items
Visual representation	Using diagrams or illustrations to model and interpret mathematical problems.	1-4
Symbolic representation	Expressing and translating mathematical ideas using symbols and mathematical notation.	5-7
Verbal representation	Organizing, communicating, and explaining mathematical ideas in written form.	8-10

To ensure the quality of the assessment instruments, validity and reliability tests were conducted on both the pretest and posttest items before their use in the study.

Instrument Validity and Reliability

The validity of the pretest and posttest instruments was examined separately using the Pearson Product-Moment correlation. The analysis involved 26 students. The degrees of freedom (df) were determined using the formula $df = N - 2$, resulting in 24 $(26 - 2)$. At a 5% significance level (two-tailed), the critical r-value was 0.388. An item was considered valid when its calculated correlation coefficient exceeded the critical r-value and its significance value was below 0.05.

The pretest validity analysis showed that all 10 items had item-total correlation coefficients ranging from 0.649 to 0.968, exceeding the critical r-value of 0.388 ($p < 0.001$). Similarly, all 10 posttest items were valid, with item-total correlation coefficients ranging from 0.848 to 0.923 ($p < 0.001$). These results indicate that all items in both instruments met the established item validity criteria.

Instrument reliability was assessed separately using Cronbach's alpha to determine the internal consistency of the pretest and posttest instruments. The reliability coefficients were interpreted based on the established criteria, in which values ranging from 0.70 to less than 0.90 indicate high reliability, while values of 0.90 or higher indicate excellent reliability. The results of the reliability analysis are presented in Table 2.

Table 2. Reliability Test Results of the Pretest and Posttest Instruments

Instrument	Cronbach's Alpha	Number of Items	Interpretation
Pretest	0.966	10	Excellent
Posttest	0.971	10	Excellent

As presented in Table 2, the pretest instrument obtained a Cronbach's alpha coefficient of 0.966, while the posttest instrument obtained a coefficient of 0.971. Both coefficients exceeded 0.90, indicating excellent internal consistency. These findings

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demonstrate that both instruments had excellent reliability for measuring students' mathematical representation skills.

Data Analysis Techniques

Qualitative data in the form of critiques and suggestions from validators were analyzed descriptively by examining feedback regarding the product's strengths, weaknesses, and aspects requiring improvement. The results of this analysis were used as a reference for revising the flipbook instructional material before it was pilot-tested. Meanwhile, quantitative data were analyzed to determine the product's level of validity, practicality, and effectiveness.

Validity analysis was conducted by calculating the percentage of the score obtained relative to the maximum score using the formula from (Sugiyono, 2019) as follows:

$$P = \frac{f}{N} \times 100\%$$

The percentage obtained is then interpreted based on the validity criteria presented in Table 3.

Table 3. Percentage of Validity Criteria

Assesment	Criteria
0% - 20%	Highly Invalid and Unusable
21% - 40%	Invalid and Not Permitted for Use
41% - 60%	Insufficiently Valid and Not Yet Usable Without Major Revisions
61% - 80%	Valid and Usable, but Requires Minor Revisions
81% - 100%	Highly Valid and Usable Without Revisions

Source: (Riduwan, 2014)

The practicality of the flipbook teaching materials was analyzed based on the responses of teachers and students after using them in the classroom. The practicality percentage was obtained by comparing the scores achieved with the maximum possible score. The calculation was performed using the formula (Sugiyono, 2019) as follows:

$$P = \frac{f}{N} \times 100\%$$

The resulting practicality percentage is then interpreted based on predetermined criteria to determine the level of practicality of the flipbook teaching material. The criteria and categories for the practicality percentage are presented in Table 4.

Table 4. Practicality Criteria Percentages

Assesment	Criteria
0% - 20%	Very Impractical and Unusable
21% - 40%	Impractical and Not Permitted for Use
41% - 60%	Not Very Practical and Cannot Be Used Without Major Revisions
61% - 80%	Practical and Usable, But Requires Minor Revisions
81% - 100%	Very Practical and Usable Without Revisions

Source: (Riduwan, 2014)

The effectiveness of the *flipbook* teaching material was analyzed by comparing students' *pretest* and *posttest* results using the Normal Gain test calculation based on the formula from (Sukarelawan et al., 2024) as follows:

$$g = \frac{S_{posttest} - S_{pretest}}{S_{ideal} - Spretest}$$

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The effectiveness of the flipbook teaching material was evaluated using Normalized Gain (N-Gain), calculated from the pretest and posttest scores of both the experimental and control groups. The analysis was conducted to compare the improvement in students' mathematical representation skills between the two groups. The N-Gain score for each group was calculated by comparing the difference between the posttest and pretest scores with the maximum possible improvement. The resulting scores were interpreted using the criteria presented in Table 5. A comparison of the N-Gain scores was then used to determine whether the experimental group demonstrated greater improvement than the control group following the implementation of the flipbook teaching material.

Table 5. N-Gain Criteria

Percentage	Criteria
$0{,}70 \leq g \leq 1{,}00$	High
$0{,}30 \leq g < 0{,}70$	Moderate
$0{,}00 < g < 0{,}30$	Low
$g = 0{,}00$	No Increase
$-1{,}00 \leq g < 0{,}00$	Decrease

Source: (Sukarelawan et al., 2024)

In addition to N-Gain analysis, the effectiveness of the instructional material was also assessed based on the percentage of students who achieved learning mastery in both the experimental and control groups. This analysis provided additional information about the proportion of students who met the established mastery criteria in each group. The results were compared to determine the extent to which the experimental group achieved learning mastery relative to the control group. The effectiveness levels were interpreted according to the percentage criteria presented in Table 6.

Table 6. Effectiveness Criteria Based on Percentage

Percentage	Criteria
$0\% \leq kf \leq 39\%$	Ineffective
$40\% \leq kf \leq 55\%$	Less Effective
$56\% \leq kf \leq 75\%$	Fairly effective
$76\% \leq kf \leq 100\%$	Highly Effective

Source: (Sukarelawan et al., 2024)

Inferential analysis was conducted to determine differences in students' mathematical representation skills between the experimental and control groups. The research hypotheses were formulated as follows:

H_o: There is no significant difference in students' mathematical representation skills between the experimental group receiving instruction using the mathematics flipbook and the control group receiving conventional instruction after the learning process.

H_a: There is a significant difference in students' mathematical representation skills between the experimental group receiving instruction using the mathematics flipbook and the control group receiving conventional instruction after the learning process.

Normality was assessed using the Shapiro–Wilk test, while homogeneity of variances was examined using Levene's test. After the assumptions were met, an independent-samples t-test was conducted to compare the mean posttest scores of the two independent groups. According to Nuryadi et al. (2017), this test is used to determine differences between two independent groups.

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The analysis was conducted using IBM SPSS Statistics version 30 at a significance level of 0.05. Decisions were based on the two-tailed significance value (Sig. 2-tailed). If the significance value was less than 0.05, H_o was rejected, indicating a statistically significant difference between the two groups and supporting H_a. Conversely, if the significance value was greater than or equal to 0.05, H_o was not rejected, indicating insufficient statistical evidence of a significant difference between the two groups.

In addition, Cohen's d was calculated to determine the magnitude of the difference between the two groups, with the results interpreted according to the criteria presented in Table 7.

Table 7. Interpretation of Cohen's d Effect Size

Effect Size	Interpretation
$0 < d < 0{,}2$	Small
$0{,}2 < d \leq 0{,}5$	Moderate
$0{,}5 < d \leq 0{,}8$	Large
$d > 0{,}8$	Very Large

Source: (Rossytasari. & Setyaningtyas, 2021)

RESULTS AND DISCUSSION

This study developed mathematics flipbook teaching materials on fractions with like denominators for fourth-grade elementary school students using the ADDIE model. The development process involved five phases: Analysis, Design, Development, Implementation, and Evaluation. The findings from each phase are presented to describe the development process, product characteristics, and assessment of the instructional material.

Analysis Phase

The analysis phase aimed to identify students' learning difficulties, instructional needs, and characteristics relevant to the development of the flipbook. Classroom observations and interviews with the fourth-grade teacher were conducted at a public elementary school in Tuban, East Java, Indonesia, from January 5 to 17, 2026.

The findings indicated that some students experienced difficulties understanding fraction concepts and expressing mathematical ideas through different forms of representation. Students also encountered difficulties connecting visual illustrations with mathematical symbols and explaining mathematical concepts in writing. These difficulties were associated with the limitations of the instructional materials used in classroom learning, which relied primarily on conventional textbooks and worksheets and provided limited opportunities for visualizing mathematical concepts.

The analysis further indicated the need for instructional materials that could facilitate students' understanding through visual, symbolic, and verbal representations. Based on these findings, a digital flipbook was selected as an alternative instructional material for teaching fractions with like denominators. The proposed material was designed to provide more varied learning experiences through the integration of visual illustrations, mathematical symbols, written explanations, and interactive learning activities.

Design Phase

The design phase focused on planning the instructional content, product structure, and learning activities based on the needs identified during the analysis phase. The flipbook was designed for fourth-grade students and aligned with the learning objectives for fractions with like denominators.

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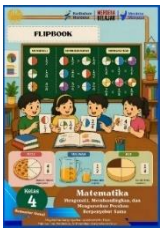
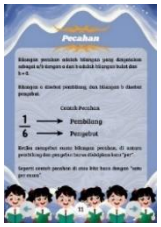
The instructional content covered three main learning objectives: recognizing fractions, comparing fractions with like denominators, and ordering fractions with like denominators. Canva was used to design the digital instructional material, with attention to color selection, typography, text size, illustrations, and page layout to support readability and accommodate elementary school students' characteristics.

The flipbook was designed as a digital book with a page-flipping feature that could be accessed through computers, laptops, and smartphones. Its planned components included a cover, foreword, usage instructions, concept map, instructional materials, illustrations, exercises, audio elements, a fraction song, and interactive activities using Polypad. A teacher's manual was also designed to provide guidance for implementing the material during classroom instruction.

The instructional design emphasized the integration of visual, symbolic, and verbal representations to help students recognize fractions, interpret mathematical symbols, and communicate their understanding through written explanations.

Based on the findings of the analysis phase, the initial design specifications of the flipbook were developed to establish the instructional structure, content organization, visual presentation, and interactive features of the teaching material. The design specifications are summarized in Table 8.

Table 8. Initial Design Specifications of the Flipbook Teaching Materials

Design	Description
	The opening page features the title of the instructional material, the logo of Surabaya State University (UNESA), the subject name, and an illustration related to the topic of fractions with the same denominator.
	A Foreword expressing gratitude to God for the completion of this technology-based mathematics teaching material. The text explains that this material was developed to support the teaching of fractions in elementary school and to help students understand the concepts more easily. The conclusion expresses the hope that this material will be beneficial to the learning process and can be further developed in the future.
	This concept map covers the topic “Identifying, Comparing, and Ordering Fractions.”
	The lesson on fractions with the same denominator explains the concept of fractions and how to compare and order them, and includes illustrations and example problems to help students understand the material.

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Design	Description
	"Learning Through Music" features songs that introduce fractions and educational songs that explain how to compare fractions in a simple and easy-to-understand way. These songs are provided so that students do not get bored during the learning process.
	This instructional material is equipped with the Polypad feature, an interactive tool that supports the visualization of fraction concepts and helps students develop their conceptual understanding.
	"Hone Your Skills" contains questions on the topic "Identifying, Comparing, and Ordering Fractions with the Same Denominator," which students must complete to assess their understanding.

The design specifications served as the foundation for the subsequent development phase. The integration of visual illustrations, mathematical symbols, written explanations, and interactive activities was intended to support students' mathematical representation skills. The planned components were subsequently developed into a digital flipbook using Canva and integrated with Polypad to provide additional opportunities for exploring fraction concepts.

Development Phase

The development phase involved producing the flipbook based on the design specifications established in the previous phase. The product was developed by integrating instructional content, visual illustrations, mathematical symbols, audio elements, practice activities, and interactive features. The development process also included the preparation of a teacher's manual to support the use of the instructional material during classroom learning.

The initial product was subsequently evaluated by media and subject matter experts to assess its feasibility before classroom implementation. Media validation was conducted by two expert validators on July 20, 2026. The media assessment covered five aspects: visual presentation, audio, interactivity, suitability for student characteristics, and usefulness. Meanwhile, the subject matter assessment covered four aspects: content suitability, material presentation, mathematical representation, and language. The validation results are presented in Table 9.

Table 9. Validation Results of the Flipbook Teaching Materials

Evaluation Aspects	Percentage	Category
Media Expert	86%	Highly Valid
Subject Matter Expert	98%	Highly Valid

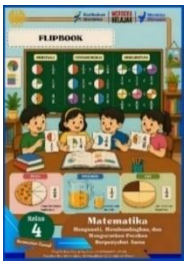
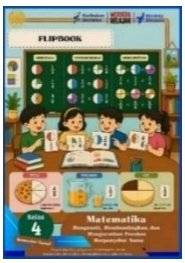
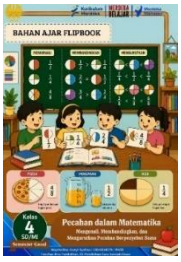
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The media validation yielded a score of 86%, while the subject matter validation yielded 98%. Both results were classified as highly valid based on the feasibility criteria used in this study.

In addition to the quantitative scores, the validators provided suggestions for improving the instructional material. The media experts recommended revisions to the cover design, font type and size, concept map, fraction notation, text placement in cloud-shaped elements, and the selection of several illustrations. The subject matter expert considered the instructional content appropriate for implementation, with minor corrections required in the material on comparing fractions.

The product was revised based on these recommendations. The revisions included improvements to the cover, typography, concept map, mathematical notation, and selected visual elements. These adjustments were intended to improve the visual presentation and mathematical accuracy of the instructional material before its implementation. The following is a preview of the flipbook teaching material, which includes the tables before and after revision.

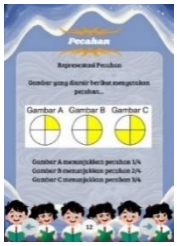
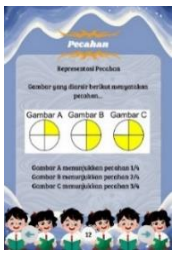
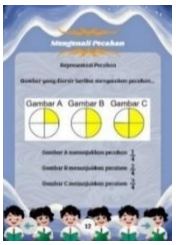
Table 10. Preview of the Flipbook Teaching Material

No.	Appearance	Description
Flipbook Teaching Materials Design Preview		
1.	 The Flipbook teaching materials can be accessed via the following link: https://heyzine.com/flip-book/21df943439.html	The opening page of the instructional material features the flipbook title, the author's name, and illustrations related to the topic of fractions. The design incorporates attractive colors and images to appeal to fourth-grade elementary school students.
Revised by a Media Expert		
Pre-revision		**Suggestions** Change the title from "Flipbook" to "Flipbook Teaching Materials," add the elementary school level, and correct the titles of the lessons.
Post-revision		**Repairs** The title has been changed, the grade level has been added, and the fraction element has been added to the lesson title.

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No.	Appearance	Description
2.		A screenshot of the "Foreword" page, which contains an introductory message, the purpose of creating the flipbook teaching material, and the author's hopes for the use of the flipbook teaching material in mathematics instruction.
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)
3.		A screenshot of the Concept Map page, which provides an overview of the topic of fractions including identifying, comparing, and ordering fractions with the same denominator as the main subject matter in the flipbook teaching material.
	Revised by a Media Expert	
	Pre-revision 	**Suggestions** Modify the concept map to make it more engaging and better suited to the characteristics of fourth-grade elementary school students.
	Post-revision 	**Repairs** The concept map has been replaced with one that is more engaging and better suited to the characteristics of fourth-grade elementary school students.
4.		This prologue provides an introduction to fractions with the same denominator, relating them to everyday life. Students are encouraged to learn about fractions through examples involving food, observation activities, using Polypad, discussions, and completing exercises.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)

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No.	Appearance	Description
	Post-revision (No repairs needed)	**Repairs** (None)
5.		The lesson on fractions with the same denominator explains the concept of fractions and how to compare and order them, and includes illustrations and example problems to help students understand the material.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)
	Post-revision (No repairs needed)	**Repairs** (None)
6.		This lesson introduces the representation of fractions through pictures. Students can see the relationship between the shaded parts and their corresponding fractions, such as $\frac{1}{4}$, $\frac{2}{4}$, and $\frac{3}{4}$.
	Revised by a Media Expert	
	Pre-revision 	**Suggestions** Correct the notation of fractions that is, use ¼ instead of $\frac{1}{4}$. This is done to prevent misconceptions among elementary school students.
	Post-revision 	**Repairs** We have corrected the notation for fractions, such as writing ¼ as $\frac{1}{4}$, and so on.
7.		This lesson explains how to compare two fractions with the same denominator using cross-multiplication. It includes examples and step-by-step instructions to help students more easily understand how to determine the value of a fraction.

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No.	Appearance	Description
	Revised by a Media Expert	
	Pre-revision	**Suggestions**
		Review and revise the material, as it contains some inaccurate statements.
	Post-revision	**Repairs**
		We have revised the material on comparing fractions with the same denominator to ensure that the concepts are accurate and easy for elementary school students to understand.
8.		"Learning Through Music" features songs that introduce fractions and educational songs that explain how to compare fractions in a simple and easy-to-understand way. These songs are provided so that students do not get bored during the learning process.
	Revised by a Media Expert	
	Pre-revision	**Suggestions**
		Display YouTube thumbnails, separated by page.
	Post-revision	**Repairs**
		We have included a preview of the YouTube video so that students know what will be played, and we have separated the first and second songs onto different pages.

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No.	Appearance	Description
9.		The flipbook teaching material is equipped with the Polypad feature as an interactive tool that supports the visualization of fraction concepts and helps students build their conceptual understanding.
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)
10.		"Hone Your Skills" contains questions on the topic "Identifying, Comparing, and Ordering Fractions with the Same Denominator," which students must complete to assess their understanding.
	Revised by a Media Expert	
	Pre-revision  **Post-revision** 	**Suggestions** Fixes to the formatting of fractional numbers and font size. **Repairs** We have corrected the formatting of fractional numbers and adjusted the font size for each question number.
11.		The Bibliography contains the sources used as references in the development of the flipbook teaching materials.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)

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No.	Appearance	Description
	Post-revision (No repairs needed)	**Repairs** (None)
Teacher's Guide Design Layout		
1.	 The Teacher's Guide can be accessed via the following link: https://heyzine.com/flip-book/3e5fa7cec2.html	The cover of the teacher's guide, which contains material on fractions with the same denominator for 4th-grade elementary school students, features illustrations of learning activities as well as examples of fractions in everyday life.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)
	Post-revision (No repairs needed)	**Repairs** (None)
2.		A screenshot of the Preface page, which contains an introductory message, the purpose of compiling the teacher's guide, and the author's hopes regarding the use of the teacher's guide in mathematics instruction.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)
	Post-revision (No repairs needed)	**Repairs** (None)
3.		This page explains the learning outcomes and objectives that students will achieve after studying the topic of fractions with the same denominator.
	Revised by a Media Expert	
	Pre-revision (No repairs needed)	**Suggestions** (No repairs needed)
	Post-revision (No repairs needed)	**Repairs** (None)
4.		This page explains how to use the instructional materials. It helps students understand the content of the instructional materials in a logical sequence.

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No.	Appearance	Description
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)
5.		This page explains how to use a flipbook, from setting up your device and opening a link or QR code to turning the pages.
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)
6.		This page explains how to use Polypad as an interactive learning tool to help students understand concepts.
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)
7.		This page contains attachments in the form of links and barcodes that can be used to access the flipbook teaching materials more easily.
	Revised by a Media Expert	
	Pre-revision (No repairs needed) **Post-revision** (No repairs needed)	**Suggestions** (No repairs needed) **Repairs** (None)

Implementation Phase

The implementation phase was conducted at a public elementary school in Tuban, East Java, Indonesia, involving 52 fourth-grade students. The participants were divided into two groups: Class 4-A, consisting of 26 students in the experimental group, and Class 4-B, consisting of 26 students in the control group.

The experimental group received mathematics instruction using the developed flipbook, whereas the control group received conventional instruction using textbooks and student worksheets. Pretests were administered to both groups before the instructional

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activities, followed by posttests after the learning sessions to assess changes in students' mathematical representation skills. The classroom implementation of the flipbook teaching materials in the experimental group is illustrated in Figure 1.



Figure 1. Classroom Implementation of the Flipbook Teaching Materials in the Experimental Group

Practicality of the Flipbook Teaching Materials

The practicality of the flipbook was assessed through response questionnaires completed by the fourth-grade teacher and students in the experimental group after the implementation. The assessment results are presented in Table 11.

Table 11. Practicality Assessment of the Flipbook Teaching Materials

Respondents	Percentage	Category
Grade 4-A Teacher	98%	Very Practical
Grade 4-A Students	98%	Very Practical

The results showed that both the teacher and students assigned a practicality score of 98%, placing the instructional material in the very practical category. The teacher's responses indicated that the flipbook was easy to use and supported by clear instructions. However, the teacher also suggested improving the color presentation on several pages because some colors appeared too bright. The product was subsequently revised in response to this feedback.

The student responses also reached 98%, indicating positive perceptions of the instructional material. The questionnaire covered aspects of ease of use, visual presentation, material clarity, interactivity, and support for mathematical representation skills.

Improvement in Mathematical Representation Skills

Students' mathematical representation skills were analyzed using the Normalized Gain (N-Gain) based on pretest and posttest scores from the experimental and control groups. The results are presented in Table 12.

Table 12. N-Gain Results for Mathematical Representation Skills

Class	Number of Students	Average N-Gain	Category
Experimental (4-A)	26	0,75	High
Control (4-B)	26	0,34	Moderate

The results in Table 12 show that the experimental group obtained an average N-Gain score of 0.75, which falls into the high improvement category, whereas the control group obtained an average N-Gain score of 0.34, classified as moderate improvement. The difference between the two groups was 0.41, indicating that the improvement in mathematical representation skills was greater in the experimental group than in the control group.

Based on the effectiveness percentage criteria applied in this study, the experimental group's N-Gain percentage of 75% was classified as fairly effective, whereas

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the control group's N-Gain percentage of 34% was classified as ineffective. These classifications provide an additional interpretation of the improvement achieved by each group based on the effectiveness criteria.

These findings suggest that students who received instruction using the developed flipbook demonstrated greater improvement than those who received conventional instruction. The higher N-Gain score in the experimental group provides evidence supporting the effectiveness of the flipbook in improving students' mathematical representation skills. This finding is further supported by the results of the independent-samples t-test, which showed a statistically significant difference in posttest scores between the two groups. Therefore, the N-Gain comparison and inferential test results provide complementary evidence of the effectiveness of the developed instructional material.

The analysis of students' responses to the mathematical representation test indicated differences in achievement across the three indicators. Visual representation showed the highest level of achievement, followed by symbolic representation, while verbal representation showed the lowest level. In visual representation, students demonstrated greater success in determining fraction values from illustrations by identifying shaded parts and relating them to the total number of equally divided parts, although some students still experienced difficulties distinguishing between the numerator and denominator. In symbolic representation, students experienced difficulties using mathematical comparison symbols, particularly in distinguishing between the greater-than (>) and less-than (<) symbols. Meanwhile, in verbal representation, some students were able to obtain correct answers but experienced difficulties explaining the mathematical reasoning behind their solutions in clear and coherent written statements.

Statistical Analysis

Normality Test

A normality test was conducted using the Shapiro-Wilk test to determine the distribution of pretest and posttest data in the experimental and control classes. The test results are presented in Table 13.

Table 13. Results of the Shapiro-Wilk Normality Test

Test Of Normality				
		Shapiro-Wilk		
Results of Mathematical Representation Skills	Class	Statistics	df	sig
	Pretest Experiment	.938	26	.121
	Posttest Experiment	.940	26	.136
	Pre-test Control	.932	26	0.89
	Posttest Control	.939	26	.124
a. Lilliefors Significance Correction				

Based on Table 13, all significance values are greater than 0.05. Thus, the pretest and posttest data for both classes meet the normality criteria based on the Shapiro-Wilk test.

Homogeneity Test

The homogeneity test was conducted using Levene's Test. The test results are presented in Table 14.

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Table 14. Results of the Levene's Test for Homogeneity of Variance

Test Of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig
Results of Mathematical Representation Skills	Based on Mean	.857	3	100	.466
	Based on Median	.646	3	100	.587
	Based on Median and with adjusted df	.646	3	96.248	.588
	Based on trimmed mean	.818	3	100	.487

Based on the results of the homogeneity test, it can be seen that the significance score *based on the mean* is 0,466. Therefore, it can be concluded that the significance scores for the experimental and control classes are greater than 0.05 (sig. > 0.05), indicating that the data from both classes share the same characteristics (i.e., they are homogeneous).

Hypothesis Testing

Differences in mathematical representation skills between the experimental and control groups were analyzed using independent-samples t-tests. Separate tests were conducted on the pretest and posttest scores, as presented in Table 15.

Table 15. Results of the Independent Samples t-test

Data Tested	Sig. (2-tailed)	Decision
Pretest	0.148	No significant difference
Posttest	< 0.001	There is a significant difference

Based on Table 15, the pretest results show a significance value of 0.148, which is greater than 0,05. Thus, there is no significant difference between the initial abilities of students in the experimental class and the control class. Meanwhile, the posttest results yielded a significance value of 0.001, which is less than 0,05. These results indicate a significant difference in students' mathematical representation skills in both classes after the instruction was implemented.

Effect Size Analysis

The magnitude of the effect of using the flipbook instructional material was analyzed using Cohen's d effect size. The analysis results are presented in Table 16.

Table 16. Results of the Analysis of Cohen's d Effect Size

Analysis	Value	Interpretation
Cohen's d	3.067	Very Large

The Cohen's d value obtained from the effect size analysis was 3.067, which falls within the "Very Large" category. This value indicates a substantial standardized difference associated with the use of flipbook teaching materials in the participating classes. Thus, the use of flipbook teaching materials directly contributes to the development of fourth-grade students' mathematical representation skills in solving problems involving fractions with the same denominator. However, considering the relatively small sample size and the involvement of students from only one public elementary school, this finding should be interpreted within the context of the present study and should not be generalized to broader student populations without further investigation.

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Evaluation Phase

Evaluation was integrated throughout the development process to identify aspects requiring improvement and to ensure that the instructional material remained aligned with students' learning needs and instructional objectives.

During the analysis phase, evaluation focused on identifying learning difficulties and determining the suitability of the proposed instructional solution. In the design phase, the alignment between learning objectives, instructional content, student characteristics, and the planned flipbook components was considered. During development, expert validation provided the basis for revising the cover, typography, concept map, mathematical notation, and visual elements.

During implementation, teacher and student responses provided additional information regarding the practicality of the instructional material. Feedback from the teacher led to further adjustments to the color presentation on several pages. Meanwhile, the pretest and posttest results provided information about changes in students' mathematical representation skills following the instructional activities.

Overall, the evaluation findings indicated that the developed flipbook met the validity and practicality criteria established in this study. The comparison of N-Gain results also showed greater improvement in the experimental group than in the control group. Nevertheless, the findings identified the need for further development, particularly in providing more varied visual, animation, and audio elements and expanding learning activities that strengthen students' symbolic and verbal mathematical representations.

Students' Mathematical Representation Skills

The findings indicate that students in the experimental group demonstrated greater improvement in mathematical representation skills than those in the control group. The difference in N-Gain scores (0.75 for the experimental group and 0.34 for the control group), together with the statistically significant difference in posttest scores, suggests that the use of flipbook teaching materials was associated with more favorable learning outcomes in the experimental group. This finding can be understood in relation to the learning experiences provided by the flipbook, which integrated fraction illustrations, mathematical symbols, written explanations, audio, fraction songs, interactive exercises, and Polypad activities. These features provided students with opportunities to engage with fraction concepts through different forms of representation rather than relying solely on written explanations and numerical procedures.

During the learning activities, students were introduced to fraction concepts through visual illustrations and written explanations. They then engaged with the "Hone Your Skills" exercises, which covered identifying, comparing, and ordering fractions with like denominators. The integration of Polypad also provided opportunities to explore fractions through visual models and mathematical symbols. Meanwhile, audio and fraction songs offered additional variety in the learning experience. These activities were relevant to the development of mathematical representation skills because students were given opportunities to observe fraction models, relate shaded parts to fraction notation, and apply their understanding when completing exercises. This interpretation is consistent with Liu and Jacobson (2022), who found that elementary school students use visual, symbolic, and verbal strategies when comparing fractions but may still experience difficulties applying these strategies and providing appropriate justifications. Similarly, Nasir et al. (2025) explain that learning fractions through concrete, representational, and abstract stages can support the development of mathematical representation skills.

When examined across the three indicators, students' achievement showed different levels of development, with visual representation ranking highest, followed by

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symbolic representation and verbal representation. This pattern suggests that students were relatively more successful in interpreting mathematical information presented visually than in expressing their understanding through mathematical symbols and written explanations. The differences across these indicators are important because mathematical representation involves not only recognizing mathematical information but also translating and communicating mathematical ideas in different forms. This finding is consistent with Sunanti et al. (2022), who reported that visual, symbolic, and verbal representation skills do not necessarily develop equally among elementary school students. Liu and Jacobson (2022) also found that fourth-grade students frequently use visual strategies when comparing fractions, while providing appropriate mathematical justifications remains challenging.

Visual representation showed the highest level of achievement because students were relatively more successful in determining fraction values from illustrations. The fraction illustrations in the flipbook provided opportunities for students to observe shaded regions and relate them to the total number of equally divided parts. This presentation was relevant to understanding fractions because students could identify the numerator as the number of selected parts and the denominator as the total number of equal parts. However, some students still experienced difficulties distinguishing between these two components. This indicates that recognizing fraction values through pictures does not necessarily mean that students fully understand the relationship between visual models and fraction notation. Therefore, visual illustrations need to be accompanied by explanations and exercises that explicitly connect shaded parts with their corresponding numerators and denominators. This interpretation is consistent with Liu and Jacobson (2022), who reported that visual strategies are frequently used by fourth-grade students when comparing fractions. Amir et al. (2021) also emphasized the importance of the relationship between visual and symbolic representations in supporting students' understanding of fractions.

Symbolic representation ranked second among the three indicators. Students' difficulties were particularly evident in distinguishing between the greater-than (>) and less-than (<) symbols, especially in their pretest responses. This suggests that understanding fraction values does not automatically enable students to express mathematical comparisons using appropriate notation. When comparing fractions with like denominators, students need to recognize that the comparison is determined by examining the numerators and then express the relationship using the correct mathematical symbol. The flipbook addressed this process by integrating fraction illustrations, written explanations, "Hone Your Skills" exercises, and Polypad activities. These features provided opportunities for students to connect visual fraction models with mathematical notation when identifying, comparing, and ordering fractions. Nevertheless, the difficulties observed in students' responses indicate that this connection still requires reinforcement through repeated practice. This finding is in line with Yuliandari et al. (2024), who emphasized the potential of varied representations to support students' conceptual understanding of fractions. It also supports the importance of connecting visual and symbolic representations, as discussed by Amir et al. (2021).

Verbal representation showed the lowest level of achievement. The students' responses indicated that some students could obtain correct answers but were not yet able to explain the reasoning behind their solutions in clear and coherent written statements. In comparing fractions with like denominators, students need to explain that the comparison is determined by examining the numerators because both fractions have the same denominator. However, some students tended to write only the final answer without explaining the relationship between the numerator, denominator, and the value of the fractions being compared or ordered. This finding suggests that obtaining a correct answer

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does not necessarily indicate the ability to communicate mathematical reasoning effectively. Although the flipbook included written explanations and practice activities, students still needed more structured opportunities to justify their answers and describe their problem-solving processes in writing. This interpretation is consistent with Sunanti et al. (2022), who identified verbal representation as an area of difficulty for some elementary school students. Liu and Jacobson (2022) also found that providing appropriate justifications remains challenging for students when comparing fractions. Therefore, future instructional activities should place greater emphasis on written-response exercises that require students to explain not only their answers but also the mathematical reasoning behind them.

The findings also highlight several aspects that need further attention in the development and implementation of the flipbook. Although the integration of illustrations, audio, fraction songs, and interactive activities provided a more varied learning experience, the visual presentation and audio features could still be improved. In addition, the use of multiple features requires sufficient instructional time and clear demonstrations so that students can access the material and use the available functions effectively. The differences in achievement across the three representation indicators also suggest that visual activities alone are insufficient to ensure that students can express mathematical ideas symbolically and verbally. Therefore, further development should focus on improving the visual and audio presentation, strengthening the connection between visual models and mathematical symbols, and providing more structured activities that encourage students to explain their mathematical reasoning in writing.

Overall, the findings suggest that the developed flipbook provided learning experiences that supported students in exploring fractions with like denominators through different forms of mathematical representation. The higher N-Gain score in the experimental group and the differences observed across the three indicators provide evidence of the potential contribution of flipbook-assisted instruction to students' mathematical representation skills in the context of this study. However, the findings should be interpreted with consideration of the quasi-experimental design and the involvement of students from only one public elementary school. Further studies involving different school settings and larger participant groups are needed to examine the applicability of the developed teaching material in broader educational contexts.

Student Responses

Student responses to the use of the flipbook instructional material showed a 98% approval rate, with the majority rating it as “very practical.” These results were supported by observations during instruction, which revealed students’ enthusiasm for learning, active engagement, participation, and interactivity in the experimental class. Students gained learning experiences through the presentation of material that combined text, illustrations, audio, fraction songs as icebreakers, exercises, and activities using Polypad. This variety provided students with the opportunity to learn the material through a wider range of activities.

The use of illustrations helped students visualize fraction concepts, while audio and fraction songs added variety to the learning process. Additionally, question-and-answer sessions between the teacher and students provided opportunities for students to participate in discussing the material. These findings align with those of Nafiah et al. (2023), who discussed the use of flipbook-based digital books to support elementary school students’ interest in learning. Intaniasari et al. (2022) also demonstrated that the use of audiovisual media can help foster students’ enthusiasm for learning. Nevertheless, these positive responses should be interpreted based on the survey results and observations within the

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context of this study, rather than as evidence that each feature, when used in isolation, necessarily increases student motivation.

Activities using Polypad also provide students with the opportunity to explore fractions through visual representations and connect them to mathematical symbols. These activities align with the objective of developing instructional materials, namely to help students understand fractions with the same denominator through various forms of representation. Naufal and Kowiyah (2025) developed a Polypad-assisted electronic mathematics module to support the understanding of fraction concepts. This study is relevant to the use of Polypad in the flipbook because both utilize digital media to help students learn fractions.

In terms of practicality, both teachers' and students' responses reached 98% in the "very practical" category. These results indicate that the product received positive feedback from users. These findings align with the research by Susiliastini & Sujana (2022), which discusses the development of digital instructional materials for elementary school learning. Thus, the results of the questionnaires and observations in this study support the assessment that flipbooks can be used as an alternative instructional material for teaching fractions with the same denominator. However, the practicality of the product must be distinguished from its effectiveness, as both are assessed through different types of analysis.

Strengths and Weaknesses of the Developed Instructional Material

The developed mathematics flipbook instructional material has the advantage of integrating text, fraction illustrations, audio, fraction songs, "Skill-Building" exercises, and Polypad activities. The illustrations help students understand the relationship between parts and the whole, while the "Skill-Building" exercises provide opportunities to apply the concepts of recognizing, comparing, and ordering fractions with the same denominator. Polypad activities also provide an alternative for students to explore fractions through images and mathematical symbols. This combination of features ensures that the flipbook not only explains the material but also provides activities students can use to learn and apply the concepts.

These advantages align with the product's development objectives, namely supporting students' mathematical representation skills through the presentation of material that connects visual, symbolic, and verbal forms. The use of Polypad is also relevant to the research by Naufal and Kowiyah (2025) on the development of Polypad-assisted electronic mathematics modules to support the understanding of fraction concepts. Additionally, digital instructional materials can be accessed again as needed by users as long as the necessary devices and the necessary access are available. Thus, the flipbook can serve as an alternative supplementary teaching material for learning fractions with the same denominator.

Nevertheless, this study has several limitations that should be considered when interpreting the findings. First, the developed flipbook and its implementation were limited to fractions with like denominators, particularly identifying, comparing, and ordering fractions. Therefore, the findings are specific to this mathematical content and do not necessarily represent the potential of the flipbook for other fraction topics or mathematical concepts. Second, the study involved 52 fourth-grade students from a single elementary school, with 26 students in the experimental group and 26 in the control group. The experimental class was selected through purposive sampling, while the control group consisted of students from another existing class. Although the pretest results indicated no statistically significant difference in students' initial abilities between the two groups, the quasi-experimental design did not involve individual random assignment. Consequently, the influence of other factors related to classroom conditions and students' learning

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experiences could not be entirely controlled, and the findings should be interpreted within the context of the participating school.

Furthermore, the assessment of students' mathematical representation skills was based on 10 pretest and posttest items covering three indicators: visual, symbolic, and verbal representation. Although these assessments provided information about changes in students' performance following instruction, the study did not include a delayed posttest to examine whether the improvements were maintained over time. In addition, the differences in achievement across the three indicators suggest that students may require further instructional support, particularly in connecting mathematical symbols with visual representations and expressing their reasoning in writing. Future research could involve students from multiple schools with broader participant characteristics, explore the use of flipbook materials across different mathematical topics, and incorporate follow-up assessments to examine the sustainability of learning outcomes. Further investigations could also provide more structured opportunities for students to connect visual, symbolic, and verbal representations during mathematics instruction.

CONCLUSION AND SUGGESTIONS

This study produced a mathematics flipbook instructional material on fractions with common denominators to improve the mathematical representation skills of fourth-grade elementary school students. The development was conducted using the ADDIE model, which includes the analysis, design, development, implementation, and evaluation stages. The developed product contains content, illustrations of fractions, learning activities, practice problems, and Polypad features that support students in understanding and representing fraction concepts. Validation results showed that the teaching material received a validation rate of 86% from media experts and 98% from content experts, thus falling into the “highly valid” category. In terms of practicality, both teachers and students rated the material at 98%, placing it in the “highly practical” category.

In terms of effectiveness, the research results show that the flipbook teaching material scored 0,75 (75%) in the “High” improvement category (Fairly Effective). These findings indicate that the developed teaching material is valid and practical and supports the improvement of students’ mathematical representation skills regarding fractions with common denominators. The use of illustrations, mathematical symbols, practice problems, and Polypad provides learning alternatives that help students understand the concept of fractions through various forms of representation. However, mathematical representation skills need to be developed in a balanced manner, particularly in the symbolic and verbal aspects. Therefore, the use of flipbooks should be accompanied by activities that encourage students to connect images with fraction symbols and to explain their reasoning and thought processes in solving problems.

Based on the research results, teachers are advised to utilize flipbook teaching materials as an alternative to supplement mathematics instruction, particularly when teaching fractions with common denominators. Before the lesson begins, teachers should demonstrate or simulate the use of the flipbook so that students understand how to access and use each of its features. Teachers also need to provide sufficient time for students to observe the illustrations, try out activities using Polypad, complete practice problems, and explain the reasoning behind their answers. These activities are expected to help students develop their visual, symbolic, and verbal representation skills in a more balanced manner.

Several limitations of this study should be considered when interpreting the findings and planning future research. The study involved 52 fourth-grade students from a single public elementary school and employed a quasi-experimental design using existing classes. In addition, the developed flipbook focused specifically on fractions with like

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denominators, and the assessment was limited to pretest and posttest measurements without follow-up assessments to examine the sustainability of learning improvements. Therefore, future research should involve larger samples from multiple schools, explore broader mathematical topics, and incorporate follow-up assessments. For future developers, the flipbook instructional material can be refined by incorporating a wider variety of visual elements, animations, and audio features while maintaining content clarity and ease of use for students. Further research could also examine the contribution of individual flipbook components, such as visual illustrations, audio, interactive activities, and Polypad, to students' mathematical representation skills. Particular attention should be given to developing activities that strengthen symbolic and verbal representations by encouraging students to connect images with mathematical symbols and express their understanding both orally and in writing.

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