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Development and Preliminary Evaluation of the Betang Transparent Card for Teaching Fraction Addition with Unlike Denominators in Elementary School

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Abstract

This study aimed to develop the Betang Transparent Card learning medium for teaching the addition of fractions with unlike denominators to fifth-grade elementary school students and to examine its feasibility, practicality, and preliminary effectiveness. The study employed a Research and Development approach using the ADDIE model, which comprises analysis, design, development, implementation, and evaluation. The research was conducted at SD Negeri 2 Karang Tunggal during the 2025/2026 academic year. The participants included six students in the limited trial and 18 students in the effectiveness assessment. Product validation involved a subject matter expert, a media expert, and a language expert. Data were collected using expert validation sheets, a student response questionnaire, classroom observations, and pretest and posttest assessments. The results showed feasibility scores of 93.33% from the subject matter expert, 96.47% from the media expert, and 100% from the language expert, all of which were classified as highly feasible. The student response score reached 90%, indicating a high level of practicality. The mean achievement score increased from 66.7 on the pretest to 87.8 on the posttest, with an N-gain score of 0.63 in the moderate category. These findings provide preliminary evidence that the Betang Transparent Card medium is feasible, practical, and potentially useful for supporting students' understanding of equivalent fractions and the addition of fractions with unlike denominators. Further studies involving larger samples and comparison groups are required to establish its effectiveness more conclusively.

Keywords: ADDIE model; elementary mathematics; fraction addition; learning media; transparent cards

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INTRODUCTION

Mathematics is a fundamental subject that plays an important role in developing students' logical, systematic, and critical thinking, as well as their problem-solving abilities, beginning at the elementary school level. Mathematics instruction in elementary schools is intended not only to enable students to master computational procedures but also to develop the conceptual understanding required for learning more advanced mathematics. Therefore, mathematics instruction should be designed meaningfully and adapted to students' cognitive developmental characteristics. According to the National Council of Teachers of Mathematics (NCTM, 2000), effective mathematics instruction should help students understand mathematical concepts, develop representational abilities, and apply mathematical knowledge in various learning contexts. This perspective indicates that successful mathematics instruction is determined not only by the content being taught but also by the instructional strategies and learning media used.

One mathematical topic that frequently presents difficulties for elementary school students is fractions, particularly the addition of fractions with unlike denominators. Fractions are abstract concepts that require students to understand part-whole

relationships and the symbolic representations used in mathematical operations. Previous studies have shown that students often experience difficulties in understanding fraction concepts and tend to memorize solution procedures without comprehending the underlying mathematical meaning. Siegler et al. (2013) stated that fractions constitute one of the most complex topics in mathematics education because they involve multiple representations and numerical relationships that are not always easily understood by students. These difficulties often result in students' limited ability to perform fraction operations, particularly when adding fractions with different denominators.

Fraction instruction that remains dominated by lecturing and the direct presentation of mathematical symbols is one factor contributing to students' difficulties in understanding the concepts being taught. Van de Walle et al. (2019) explained that fraction concepts should be taught through various visual representations and manipulative activities so that students can construct meaning from each mathematical procedure they perform. When instruction focuses solely on mathematical algorithms, students tend to memorize procedural steps without understanding the mathematical reasoning underlying those procedures. This condition demonstrates the need for learning media that can visually represent fraction concepts in elementary mathematics instruction.

Learning media play a strategic role in helping students understand abstract mathematical concepts. The appropriate use of learning media can increase students' engagement during instruction and help teachers present learning materials in a more concrete and appealing manner. Arsyad (2019) defined learning media as any means that can be used to communicate instructional messages and stimulate students' attention, interest, and understanding. In mathematics instruction, learning media function not only as teaching aids but also as tools that enable students to explore the concepts being studied. Therefore, developing learning media that correspond to the characteristics of mathematical content is one approach that can be adopted to improve the quality of elementary school instruction.

The use of concrete learning media in mathematics instruction should also consider students' cognitive developmental characteristics. According to Piaget's theory of cognitive development, elementary school students are generally in the concrete operational stage and therefore understand information more easily when it is presented through tangible objects or visual representations that can be directly observed and manipulated. Consequently, mathematics instruction at the elementary level should employ media that allow students to engage in concrete learning activities before progressing to more abstract symbolic representations. Bruner similarly proposed that learning occurs through three modes of representation: enactive, iconic, and symbolic. These modes emphasize the importance of learning media that gradually connect manipulative activities, visual representations, and mathematical symbols.

Various manipulative learning media for teaching fractions have been developed in previous studies. Fraction strips, fraction circles, flash cards, and digital media have been used to help students understand fraction concepts more concretely. Cramer et al. (2009) reported that the use of manipulatives in fraction instruction helps students understand relationships among fractions and improves their mathematical representation abilities. Nevertheless, some existing learning media still have limitations in illustrating the process of finding common denominators in the addition of fractions in a simple and accessible manner for elementary school students. In addition, some media require supplementary equipment or have not been fully designed to match the characteristics of classroom instruction.

A review of previous studies indicates that further innovation is required to develop learning media that address students' needs in understanding the addition of fractions

with unlike denominators through concrete and interactive learning activities. The developed medium should enable students to directly observe the process of finding common denominators and adding fractions. In this way, instruction is not limited to procedural problem solving but also supports students in developing a systematic understanding of the mathematical concepts being studied. The medium should also be easy to use, clearly presented, and appropriate for the cognitive developmental characteristics of elementary school students.

This study developed the Betang Transparent Card learning medium to assist students in learning the addition of fractions with unlike denominators through visual representations presented on transparent cards. The medium allows students to observe relationships among fractions more concretely through simple learning activities that can be readily implemented in the classroom. Transparent cards were selected because they provide a clear visualization of fraction concepts and support learning activities that correspond to the characteristics of elementary school students. The medium was developed using the ADDIE model, ensuring that each stage of development was conducted systematically through needs analysis, design, development, implementation, and evaluation.

Systematic learning media development is an important factor in producing an instructional product that is suitable for classroom use. Branch (2017) explained that the ADDIE model is widely used in instructional development because it provides a clear framework for designing and evaluating educational products. Through this model, the developed learning medium is evaluated not only in terms of its design and content but also regarding its practicality and effectiveness in supporting the learning process. Thus, the resulting medium is expected to address the needs of both students and teachers in elementary mathematics instruction.

Based on these considerations, this study aimed to develop the Betang Transparent Card learning medium for teaching the addition of fractions with unlike denominators to fifth-grade elementary school students and to examine its feasibility, practicality, and effectiveness in mathematics instruction.

METHODOLOGY

This study employed a Research and Development (R&D) method using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation, as proposed by Branch (2017). The ADDIE model was selected because it provides systematic development stages for producing learning media that meet the criteria of feasibility, practicality, and effectiveness before being implemented in the learning process.

The development of the Betang Transparent Card learning medium followed the five stages of the ADDIE model, as presented in Figure 1.

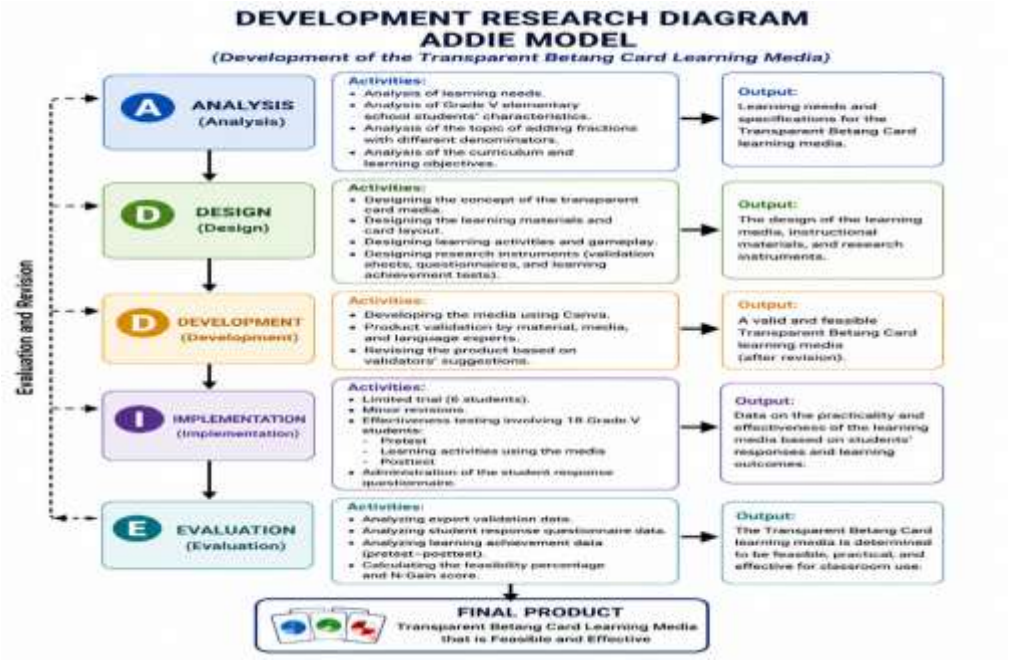

Figure 1. Flowchart of the Development of the Betang Transparent Card Learning Medium Using the ADDIE Model

During the Analysis stage, a needs analysis was conducted to identify instructional requirements, students' characteristics, and the content related to the addition of fractions with unlike denominators to be incorporated into the learning medium. The Design stage involved preparing the initial design of the medium, instructional materials, and research instruments. The Development stage included producing the learning medium using Canva and validating the product through subject matter, media, and language experts. The Implementation stage consisted of a limited trial and an effectiveness test involving students. Finally, the Evaluation stage was conducted to examine the product validation results, student responses, and learning outcomes following the use of the learning medium.

The study was conducted at SD Negeri 2 Karang Tunggal during the second semester of the 2025/2026 academic year. The research participants consisted of 18 fifth-grade students who participated in the effectiveness test of the learning medium. A limited trial was conducted with six students selected to represent different levels of academic ability in order to obtain preliminary information regarding the usability of the medium. In addition, the product validation process involved three validators, comprising one subject matter expert, one media expert, and one language expert.

The research instruments included validation sheets completed by the subject matter, media, and language experts to assess the feasibility of the learning medium; a student response questionnaire to measure its practicality; and learning achievement tests administered as a pretest and posttest to examine changes in students' learning outcomes after using the medium.

The data were analyzed using quantitative descriptive analysis. The expert validation and student response questionnaire scores were converted into percentages to determine the feasibility and practicality categories of the learning medium. The effectiveness of the medium was examined by comparing the mean pretest and posttest scores and calculating the normalized gain (N-gain) to determine the improvement in students' learning outcomes after using the learning medium. The interpretation of the N-gain scores followed the criteria proposed by Hake (1999): low ((g < 0.30)), moderate ((0.30 \leq g < 0.70)), and high ((g \geq 0.70)). The learning medium was considered to have met the development criteria when it achieved a highly feasible category based on

expert validation, received positive responses from students, and demonstrated an improvement in learning outcomes based on the N-gain analysis.

RESULTS AND DISCUSSION

Needs Analysis

This study produced the Betang Transparent Card learning medium for teaching the addition of fractions with unlike denominators to fifth-grade elementary school students. The medium was developed using the ADDIE model, comprising the analysis, design, development, implementation, and evaluation stages. The findings focused on the results of the needs analysis, expert validation, limited trial, and preliminary effectiveness assessment.

Observations and interviews with the fifth-grade teacher at SD Negeri 2 Karang Tunggal indicated that instruction on the addition of fractions with unlike denominators remained dominated by lectures and textbook use. This instructional condition made it difficult for students to understand the process of finding common denominators and adding fractions correctly. Moreover, the availability of engaging and interactive learning media was limited, resulting in relatively low levels of active student participation.

The analysis of student characteristics showed that the students were 9–10 years old and generally demonstrated characteristics associated with the concrete operational stage of cognitive development. They tended to understand mathematical concepts more easily through visual media and manipulative activities. Therefore, the Betang Transparent Card medium was developed to facilitate a concrete understanding of fraction addition through transparent cards that could be overlaid to represent relationships among fractions.

Expert Validation Results

The developed product was evaluated by a subject matter expert, a media expert, and a language expert. The expert review was conducted to determine the feasibility of the medium before its classroom implementation.

Table 1. Expert Validation Results for the Betang Transparent Card Medium

Validation Aspect	Percentage (%)	Category
Subject matter expert	93.33	Highly feasible
Media expert	96.47	Highly feasible
Language expert	100.00	Highly feasible

As presented in Table 1, the Betang Transparent Card medium obtained feasibility scores of 93.33% from the subject matter expert, 96.47% from the media expert, and 100% from the language expert. All scores were classified as highly feasible. These findings indicate that the developed medium met the expected criteria in terms of content accuracy, visual and functional design, and language appropriateness. Consequently, the product was considered suitable for implementation in elementary mathematics instruction.

Limited Trial Results

A limited trial was conducted with six fifth-grade students from SD Negeri 2 Karang Tunggal. The students were selected to represent different levels of academic ability. The trial was intended to obtain preliminary information regarding the readability, usability, and initial acceptance of the developed medium.

Classroom observations showed that the students were enthusiastic about using the Betang Transparent Card medium. They were able to follow the instructions and

complete the assigned learning activities appropriately. The students also responded positively to the appearance and ease of use of the medium.

The student response questionnaire produced a score of 90%, indicating a high level of practicality. This result suggests that the medium was easy for students to use and was appropriate for the learning characteristics of elementary school students.

Preliminary Effectiveness Results

The preliminary effectiveness assessment involved 18 fifth-grade students from SD Negeri 2 Karang Tunggal. A pretest was administered before the use of the Betang Transparent Card medium, followed by a posttest after the learning activities had been completed.

Table 2. Students' Pretest and Posttest Results

Test	Number of Students	Mean Score
Pretest	18	66.7
Posttest	18	87.8

The students' mean score increased from 66.7 on the pretest to 87.8 on the posttest, representing an increase of 21.1 points. This improvement indicates that students demonstrated better performance in adding fractions with unlike denominators after participating in instruction using the Betang Transparent Card medium.

The normalized gain analysis yielded an N-gain score of 0.63. Based on Hake's (1999) criteria, this score was classified as moderate. The result provides preliminary evidence that the developed medium was associated with an improvement in students' learning outcomes.

Observations conducted during the learning activities also indicated that students were more active and motivated to participate. By overlaying the transparent cards, students could visualize the process of finding common denominators and combining fractional parts. Consequently, concepts that had previously appeared abstract could be represented in a more concrete and comprehensible form.

Product Evaluation

Product evaluation was conducted by reviewing the results of the expert validation, student response questionnaire, classroom observations, and learning achievement tests. The mean score obtained from the three expert assessments was 96.60%, which was classified as highly feasible. This result indicates that the Betang Transparent Card medium demonstrated strong feasibility in terms of instructional content, media design, and language use.

The findings from the limited trial also showed that students could use the medium without substantial difficulty. The positive student response score and the improvement between the pretest and posttest suggest that the Betang Transparent Card medium has the potential to support mathematics instruction on the addition of fractions with unlike denominators.

The findings indicate that the Betang Transparent Card learning medium met the established feasibility and practicality criteria and was associated with improved student performance in adding fractions with unlike denominators. The feasibility scores provided by the subject matter, media, and language experts were 93.33%, 96.47%, and 100%, respectively. In addition, the student response score reached 90%, while the mean achievement score increased from 66.7 on the pretest to 87.8 on the posttest. The N-gain score of 0.63 placed the observed improvement in the moderate category. These findings suggest that the developed medium was appropriately designed for classroom use and

showed promising preliminary effectiveness. Nevertheless, the improvement should not be interpreted as definitive evidence of a causal effect because the study employed a one-group pretest–posttest design without a comparison group.

The high feasibility scores indicate that the Betang Transparent Card medium was considered appropriate in terms of mathematical content, visual design, usability, and language. Product validation is an important component of instructional development because it helps determine whether a medium accurately represents the intended concepts and is suitable for its target users. According to Branch (2017), the development stage of the ADDIE model includes the production, validation, revision, and preparation of instructional products before implementation. The positive expert assessments therefore provide evidence that the medium was sufficiently aligned with the instructional objectives and the characteristics of fifth-grade students.

From the content perspective, the medium was designed to address a specific conceptual difficulty in elementary mathematics, namely understanding why fractions with unlike denominators cannot be added directly before equivalent fractional units are established. This problem is not merely procedural. Students must understand fraction magnitude, equivalence, part-whole relationships, and the role of a common unit before applying the addition algorithm. Research on fraction instruction consistently shows that students often memorize computational procedures without understanding the mathematical relationships underlying those procedures. Consequently, interventions that combine concrete or visual representations with explicit and systematically sequenced instruction tend to produce stronger learning outcomes than approaches that focus primarily on symbolic calculation (Roesslein & Codding, 2018; Shin & Bryant, 2015; Papadimitriou & Tzivinikou, 2020).

The Betang Transparent Card medium addresses this issue by allowing students to overlay transparent fraction representations. Through this process, students can observe how fractional parts with different denominators can be reorganized into equivalent units. This feature may help make the process of finding a common denominator more conceptually accessible. Rather than treating the common denominator as an arbitrary computational rule, students can observe the relationship between the original fractions and their equivalent representations. This interpretation is consistent with research showing that concrete and visual manipulatives can support students in connecting fraction magnitude, equivalence, and symbolic procedures (Bouck et al., 2018; Flores et al., 2023; Schumacher et al., 2018).

The mechanism of the Betang Transparent Card medium also reflects the principles of the concrete-representational-abstract approach. In a CRA sequence, students first interact with concrete objects, then interpret visual or pictorial representations, and finally work with abstract mathematical symbols. CRA-I extends this progression by integrating additional representational and instructional supports. Previous studies have shown that CRA and CRA-I instruction can improve conceptual understanding and procedural performance in fraction tasks, including the addition of fractions with unlike denominators (Flores et al., 2023; Papadimitriou & Tzivinikou, 2020). The transparent cards function as a bridge between direct manipulation and symbolic fraction notation. Students manipulate the cards physically, observe the represented fractional regions, and then connect these representations to the numerical procedure.

However, the effectiveness of the medium cannot be explained by physical manipulation alone. Research on fraction interventions emphasizes that manipulatives are most effective when their mathematical meaning is explicitly explained and when transitions between representations are carefully guided (Shin & Bryant, 2015; Osana & Pitsolantis, 2011). Without adequate instructional guidance, students may focus on the physical appearance of a medium rather than the mathematical relationships it is

intended to represent. Therefore, the positive results observed in this study were likely influenced not only by the availability of the transparent cards but also by the teacher's explanations, prompts, demonstrations, and sequencing of the learning activities.

This point is important because the use of a manipulative does not automatically produce conceptual understanding. Students need explicit opportunities to explain why fractions are converted into equivalent forms, how overlapping representations relate to a common unit, and why only the numerators are added after the denominators have been made equivalent. Verbal explanation, questioning, and guided student reasoning should therefore accompany the use of the Betang Transparent Card medium. Evidence from multimodal fraction interventions also suggests that verbal explanations, gestures, and visual representations can jointly strengthen conceptual organization and mathematical problem solving (Mao et al., 2025; Parungao, 2021).

The student response score of 90% indicates that the medium had a high level of practicality and acceptance among the participants. During the limited trial, students were able to follow the instructions, manipulate the cards, and complete the learning activities without substantial difficulty. This result is relevant because instructional products that are theoretically appropriate may still be impractical in actual classrooms. A practical medium should be sufficiently simple to prepare, understand, and use within the available instructional time.

The physical design of the Betang Transparent Card medium appears to offer several practical advantages. The cards are relatively simple, portable, and do not require electronic equipment or stable internet access. These characteristics may make them suitable for schools with limited digital infrastructure. The medium also allows repeated use and direct student interaction, which can support individual, paired, or small-group activities. Such characteristics align with the practical requirements identified in manipulative-based interventions, including straightforward materials, clear instructional prompts, manageable classroom routines, and opportunities for repeated practice (Amoah et al., 2019; Bassette et al., 2019).

Nevertheless, the high practicality score should be interpreted within the context of the limited trial, which involved only six students. Small-group implementation allows teachers or researchers to provide more direct support than may be possible in a full classroom. The level of usability may therefore differ when the medium is implemented simultaneously with a larger number of students. Future classroom trials should examine preparation time, durability, classroom management, distribution of materials, teacher workload, and the extent to which students can use the cards independently.

The increase in the mean score from 66.7 to 87.8 and the moderate N-gain score of 0.63 suggest that students demonstrated meaningful improvement after the intervention. This finding is consistent with broader evidence showing that multicomponent fraction interventions can improve outcomes closely related to the skills directly taught during instruction (Roesslein & Codding, 2018; Mao et al., 2025). In the present study, the assessment focused on the addition of fractions with unlike denominators, which was also the principal content represented by the medium. The alignment between the instructional activity and the assessment may partly explain the observed improvement.

The findings also correspond with studies reporting that concrete and visual media can improve accuracy and independence in solving fraction problems. Both concrete and virtual manipulatives have been successfully used to teach fraction concepts and operations to elementary and middle-school students, including learners with mathematics difficulties or disabilities (Bassette et al., 2019; Bouck et al., 2018; Satsangi & Raines, 2022; Yakubova et al., 2023). However, these studies do not establish that one type of medium is universally superior. Some students perform better with concrete

materials, whereas others demonstrate greater independence or preference when using virtual manipulatives.

This variation is relevant when interpreting the current findings. The positive results support the instructional potential of the Betang Transparent Card medium, but they do not demonstrate that transparent cards are more effective than fraction strips, fraction circles, number lines, or virtual applications. The broader literature indicates that instructional design, explicit guidance, representational sequencing, and learner characteristics may be more influential than whether the medium is physical or digital (Bouck & Long, 2021; Bouck et al., 2018; Satsangi & Raines, 2022). Therefore, the Betang Transparent Card medium should be viewed as one representational option rather than as a universally superior solution.

The medium may be further strengthened by integrating it with other fraction representations. Number lines, for example, can help students understand fraction magnitude, ordering, equivalence, and the relationship between conceptual understanding and computational procedures (Schumacher et al., 2018; Osana & Pitsolantis, 2011). Transparent area representations may clearly illustrate how parts of a whole can be partitioned into equivalent units, while number lines can show fractions as numerical magnitudes and distances from zero. Combining these representations may reduce the risk that students understand fractions only as shaded parts of shapes.

The observed improvement should also be interpreted as a proximal learning outcome. Proximal outcomes refer to performance on tasks that closely resemble the material taught during an intervention. Reviews of fraction instruction indicate that such outcomes often improve more consistently than distal outcomes, including broader mathematical achievement, transfer to unfamiliar problems, or long-term retention (Roesslein & Codding, 2018; Mao et al., 2025). The present study did not examine whether students could transfer their understanding to subtraction of fractions, fraction word problems, mixed numbers, or unfamiliar representations. It also did not include a delayed posttest to determine whether the improvement was retained.

Accordingly, the moderate N-gain score should not be interpreted as evidence that the medium improved all dimensions of fraction understanding. The test results demonstrate improvement on the assessed content, but additional evidence is needed to determine whether students developed a durable and transferable conceptual understanding. Future assessments should separately measure procedural accuracy, explanation of fraction equivalence, representation of fraction magnitude, error analysis, and application in contextual problems.

Teacher involvement is another factor that may determine whether the medium remains feasible and effective beyond the initial study. Research on the integration of manipulatives indicates that professional development and teacher participation in instructional design can improve alignment with curriculum, classroom routines, and assessment practices (Hansen et al., 2016). Teachers need to understand not only how to operate the medium but also how to connect the manipulative activity to mathematical language and symbolic notation. Without such pedagogical knowledge, the cards may be used as an attractive classroom activity without sufficiently supporting conceptual development.

The Betang Transparent Card medium may therefore be implemented most effectively through a structured instructional sequence. The teacher can begin by eliciting students' prior understanding of fraction equivalence, demonstrate the use of overlapping cards, guide students in explaining the represented relationships, and gradually transition toward symbolic procedures. Students should also be encouraged to verbalize their reasoning, compare different solution strategies, and identify common

errors, such as adding denominators directly. This sequence would align the medium more closely with explicit instruction and CRA-based learning principles.

Although the findings are promising, several methodological limitations restrict the strength of the conclusions. First, the study involved only 18 students from one elementary school. The sample was therefore too small and context-specific to support broad generalization. Second, the absence of a comparison group means that the increase in scores may have been influenced by repeated testing, teacher support, additional instructional time, or students' growing familiarity with the assessment. Third, the analysis relied primarily on descriptive statistics and N-gain scores. No inferential test or effect-size analysis was conducted to examine the statistical and practical magnitude of the difference between pretest and posttest scores.

Fourth, the study did not compare the transparent cards with other concrete, visual, or virtual media. It therefore remains unclear whether the observed outcomes were specifically related to the transparent overlay mechanism or to the use of manipulatives and explicit instruction more generally. Fifth, the study focused on immediate learning outcomes and did not assess retention or transfer. These limitations support the use of the term preliminary effectiveness rather than a definitive claim that the medium caused the improvement.

Future research should involve larger samples from multiple schools and use quasi-experimental or experimental designs with appropriate comparison groups. Comparisons could be conducted between the Betang Transparent Card medium, conventional instruction, other concrete manipulatives, and virtual fraction tools. Mixed-method approaches could also examine how students reason while using the cards, which visual features support understanding, and which misconceptions persist after instruction. Delayed posttests and transfer tasks should be included to determine whether the learning outcomes remain stable and extend beyond the specific problems practiced during the intervention.

Despite these limitations, the findings provide preliminary support for the use of the Betang Transparent Card medium in elementary fraction instruction. Its principal value lies in its capacity to make the process of establishing equivalent fractional units visible and manipulable. When combined with explicit instruction, structured representational transitions, mathematical discussion, and systematic practice, the medium has the potential to support both conceptual understanding and procedural learning. The evidence does not indicate that the cards should replace all other representations. Instead, they can serve as one component of a broader instructional approach that integrates concrete manipulation, visual representation, number lines, verbal reasoning, and abstract symbolism.

CONCLUSION

This study developed the Betang Transparent Card learning medium for teaching the addition of fractions with unlike denominators to fifth-grade elementary school students using the ADDIE model. The developed medium obtained feasibility scores of 93.33% from the subject matter expert, 96.47% from the media expert, and 100% from the language expert, indicating that it was highly feasible in terms of content, design, usability, and language. The student response score of 90% also showed that the medium was highly practical and could be used by students without substantial difficulty.

Students' mean achievement score increased from 66.7 on the pretest to 87.8 on the posttest, with an N-gain score of 0.63 in the moderate category. These results provide preliminary evidence that the Betang Transparent Card medium can support students' understanding of the addition of fractions with unlike denominators by making equivalent fractions and common denominators more visually observable. However,

because the study involved a small sample from one school and used a one-group pretest–posttest design, the findings should not be interpreted as definitive evidence of causal effectiveness. Further studies involving larger samples, comparison groups, delayed posttests, and transfer tasks are required to examine the effectiveness and broader applicability of the medium.

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RECOMMENDATION

Teachers may use the Betang Transparent Card medium as an alternative instructional aid for teaching the addition of fractions with unlike denominators, particularly to help students visualize equivalent fractions and the process of finding common denominators. Its implementation should be accompanied by explicit instruction, guided questioning, and a gradual transition from concrete manipulation to visual representation and abstract mathematical notation. The medium may also be combined with number lines, fraction strips, and contextual problems to strengthen students' conceptual understanding and reduce reliance on procedural memorization.

Further research should involve larger and more diverse samples from multiple schools and employ quasi-experimental or experimental designs with comparison groups. Future studies should also examine students' retention, transfer of learning to other fraction operations, and ability to solve unfamiliar or contextual problems. Additional evaluation of the medium's durability, preparation time, classroom management requirements, and independent usability in larger classes is needed to establish its practicality under broader instructional conditions. The development of digital or blended versions may also be considered, although their effectiveness should be compared empirically with the existing concrete version.

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