Students' Procedural Fluency in Fraction Addition through Built-in Definition Fraction Media

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ABSTRACT

This study aims to describe elementary students' procedural fluency in solving fraction addition problems using the built-in definition fraction media. Fraction operations are often challenging for students, particularly when determining common denominators and applying calculation procedures accurately. These difficulties are commonly associated with weak procedural understanding and limited opportunities to use concrete learning media. This descriptive study involved 30 fourth-grade students from SDN 204 Palembang who had previously learned basic fraction concepts. Data were collected through a written test consisting of three levels of procedural fluency tasks and supported by interviews to explore students' reasoning processes. The results show that 47% of students were able to solve fraction addition problems with denominators (Level 1), 33% managed tasks involving adjustment of one denominator (Level 2), and only 13% successfully solved problems requiring the determination of the least common multiple of denominators (Level 3). These findings indicate that students' procedural fluency development is not linear but constrained at transition points from concrete visual manipulation to abstract procedural reasoning. While the built-in definition fraction media effectively supported early procedural stages by strengthening visual–procedural connections, it was less effective in facilitating higher-level abstraction required for complex fraction operations. The study contributes to procedural fluency literature by identifying specific procedural transition points where students begin to experience difficulties.

ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan kelancaran prosedural siswa sekolah dasar dalam menyelesaikan soal penjumlahan pecahan menggunakan media Built-in Definition Fraction. Operasi pecahan sering kali menjadi tantangan bagi siswa, khususnya dalam menentukan penyebut yang sama dan menerapkan prosedur perhitungan secara tepat. Kesulitan ini umumnya berkaitan dengan lemahnya pemahaman prosedural serta terbatasnya kesempatan siswa dalam menggunakan media pembelajaran konkret. Penelitian deskriptif ini melibatkan 30 siswa kelas IV SDN 204 Palembang yang telah mempelajari konsep dasar pecahan. Data dikumpulkan melalui tes tertulis yang terdiri atas tiga tingkat tugas kelancaran prosedural dan didukung oleh wawancara untuk menggali proses penalaran siswa. Hasil penelitian menunjukkan bahwa 47% siswa mampu menyelesaikan soal penjumlahan pecahan dengan penyebut yang sama (Level 1), 33% siswa mampu menyelesaikan tugas yang melibatkan penyesuaian satu penyebut (Level 2), dan hanya 13% siswa yang berhasil menyelesaikan soal yang menuntut penentuan kelipatan persekutuan terkecil (KPK) dari penyebut (Level 3). Temuan ini mengindikasikan bahwa perkembangan kelancaran prosedural siswa tidak bersifat linear, melainkan terhambat pada titik transisi dari manipulasi visual konkret menuju penalaran prosedural yang lebih abstrak. Meskipun media Built-in Definition Fraction efektif dalam mendukung tahap awal kelancaran prosedural dengan memperkuat keterkaitan visual–prosedural, media ini kurang efektif dalam memfasilitasi tingkat abstraksi yang lebih tinggi yang dibutuhkan dalam operasi pecahan yang kompleks. Penelitian ini memberikan kontribusi pada kajian kelancaran prosedural dengan mengidentifikasi titik-titik transisi prosedural tertentu di mana siswa mulai mengalami kesulitan.

INTRODUCTION

Mathematics is a basic discipline that plays a vital role in education and everyday life. Through mathematics learning, students are equipped not only with calculation skills but also with higher-order thinking skills such as logical, systematic, objective, critical, and rational thinking. These thinking skills are a crucial foundation for developing high-quality human resources capable of adapting to changing times (Syukra et al., 2025). Mathematics learning is also expected to foster students' critical and innovative thinking skills in solving various real-life problems (Pratidiana & Muhayatun, 2021). Thus, mathematics education plays a fundamental role in preparing a competent and competitive generation.

Procedural fluency is one of the essential skills in mathematics learning. This ability refers to students' capacity to implement problem-solving steps systematically, accurately, and efficiently (Safitri & Lestari, 2022). Procedural fluency encompasses not only the correct execution of mathematical procedures but also the ability to apply them smoothly based on conceptual understanding and awareness of various aspects of mathematical fluency. Furthermore, Afianti et al.(2022) emphasize that students who possess procedural fluency are able to flexibly select and use appropriate procedures according to the demands of a given problem. Without a strong foundation in procedural fluency, students tend to struggle with applying calculation algorithms correctly and understanding the relationships between mathematical concepts, which ultimately leads to suboptimal learning outcomes (Sartika et al., 2022).

Despite its critical role, numerous studies indicate that elementary school students' procedural fluency remains relatively low. Research by Purnawan and Hidayati (2021)reveals that mathematics learning difficulties among elementary students are often characterized by weak abilities in understanding and applying problem-solving steps. Instead of developing meaningful understanding, students frequently rely on memorizing formulas without comprehending the underlying concepts (Pratidiana & Muhayatun, 2021). This condition has a direct negative impact on students' learning outcomes (Muqtafia et al., 2022).

One mathematical topic that consistently poses difficulties for students is fraction addition, particularly problems involving unlike denominators. These challenges arise when students are required to determine the least common multiple (LCM), equalize denominators, and then apply the correct calculation procedures (Rauzatul Narita et al., 2022). Supporting this finding, Purba (2020) reports that common errors include directly adding numerators and denominators and an inability to determine the LCM. Such errors indicate that students have not yet developed a sufficient understanding of fraction concepts and lack mastery of the procedural steps required for accurate fraction operations.

To address these issues, various studies recommend the use of learning media as a strategy to improve students' procedural fluency. Procedural fluency is knowledge about procedures, knowing when and how to use them appropriately, and the skill to work flexibly, efficiently, and effectively in solving problems, which is one of the supporting factors for students to be proficient in learning mathematics. Learning media is known to strengthen conceptual understanding (Nurfatah, 2025), make abstract concepts more concrete and easier to understand (Purba, 2020), and help improve students' calculation skills (Zuliana, 2025). The use of enjoyable media can also create a more engaging learning environment and encourage student engagement (Karna et al., 2025). Furthermore, learning media has been shown to improve students' understanding of various mathematics materials (Nursella, 2024).

Various types of media have been used in mathematics learning, such as beads, which have been shown to improve elementary school students' arithmetic skills (Zuliana, 2025). Learning using media also produces different and more effective results than learning without media, which focuses solely on abstract concepts (Beeler et al., 2023). Research by Abdullah & Yunianta (2018) ashows that educational math games on trigonometry are valid, effective, and practical in improving student learning outcomes. Furthermore, digital media such as EdPuzzle are also considered effective in supporting the learning process and improving learning outcomes (Gusti et al., 2022). A study conducted by Rukono et al (2025) specifically reviewed the literature related to the use of manipulative media (blocks, paper, transparent sheets, etc.) and found that these media are effective in improving mathematics learning outcomes, including fraction addition operations. The use of media can also help students understand the steps to solve problems in a more structured and systematic manner, as supported by research by Fatrina et al. (2023). In addition, learning designed through mathematical modeling also trains students to apply procedures sequentially, starting from understanding problems to completing calculations correctly (Muharani et al., 2025).

However, research that specifically examines the use of concrete built-in definition fractions media designed based on fraction definitions that allows students directly explore the fraction concepts remains very limited. This media enables students to observe fractions in real contexts, construct equivalent fractions, and equalize denominators through visual representations. By identifying specific procedural transition points where students begin to struggle, this research offers a more nuanced understanding of procedural fluency development and highlights the need for instructional designs that explicitly support students' movement from concrete representations to abstract procedural reasoning. Such insights contribute to the refinement of procedural fluency theory and provide empirical evidence relevant to mathematics education research

To date, few studies have investigated how effectively this media supports students' procedural fluency across varying levels of difficulty in fraction addition, starting from fractions with the same denominator to those with different denominators. As a result, the contribution of Built-in Definition Fractions to students' mastery of procedural steps in fraction addition is not yet well understood.

METHOD

This study employed a descriptive research (Cresswell, 2019) method aimed at providing an in-depth analysis of elementary students' procedural fluency in solving fraction addition problems using the Built-in Definition Fraction media. Although the number of participants involved in this study was relatively small, consisting of 30 fourth-grade students, the purpose of this research was not to generalize the findings to a broader population. Instead, this study focused on capturing a detailed and contextualized description of students' procedural fluency as it naturally emerged during learning activities. Descriptive research is particularly appropriate for identifying patterns of procedural behaviour, common errors, and levels of mastery that may not be visible through large-scale quantitative approaches. Therefore, the strength of this study lies in the depth of analysis rather than the breadth of the sample, and the findings are intended to provide exploratory insights that can inform future experimental or large-sample studies.

The stages of this study consisted of the preparation stage, the implementation stage, and the data analysis stage, each of which played an important role in ensuring that the research was conducted systematically and produced credible results. During the preparation stage, the researchers conducted a comprehensive literature review related to fraction learning, procedural fluency, and the use of concrete learning media in elementary mathematics classrooms. This review served as the basis for designing the Built-in Definition Fraction media, which was developed based on the formal definition of fractions as part–whole relationships. Unlike commonly used fraction tools such as fraction circles or fraction bars, this media allows students to directly construct and reconstruct fraction representations using interchangeable components within a fixed whole. Through this design, students can physically create equivalent fractions, observe proportional relationships between numerators and denominators, and verify fraction addition results before expressing them symbolically. This feature represents the novelty of the media, as it explicitly connects concrete manipulation with procedural execution rather than functioning solely as a static visual aid.

After the Built-in Definition Fraction media was developed, it was subjected to expert validation to ensure its feasibility for classroom use. The validation process involved two lecturers from the Mathematics Education Study Program who evaluated the media in terms of content accuracy, clarity of instructions, suitability for elementary school students, practicality during learning activities, and its potential to support both conceptual understanding and procedural fluency. Based on the experts' evaluation, the media was declared valid and practical, and therefore deemed appropriate for use in the implementation stage of the study.

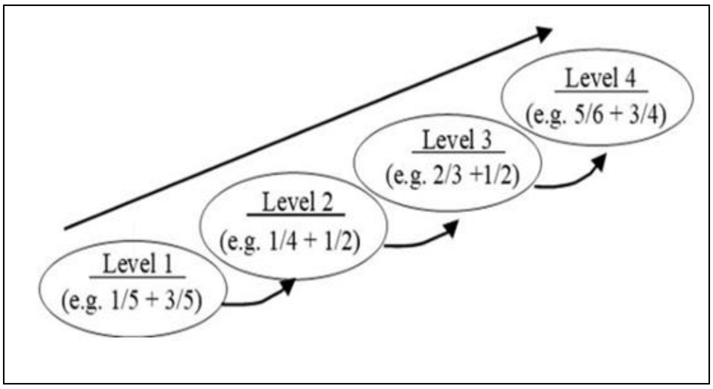
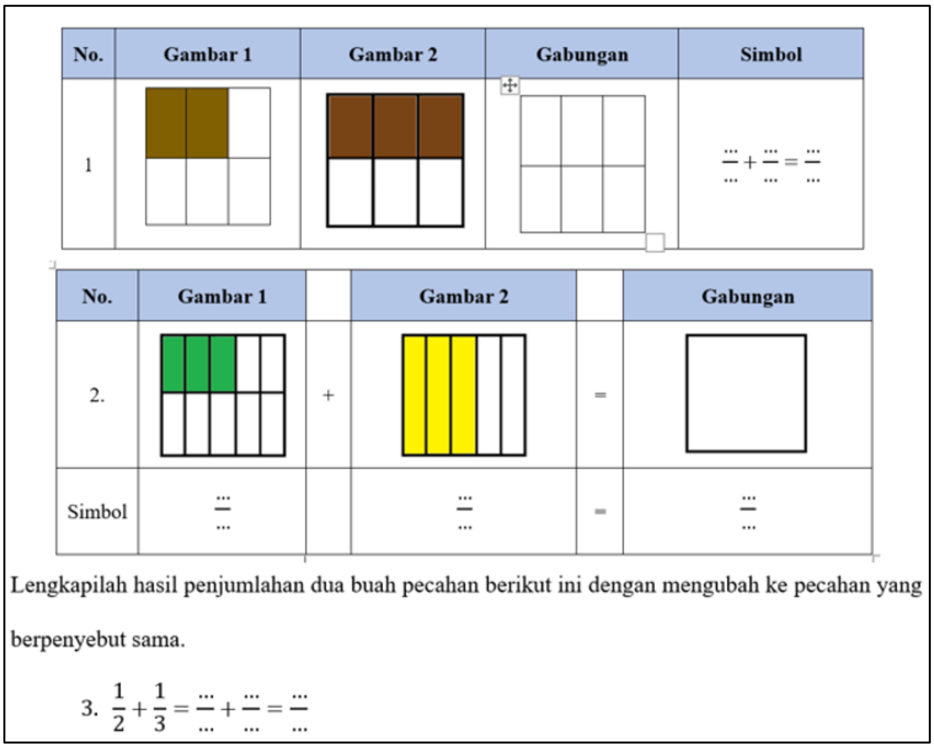


Figure 1. Levels of procedural fluency (Li, 2025)

Figure 1 presents the levels of procedural fluency adapted from Li (2025), which classify students' abilities based on the increasing complexity of fraction addition tasks. Level 1 involves the addition of fractions with the same denominator, where students are required to add the numerators while keeping the denominator unchanged. Level 2 involves fraction addition with different denominators, where one denominator is adjusted to match the other through the formation of equivalent fractions. At this level, students must understand how to transform a fraction so that both fractions share a common denominator before performing the addition. Level 3 represents a higher level of complexity, requiring students to add fractions with different denominators by identifying common multiples or determining the least common multiple (LCM).

Although the Built-in Definition Fraction media effectively supports students in visualizing fraction equivalence and understanding denominator alignment, its effectiveness decreases at higher procedural fluency levels. Tasks at Level 3 require abstract reasoning related to factorization and the identification of common multiples, which cannot be fully represented through concrete manipulation alone. Students who lack prior conceptual understanding of multiples and factor relationships tend to rely excessively on visual cues provided by the media, which may lead to procedural errors when transitioning from concrete representations to symbolic calculations. This limitation highlights that while concrete media are highly effective for early procedural development, higher-level fraction operations require explicit instructional support and guided abstraction.

The data analysis stage was carried out by measuring students' abilities based on their procedural fluency level. Procedural fluency, as explained in a previous study by Safitri & Lestari (2022) is categorized into three categories: accuracy, efficiency, and flexibility. This study focuses on the accuracy category of students' procedural fluency, which is then measured through procedural fluency levels, as shown in **Figure 2** below.



No.	Gambar 1	Gambar 2	Gabungan	Simbol
1				$\frac{...}{...}+\frac{...}{...}=\frac{...}{...}$

No.	Gambar 1		Gambar 2		Gabungan
2.		+		=	
Simbol	$\frac{...}{...}$		$\frac{...}{...}$	=	$\frac{...}{...}$

Lengkapilah hasil penjumlahan dua buah pecahan berikut ini dengan mengubah ke pecahan yang berpenyebut sama.

3. $\frac{1}{2}+\frac{1}{3}=\frac{...}{...}+\frac{...}{...}=\frac{...}{...}$

Figure 2. Procedural fluency test questions

Each test level consisted of only one question that represented the specific procedural fluency skill being assessed. Qualitative data were obtained primarily from students' written test results, while additional supporting information was collected through student interviews. For the scoring process, one point was awarded for each correct answer, and zero points were given for incorrect answers. The written test data were then analyzed by assessing students' accuracy and procedure use, after which their abilities were categorized according to the established levels of procedural fluency. Meanwhile, the interview data were transcribed into written form to facilitate further interpretation and to strengthen the findings from the test results.

The stages in this study included the preparation stage, the implementation stage, and the data analysis stage. The preparation stage produced the learning media used in this research, namely the *Built-in Definition Fraction*. This media serves as a concrete learning tool designed to help students understand the concept of fractions through direct manipulation and exploration. The Built-in Definition Fraction allows students to visualize fractional parts, create equivalent fractions, and observe relationships between numerators and denominators, making the learning process more tangible and meaningful.

The implementation stage consisted of a series of learning activities conducted across two meetings prior to administering the written test. During these meetings, students engaged in guided exploration using the Built-in Definition Fraction media, practiced fraction addition procedures, and discussed their reasoning with the teacher and peers. This stage was essential to ensure that students had sufficient exposure to the media and were able to develop an initial understanding before being assessed through the written test

The data collection technique in this study involved the use of a written test consisting of three questions, each representing one of the three levels of procedural fluency, as well as interviews conducted to support and validate students' written responses. The written test served as the primary instrument for measuring students' procedural fluency in solving fraction addition problems, while interviews provided additional insight into students' reasoning processes, misconceptions, and strategies used when completing the tasks. The following are the test questions used in this study.

In these three test items, students were instructed to observe the colored parts of each visual representation and determine the value of the fractions depicted. They were then required to combine the fractions shown in the images to form a visual representation of the total amount. This visual-to-symbolic process aimed to strengthen the connection between conceptual understanding and procedural fluency execution. For questions involving fractions with different denominators, students were required to first generate equivalent fractions that shared a common denominator. This step ensured that students understood the need for denominator alignment before performing addition.

After determining the equivalent fractions, students proceeded to write the result in symbolic fraction form by following the appropriate procedural fluency steps: equalizing the denominators, adding the numerators, and writing the final simplified result if necessary.

Through this activity, students were trained to understand the concept of fraction addition concretely using visual aids while simultaneously developing their procedural fluency. The combination of visual representation, hands-on reasoning, and written procedural steps allowed students to practice both conceptual comprehension and procedural accuracy, thereby providing a comprehensive view of their fraction addition skills.

RESULTS AND DISCUSSION

As this research consisted of three main stages: preparation, implementation, and data analysis. During the preparation stage, the researcher conducted a series of initial activities, including developing research instruments, designing learning steps, and preparing the media to be used. One important product at this stage was the built-in fraction definition media. This media was designed as a concrete aid that allows students to understand the concept of fractions through easily observed visual representations. With this media, students can directly manipulate fraction parts, making the learning process more interactive and meaningful.

Figure 3. Built-in Definition Fraction Media

The implementation phase was the core process of this research, involving two learning sessions prior to a written test. The study subjects consisted of 30 fourth-grade elementary school students with varying mathematical abilities: high, medium, and low. In the first session, students were taught the theory of adding fractions using a built-in definition fraction tool. This tool was used to help students understand the concept of adding fractions concretely through visual representations that could be directly manipulated.

In the second session, the researchers administered a written test to the students to measure their procedural fluency. This test continued to utilize the built-in definition fraction tool to enable students to connect conceptual understanding with procedural fluency steps in solving problems. Through this series of activities, the researchers were able to obtain a more comprehensive picture of students' procedural fluency in adding fractions.

The data analysis phase involved scoring the written test results and categorizing students' answers based on their level of procedural fluency. After all answer sheets were scored, the data were grouped into three levels of procedural fluency: Level 1, Level 2, and Level 3. This categorization process aimed to more clearly understand the distribution of students' abilities.

In addition, supporting data from interviews was analyzed to strengthen the findings from the written test, particularly regarding students' reasons for choosing the solution steps they used. The results of this analysis were then presented in tabular form to provide a more structured overview. **Table 1** below shows the complete details of the research results.

Table 1. Written test results.

Student ability category	Student Percentage
Level 0	6%
Level 1	47%
Level 2	33%
Level 3	13%

Table 1 shows that 13% of students answered correctly at level 3. This achievement is supported by their problem-solving process, which demonstrates the appropriate use of the media, correct writing of mathematical symbols, and the ability to accurately determine the multiples of both denominators when completing the test. Students in this category show strong procedural fluency because they are able to carry out each step logically, systematically, and without significant errors.

A total of 33% of students were categorized at level 2, meaning they answered partially correctly but still experienced difficulties in determining the common multiples of the two denominators. The errors found at this level generally occurred when students attempted to equalize the denominators, such as selecting the wrong multiples or incorrectly converting the fractions to equivalent forms. This indicates that these students understand the basic concept of fraction addition but have not yet mastered more complex procedural steps.

Meanwhile, 47% of students answered correctly at level 1. Students in this group successfully completed addition problems involving fractions with the same denominator. However, they still struggled with problems that required manipulating fractions with different denominators. This suggests that their procedural fluency is still limited to simpler forms of the operation. Only 6% of students were unable to provide correct answers. This finding indicates that a small portion of students have a very low understanding of fraction concepts, preventing them from following the required steps even when supported with learning media. As a result, their procedural fluency in solving fraction addition problems remains weak.

Overall, these results show that the Built-in Definition Fraction media helps many students understand fraction addition; however, additional support and instructional guidance are still needed, particularly for those who struggle with finding common denominators and determining multiples. Students still make several errors related to the steps in equalizing denominators, particularly in determining the common multiple of two unlike denominators. These errors typically occur when students attempt to convert fractions to equivalent form before adding them.

The following section presents examples of students' written responses, which are carefully analyzed to illustrate their procedural fluency skills. Through this analysis, students' levels of understanding, the types of procedural errors they make, and the specific steps they encounter are identified. This provides the basis for categorizing students into appropriate procedural fluency levels and understanding the challenges they face during the fraction addition process.

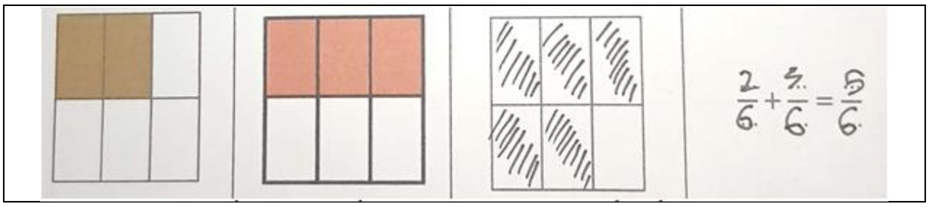


Figure 4. Level 1 correct answers

Figure 4 presents students' answers that demonstrate good procedural fluency skills at Level 1. This can be seen from their ability to correctly recognize the fractions 2/6 and 3/6 from the visual representation and then combine them to obtain 5/6 using appropriate procedural steps. At this level, students show an understanding of how to interpret fraction models, maintain the same denominator, and accurately connect concrete representations to symbolic notation. These findings are consistent with previous studies indicating that students generally exhibit stronger procedural fluency when adding fractions with denominators, as the procedure relies on direct numerator addition without requiring denominator transformation (Imaroh et al., 2021; Safitri & Lestari, 2022). Such abilities indicate that students have achieved fluency and accuracy in performing basic fraction addition procedures.

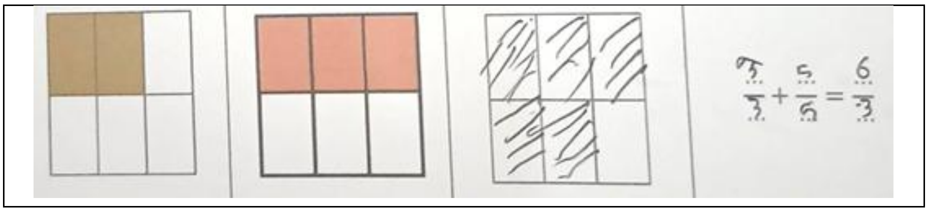


Figure 5. Level 1 incorrect answers

Figure 5 shows the students' answers indicating that they have understood the concept of fraction addition through pictorial representation. This is evident from the correctly shaded parts that represent the combination of the two fractions. The visual representation demonstrates that students are able to interpret fraction models and comprehend the process of combining fractional parts in a concrete manner.

However, at this level, students still experience difficulties in representing the results using mathematical symbols. Based on their responses, students can express their understanding through pictures, but they are unable to correctly write the results in fraction form. This error appears in the inaccurate recording of numerators and denominators, which does not match the results they had successfully represented visually. This indicates that although students have developed conceptual understanding through visual models, their procedural ability to express the results in symbolic mathematical form still needs improvement. This is also supported by research conducted by Imaroh et al. (2021), which states that some students still do not understand how to write fraction names correctly and properly.

These findings indicate that students' procedural fluency at Level 1 still needs further improvement. The results at this level show that students generally possess fairly good basic procedural skills, as evidenced by their ability to add fractions using both pictorial representations and symbolic fraction notation. However, there are still several students who have not yet achieved Level 1 proficiency. This suggests that although some students can correctly perform addition with fractions that share the same denominator, others continue to struggle with recognizing fraction values or applying the fundamental steps consistently. Therefore, strengthening students' foundational understanding and reinforcing basic procedural steps remain essential.

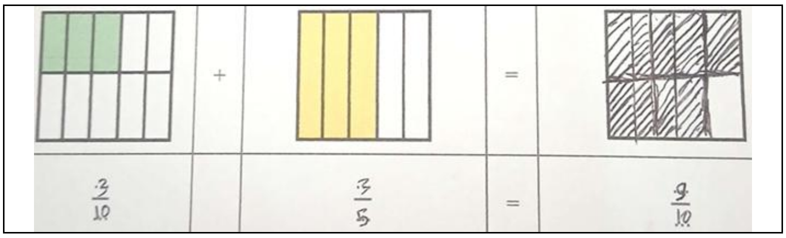


Figure 6. Level 2 correct answer

Figure 6 illustrates students' strong procedural fluency skills in solving fraction addition problems with different denominators. At this level, students demonstrated the ability to carefully analyze the visual representations of the fractions provided in the diagram. They were able to identify the size and number of partitioned units in each image, recognize differences in denominators, and determine appropriate strategies to make the two fractions comparable. This finding supports previous research indicating that visual representations can facilitate students' understanding of fraction equivalence and support the transition from concrete representations to procedural operations (Purba, 2020; Rukono et al., 2025).

The students successfully transformed the fractions into equivalent forms by equalizing the denominators to 10, demonstrating an understanding of how visual models can be translated into mathematical procedures. This process required students to consider part–whole relationships, determine appropriate multiples, and adjust fractional units accordingly. Such abilities are characteristic of procedural fluency at an intermediate level, where students are able to apply procedures accurately while still relying on visual support (Safitri & Lestari, 2022).

After completing the visual conversion, students proceeded to write the symbolic representation of the addition, $\frac{3}{10}+\frac{3}{5}=\frac{9}{10}$, accurately applying key procedural steps: (1) determining equivalent fractions, (2) maintaining a common denominator, and (3) adding the numerators correctly. Their written work demonstrates not only conceptual understanding but also the ability to integrate visual reasoning with formal symbolic notation. This integration is consistent with findings by Oktasari et al. (2023), who reported that students who successfully equalize denominators tend to exhibit stronger procedural control in fraction addition. Overall, these results indicate that the students met the criteria for Level 2 procedural fluency, as they were able to carry out the required procedures systematically and accurately. Their performance suggests that they have progressed beyond basic fraction addition and are capable of applying more complex strategies involving denominator equalization, although continued instructional support remains necessary to strengthen their transition toward higher procedural fluency levels.

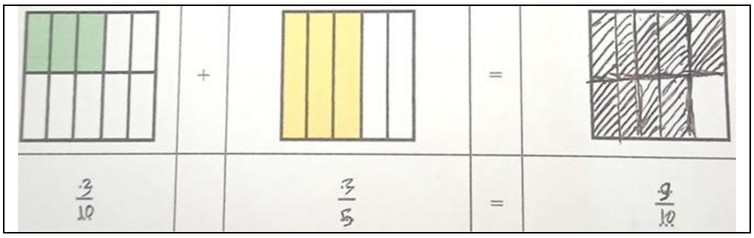


Figure 7. Level 2 incorrect answers

Figure 7 shows that students' visual abilities are not correct. Even though they wrote the mathematical symbols correctly, some still made mistakes when adding. The main difficulties students face at this level focus on two things: first, they are not yet able to find the same denominator from two different denominators, and second, they still add the numerator and denominator together in the calculation.

This clearly shows that students have not applied systematic steps and the correct algorithm in adding fractions with different denominators, so they have not reached level 2 of procedural fluency. This was also found in research conducted by Oktasari et al (2023) Illustrates that fifth-grade elementary school students still experience significant difficulties in adding fractions, especially when the denominators are different, indicating a weak mastery of concepts/procedures.

At level 2, only a few students demonstrated good procedural fluency skills by being able to equate denominators, understand visual representations, and write fraction symbols correctly. However, many other students still made errors in the systematic steps and addition algorithms, such as visual marking errors, fraction symbol errors, and calculation errors. This indicates that procedural fluency skills in the subject studied at level 2 are not yet met by many students and still need to be strengthened through exercises that emphasize the relationship between visuals, algorithms, and fraction symbols.

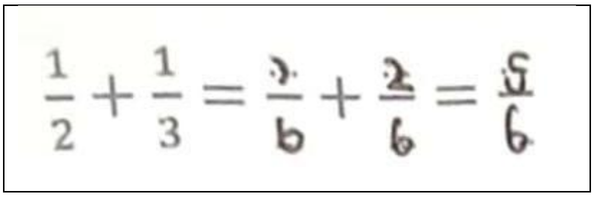


Figure 8. Level 3 correct answers

Figure 8 shows the results of the students' written test, indicating that only a small percentage of students achieved Level 3 procedural fluency. This level is characterized by students' ability to determine common multiples of two different denominators before performing fraction addition. The students' responses demonstrate that they recognized the necessity of equalizing denominators by identifying an appropriate common multiple as the basis for converting the fractions into equivalent forms. This finding aligns with previous studies which emphasize that the ability to determine least common multiples is a critical indicator of advanced procedural fluency in fraction operations (Safitri & Lestari, 2022; Pratidiana & Muhayatun, 2021).

After obtaining equivalent fractions with the same denominators, students proceeded to add the numerators and accurately record their final answers in symbolic form. This process reflects a strong understanding of the more complex procedural steps required in adding fractions with unlike denominators, including factorization, denominator alignment, and consistent application of algorithms. According to Oktasari et al. (2023), students who are able to carry out these steps systematically demonstrate higher levels of procedural control and accuracy. Therefore, the students' performance in **Figure 8** meets the criteria for Level 3 procedural fluency, as they were able to execute fraction addition procedures independently and correctly without relying solely on visual cues.

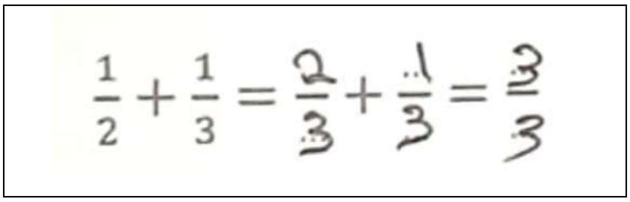


Figure 9. Level 3 incorrect answers.

Figure 9 shows that some students have not yet reached Level 3 procedural fluency. These students experienced difficulties, particularly when adding fractions with unlike denominators. The main challenge lies in their inability to equalize the denominators using the Least Common Multiple (LCM). In addition, several students made procedural errors in the final calculation step, such as adding the denominator to the numerator or combining numerators and denominators directly. Such errors indicate an incomplete understanding of fraction addition procedures and weak procedural control. Similar error patterns have been widely reported in previous studies, where students tend to apply incorrect algorithms when they lack a solid understanding of denominator relationships and fraction equivalence (Purba, 2020; Oktasari et al., 2023).

At Level 3, although some students were able to determine common multiples of two unlike denominators before performing addition-demonstrating good procedural fluency many others struggled to identify appropriate multiples due to limited understanding of denominator factorization. According to Safitri and Lestari (2022), difficulties in procedural fluency at higher levels often stem from students' inability to coordinate multiple procedural steps independently and systematically. This finding is further supported by Pratidiana and Muhayatun (2021), who reported that students frequently experience confusion when determining when and how to apply procedures in problems requiring higher-order reasoning. Therefore, the results indicate that a significant number of students have not yet achieved Level 3 procedural fluency and require targeted instructional support, particularly in developing understanding of factorization, common multiples, and the systematic application of fraction addition algorithms.This is consistent with the findings of Safitri & Lestari (2022), who reported that students' mathematical procedural fluency remains below the minimum competency standards and is categorized as low, particularly when viewed from the aspect of students' learning independence. Their study highlights that many students have not yet developed the ability to carry out mathematical procedures systematically and accurately, which affects overall learning outcomes.

Similarly, the results of a study by Pratidiana & Muhayatun (2021) show that only one student met all indicators of mathematical procedural fluency, while the majority of students were only able to identify some of the known and required elements of the problem. Most of them still made errors during the calculation process, indicating weaknesses in applying steps correctly and consistently. These findings reinforce the conclusion that students' procedural fluency is still insufficient and requires more structured practice and targeted instructional support. Students' procedural ability in solving mathematical problems is not smooth; they are confused about when and how to use procedures in performing algebraic operations, and they are inconsistent in operating on the same or different terms, indicating that the conceptual understanding and procedural knowledge of students with moderate ability are still low.

In addition, the findings of this study provide further evidence that the development of procedural fluency in fraction addition is highly dependent on students' ability to coordinate multiple procedural steps simultaneously. While the Built-in Definition Fraction media successfully supported students at lower procedural levels by facilitating visual interpretation and basic denominator alignment, the sharp decline in performance at Level 3 suggests a critical limitation in students' abstraction processes. This result aligns with previous studies indicating that higher-level fraction operations require not only visual support but also a well-established understanding of factorization and multiplicative relationships among denominators. The observed difficulties at this level indicate that procedural fluency cannot be developed solely through concrete manipulation; rather, it requires instructional scaffolding that explicitly bridges visual representations and symbolic reasoning. Consequently, this study highlights the importance of integrating concrete media with targeted conceptual instruction to support students' transition from visually guided procedures to independent and abstract procedural reasoning.

CONCLUSION

Based on the analysis results, it was found that the average student was at level 1. This shows that most students are still at a basic procedural fluency skill level, while only a small number are able to reach the highest level, which is level 3. Therefore, it can be concluded that students' procedural fluency skills in general still need to be improved. Limited learning time also affects the process of observing the development of procedural fluency skills in greater depth. This media has not reached level 4, therefore for further re Based on the results of the analysis, it was found that the majority of students were positioned at level 1 of procedural fluency. This finding illustrates that most students are still operating at the most basic stage, where their ability to apply mathematical procedures especially those related to fraction addition is limited. At this level, students tend to rely heavily on direct guidance, show difficulty in determining appropriate steps independently, and often make errors in fundamental procedures such as identifying equivalent fractions or equalizing denominators. Only a very small number of students demonstrated the ability to reach level 3, which represents a more advanced stage of procedural fluency. At this level, students are able to select appropriate procedures, apply them flexibly, and show a more consistent understanding of the relationship between fraction concepts and the steps required to solve problems.

These findings suggest that overall, students' procedural fluency still requires significant improvement. The limited advancement beyond level 1 indicates that many students have not yet developed the conceptual foundations necessary to support higher-level procedural skills. Factors such as misconceptions about fraction representation, inadequate exposure to hands on learning experiences, and reliance on rote memorization may contribute to these difficulties. Moreover, the limited learning time for implementing the media during the study also influenced the ability to observe deeper developmental progress. With a longer implementation period, it is possible that students would have had more opportunities to practice, strengthen their understanding, and gradually move to higher levels of procedural fluency.

This study makes a significant contribution to mathematics education research by providing a detailed, level-based analysis of elementary students' procedural fluency in fraction addition through the use of Built-in Definition Fraction media. Unlike prior studies that primarily focus on learning outcomes or error identification, this research conceptualizes procedural fluency as a non-linear developmental process and empirically identifies critical procedural transition points from concrete visual manipulation to abstract procedural reasoning. Furthermore, the study contributes to the instructional media literature by demonstrating that while concrete, definition-based fraction media effectively support early procedural stages, they are insufficient on their own to foster higher-level procedural abstraction, particularly in tasks requiring least common multiple determination. By integrating structured procedural fluency levels with qualitative insights into students' reasoning processes, this study enriches theoretical understanding of procedural fluency development and offers a methodological reference for future research aiming to design instruction and learning media that explicitly support students' progression across increasing levels of procedural complexity.

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