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Creating a diagnostic test to assess conceptual understanding of fraction operations

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Abstract

Background: Fraction operations are fundamental in mathematics education, yet many students face challenges in mastering these concepts. Effective assessment tools are crucial for identifying areas of difficulty and guiding instructional improvements.

Aim: This study aims to develop a diagnostic test to accurately measure the conceptual understanding of fraction operations among students in the Elementary School Teacher Education Program (PGSD) at STKIP Melawi.

Method: Utilizing a research and development approach with mixed methods, this study follows Ebel's Model of Test Development. The process includes item selection, validation, and reliability testing, involving both qualitative and quantitative analyses.

Results: The developed diagnostic test demonstrated strong validity and reliability metrics. Analysis revealed that students commonly struggle with both the conceptual and procedural aspects of fraction operations. Frequent errors were noted in the interpretation and execution of solution steps. No student achieved the highest possible score, indicating significant gaps in understanding. The N-Gain analysis showed an average score of 0.5610, suggesting medium to high effectiveness in identifying learning challenges, with individual scores ranging from 0.32 to 0.93.

Conclusion: The diagnostic test developed in this study provides a robust tool for assessing the conceptual understanding of fraction operations. It highlights specific areas where students encounter difficulties, offering valuable insights for targeted instructional strategies. Integrating this diagnostic test into the curriculum can enhance the ability to diagnose and address learning obstacles, ultimately improving mathematics education outcomes.

INTRODUCTION

Fraction operations are a fundamental aspect of mathematics education, forming a critical foundation for more advanced mathematical concepts (Bailey et al., 2012; M. Shin & Bryant, 2015; Wilkins & Norton, 2018). Mastery of fraction calculations is not only pivotal for succeeding in higher-level mathematics courses but also for practical applications in daily life, such as cooking, budgeting, and understanding measurements (Fennell & Karp, 2017). Despite the clear importance of these skills, many students consistently struggle to grasp the concepts underlying fraction operations. This struggle often manifests in difficulties with performing arithmetic operations, understanding fractional relationships, and applying these concepts to solve real-world problems. These challenges in understanding fractions can significantly impede students' overall

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mathematical proficiency and confidence, making it crucial to address these learning gaps early on (Jing & Siegler, 2016; Siegler & Pyke, 2013). Therefore, enhancing students' comprehension of fraction operations is essential for their academic success and their ability to navigate everyday tasks that require mathematical reasoning.

Numerous studies have consistently shown that students face significant challenges in understanding and accurately performing fraction operations (Bentley & Bossé, 2018; Dyson et al., 2018). These challenges often stem from a variety of factors, including difficulties in conceptualizing fractions as parts of a whole and recognizing their equivalence in different forms. Students frequently make errors in performing arithmetic operations involving fractions, such as addition, subtraction, multiplication, and division (Bottge et al., 2014). Additionally, there is a notable struggle in applying these concepts to solve practical problems, which requires a deeper understanding and flexibility in thinking. These difficulties are not isolated incidents but rather widespread issues that hinder students' progress in mathematics. Compounding these issues is the lack of effective instructional strategies and assessment tools that are specifically designed to diagnose and address the unique difficulties students encounter with fractions. As a result, there is a pressing need for educational tools and methods that can better identify and remediate these learning gaps, thereby improving students' overall mathematical abilities and confidence.

Given the widespread difficulties students face with fraction operations, as previously discussed, diagnostic tests are invaluable in education for providing detailed insights into students' conceptual understanding and identifying specific areas where they struggle. These assessments play a crucial role in revealing the intricacies of students' comprehension, particularly in complex subjects like fraction operations (Pratiwi & Raharjo, 2021). By systematically identifying specific misconceptions and procedural errors, diagnostic tests allow educators to gain a deeper understanding of the root causes behind students' difficulties (Gürel et al., 2017; Soeharto et al., 2019). This level of insight is essential for developing targeted instructional strategies that directly address the identified weaknesses. Additionally, diagnostic tests can distinguish between superficial errors and deeper conceptual misunderstandings, enabling more precise and effective remediation (Bhakti et al., 2022; Yuberti et al., 2020). In the context of fraction operations, where students often grapple with both abstract concepts and practical applications, the importance of diagnostic tests becomes even more pronounced. A well-designed diagnostic test not only identifies common errors but also provides a roadmap for educators to implement targeted interventions. These interventions can be tailored to meet the individual needs of students, thereby enhancing their conceptual understanding and overall mathematical proficiency. Consequently, integrating diagnostic tests into the educational curriculum can significantly improve learning outcomes by ensuring that instructional approaches are both precise and effective.

METHODS

Research Design:

This study uses a mixed methods approach, combining both qualitative and quantitative methods. The aim is to explore the understanding of fraction operations among students and to evaluate the development of a diagnostic test designed to measure their understanding. The quantitative approach is used to develop and test the validity and reliability of the diagnostic test, while the qualitative approach helps to explore the difficulties students face through interviews and observations. The Ebel's Model of Test Development (Shin & Kim, 2024) was chosen to guide the systematic steps in creating the test instrument.

Participants

The participants are students from the Elementary School Teacher Education Program (PGSD) at STKIP Melawi, selected through purposive sampling. They are divided by semester and class level, with the addition of lecturers teaching related courses to provide insights on the challenges of teaching fraction operations. A total of 100 students were selected to represent a range of understanding and skills in fraction operations.

Instruments

The main instrument used in this study is the diagnostic test for fraction operations, developed using Ebel's Model of Test Development. The development of this instrument involves several stages: (1) Setting the test objectives to measure the students' understanding of fraction operations, based on curriculum analysis and literature review, (2) Defining the domain specifications, including identifying key concepts and relevant skills related to fraction operations, and developing a test blueprint, (3) Developing test items, which involves creating questions that cover a range of difficulties, according to the domain specifications, (4) Content validation, conducted by a panel of experts to ensure the questions are appropriate and aligned with the study's goals, (5) Pilot testing, where the test is tried out on a small group of students to identify issues and make necessary improvements, (6) Revising the test, based on the feedback from pilot testing, content validation, and expert opinions, (7) Test implementation, where the final version of the test is given to all participants to assess their understanding of fraction operations, (8) Data Analysis and Conclusion, use descriptive statistics and qualitative analysis to assess the test results and draw conclusions.

Additionally, in-depth interviews and observations are used as qualitative instruments to gain further insights into students' challenges. A questionnaire is also distributed to gather students' feedback on the diagnostic test. Below is Figure 1, which shows the steps involved in developing the diagnostic test based on the modified Ebel's Test Development Model:

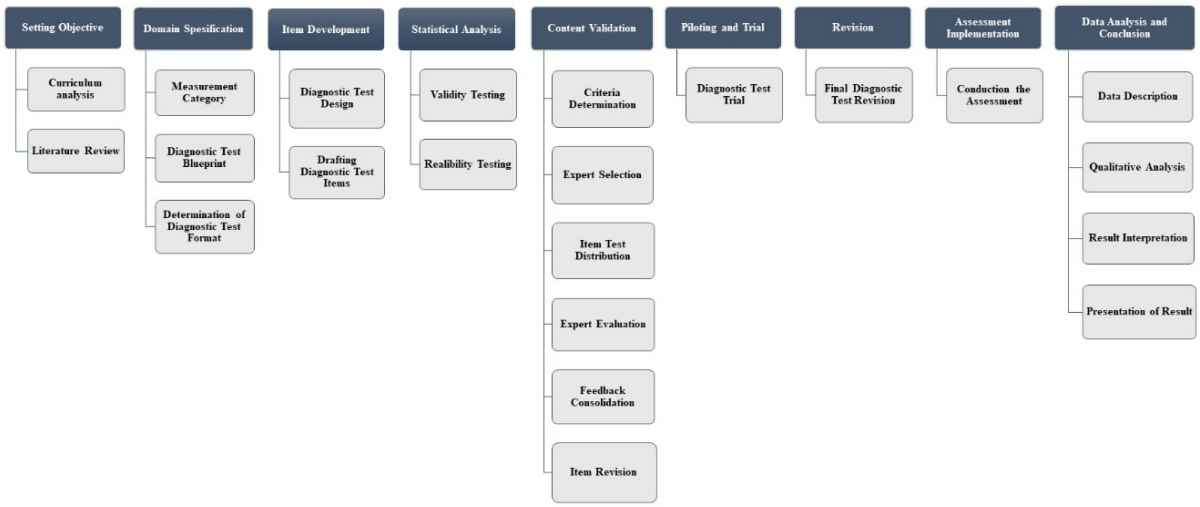

Figure 1. steps of Ebel's Test Development Model

Figure 2 illustrates the detailed steps followed in developing the diagnostic test for fraction operations, adapted from the Ebel's Test Development Model. Each step, from setting objectives to data analysis, is systematically explained to ensure that the instrument developed meets validity and reliability standards.

Data Analysis:

Quantitative data from the diagnostic test will be analyzed using descriptive statistics to show the distribution of test scores and the variations in students' understanding of fraction operations. Additionally, reliability and validity tests will be conducted to ensure the test is a reliable and valid instrument. The N-Gain formula will be used to measure the improvement in students' understanding before and after the test. The N-Gain score will indicate how much their understanding has increased as a result of taking the diagnostic test. Qualitative data from interviews and observations will be analyzed using thematic analysis to identify patterns in students' difficulties with understanding fraction concepts. This analysis will involve coding the data and identifying key themes to gain deeper insights into the factors affecting students' challenges with fraction operations.

RESULTS AND DISCUSSION

This study aims to develop a diagnostic test and explore the understanding of fraction operations concepts among PGSD students at STKIP Melawi. The study adopts a research and development approach that combines both qualitative and quantitative aspects using mixed methods and applies Ebel's Model of Test Development (Shin & Kim, 2024). The research sample consists of STKIP Melawi students from the odd semester of the 2023/2024 academic year.

Result

This study produced a diagnostic test to measure the understanding of fraction operations among first-semester PGSD students at STKIP Melawi. Using Ebel's Model of Test

Development (Shin & Kim, 2024), the test development followed several stages. First, the test objectives were set based on the Program Learning Outcomes (PLO) from the basic mathematics course, specifically focusing on fraction operations, with three main objectives: (1) mastering the basic concept of fractions, (2) applying mathematical operations to fractions, and (3) solving real-world problems using fraction operations. The test specifications covered two dimensions: non-cognitive and cognitive. The non-cognitive aspect measured students' practical skills in applying fraction concepts in real-life situations, while the cognitive aspect measured their understanding, interpretation, and application of fraction operations in verbal, figural, and symbolic forms.

Table 1. Diagnostic TEST Purpose Domain Specification

Non-cognitive	Cognitive
1) Motivation: Students show motivation to apply mathematical operations to fractions with determination and perseverance in facing challenges. 2) Creativity: Students apply imagination and creativity to find innovative solutions to real-world problems using fraction operations. 3) Responsibility: Students demonstrate responsibility in completing tasks related to fraction operations, including time management and work quality. 4) Perseverance: Students demonstrate perseverance in solving real-world problems using fraction operations, showing the ability to persist in facing difficulties.	PLO 2: Students are able to apply mathematical operations to fractions. - Verbal: Students can explain the steps of mathematical operations on fractions verbally and provide examples of situations where fraction operations are applied in real-world contexts. - Figural: Students can create graphic representations of the steps for fraction operations, visualizing the calculation process through diagrams or charts. - Symbolic: Students can perform fraction operations using correct mathematical notation, demonstrating symbolic understanding of fraction operations.

Question Development: Based on Table 1, the fraction operation test items were developed by creating a diagnostic test blueprint in line with the overall research objectives, domain specifications, and covering various levels of difficulty, as shown in Table 2 below.

Table 2. Test Blueprint and Diagnostic Test Questions

No	Material	Question Indicator	Question Type (Question Number)	Score
1	Fraction addition	Students are able to determine the result of fraction addition both verbally, figurally, and symbolically.	Calculate the result of $\frac{1}{6}+\frac{2}{3}$, and write down how you got the result verbally, figurally, and symbolically.	5
2	Fraction subtraction	Students are able to determine the result of fraction subtraction both verbally, figurally, and symbolically.	Calculate the result of $\frac{5}{6}-\frac{2}{3}$, and write down how you got the result verbally, figurally, and symbolically.	5
3	Fraction addition and subtraction	Students are able to determine the value of a, a by adding and subtracting fractions both verbally, figurally, and symbolically.	Given $a-\frac{3}{7}=\frac{2}{5}$, determine the number that replaces a a so the statement is true both verbally, figurally, and symbolically.	5
4	Fraction multiplication	Students are able to determine the result of fraction multiplication both verbally, figurally, and symbolically.	Calculate the result of $\frac{2}{16}\times\frac{8}{4}$, and write down how you got the result verbally, figurally, and symbolically.	5

No	Material	Question Indicator	Question Type (Question Number)	Score
5	Mixed fraction multiplication	Students are able to determine the result of mixed fraction multiplication with whole numbers both verbally, figurally, and symbolically.	Calculate the result of $2\frac{1}{2} \times 3$, and write down how you got the result verbally, figurally, and symbolically.	5
6	Fraction division	Students are able to determine the result of fraction division both verbally, figurally, and symbolically.	Calculate the result of $\frac{3}{4} : \frac{5}{7}$, and write down how you got the result verbally, figurally, and symbolically.	5
7	Whole number division by mixed fractions	Students are able to determine the result of dividing a whole number by mixed fractions both verbally, figurally, and symbolically.	Calculate the result of $4 : 3\frac{3}{4}$, and write down how you got the result verbally, figurally, and symbolically.	5
8	Applying fractions in real situations	tudents are able to determine the result of fraction operations in real-world situations both verbally, figurally, and symbolically.	A stick that is $\frac{10}{4}$ meters long is placed vertically in water. If $\frac{10}{12}$ meters of the stick is visible above the surface, how long is the part of the stick that is underwater?	5

In the development process of the diagnostic test, which consists of 8 essay questions, each item was designed by detailing the achievement indicators of the Program Learning Outcomes (PLO) for basic fraction operations while considering the domain specifications of the research objectives. The alignment between the achievement indicators and the research objectives creates a strong conceptual foundation for designing the diagnostic test, ensuring that students' understanding of fraction operations is enhanced. This approach guarantees that each diagnostic question makes a significant contribution to measuring students' abilities. The alignment between the PLO, domain specifications, and question indicators results in an accurate and valid evaluation instrument, with clear achievement indicators. After the test trial, the data was analyzed using SPSS software to evaluate reliability and validity. The recapitulation of students' responses during the trial is presented in Table 3, providing a detailed understanding of the instrument's quality and the validity of the trial data. This approach ensures the consistency and accuracy of the diagnostic test before its use in an academic context, forming a solid basis for result interpretation and evaluation decisions.

Table 3. Results of the Validity Test of the Diagnostic Test Trial

Indicator	R_{count}	R_{table}	Criteria	Information
P1	0,698	0.3202	Sedang	Valid
P2	0,722	0.3202	Tinggi	Valid
P3	0,621	0.3202	sedang	Valid
P4	0,773	0.3202	Tinggi	Valid
P5	0,658	0.3202	sedang	Valid
P6	0,784	0.3202	Tinggi	Valid
P7	0,887	0.3202	Tinggi	Valid
P8	0,687	0.3202	sedang	Valid

Reliability testing was conducted using the Reliability Analysis Statistic method, referring to the value of Cronbach's Alpha (α). The results showed a Cronbach Alpha value exceeding the 0.6 threshold, indicating that all question items on the test instrument can be considered reliable. These reliability findings are presented in Table 4, strongly supporting the instrument's reliability and its ability to provide high consistency in measuring fraction operation concepts. The results of this reliability test offer an empirical basis for trusting the diagnostic test as a reliable tool in supporting this research.

Table 4. Diagnostic Test Reliability Testing

Item-Total Statistics					
	Scale Mean if Item Deleted	*Scale Variance if Item Deleted*	*Corrected Item-Total Correlation*	*Squared Multiple Correlation*	*Cronbach's Alpha if Item Deleted*
XI	16.2368	26.186	0.559	0.448	0.861
X2	17.0789	27.913	0.629	0.578	0.849
X3	16.9474	28.862	0.502	0.467	0.862
X4	16.7368	28.253	0.706	0.632	0.844
X5	16.7105	27.887	0.534	0.601	0.860
X6	16.7632	25.915	0.691	0.587	0.842
X7	17.1579	26.569	0.847	0.799	0.828
X8	17.2105	27.954	0.579	0.487	0.854
Reliability Statistics					
Cronbach's Alpha		*Cronbach's Alpha Based on Standardized Items*			N of Items
0.866		0.874			8

Based on the reliability analysis presented in Table 4, the reliability score for all items in the fraction operation diagnostic test reached 0.866. This score meets the reliability criteria, with a threshold value above 0.6, indicating a high level of reliability in the test instrument. Therefore, this diagnostic test can be regarded as a reliable and consistent tool for measuring the understanding of fraction operations among PGSD students at STKIP Melawi. The success in fulfilling both validity and reliability criteria makes it a suitable choice for further research use.

Figure 2. Documentation of Diagnostic Test Implementation on Fraction Operations

Next, an N-Gain test analysis was conducted to evaluate the effectiveness of the diagnostic test instrument in improving students' understanding of fraction operations at PGSD STKIP Melawi. This analytical approach was holistically designed to explore data characteristics, examine significant differences between groups, evaluate the

simultaneous effects of variables, and determine the extent to which the diagnostic test instrument measures students' understanding of fraction operations. The aim of this analysis is to provide a comprehensive understanding of the impact and effectiveness of the diagnostic test instrument in achieving its measurement objectives within the academic context of PGSD STKIP Melawi.

Table 5. Recapitulation of Measurement Results Using the Diagnostic Test

Subject	Diagnostic Test Measurement Results	Application of Diagnostic Tests	Subject	Diagnostic Test Measurement Results	Application of Diagnostic Tests
A862320038	N	82,00	A862320057	55,00	73,00
A862320039	77,50	93,50	A862320058	45,00	73,00
A862320040	72,50	87,50	A862320059	50,00	82,00
A862320041	62,50	87,50	A862320060	52,50	72,50
A862320042	62,50	87,50	A862320061	40,00	76,00
A862320043	67,50	89,50	A862320062	42,50	67,50
A862320044	75,00	87,00	A862320063	50,00	88,00
A862320045	60,00	79,00	A862320064	50,00	80,00
A862320046	75,00	89,00	A862320065	42,50	67,50
A862320047	60,00	87,00	A862320066	45,00	80,00
A862320048	57,50	83,50	A862320067	47,50	76,50
A862320049	52,50	80,50	A862320068	55,00	70,00
A862320050	47,50	76,50	A862320069	22,50	47,50
A862320051	47,50	70,50	A862320070	47,50	81,50
A862320052	52,50	74,50	A862320071	60,00	89,00
A862320053	70,00	98,00	A862320072	50,00	77,00
A862320054	47,50	64,50	A862320073	50,00	74,00
A862320055	42,50	82,50	A862320074	62,50	84,50
A862320056	65,00	81,00			

Explanation: X refers to the measurement results of STKIP Melawi students using the Fraction Operations Diagnostic Test, while Y refers to the implementation of the diagnostic test. Descriptive statistics were performed to provide an overview of the data distribution, including the mean, median, mode, standard deviation, and other relevant parameters.

Table 6. Recapitulation of Descriptive Statistics Using SPSS

Statistics			
		X	Y
N	Valid	37	37
	Missing	0	0
Mean		55,0541	79,7297
Std. Error of Mean		1,89552	1,54203
Median		53,0000	81,0000
Mode		48.00[a]	88,00
Std. Deviation		11,53002	9,37979
Variance		132,941	87,980
Range		55,00	50,00
Minimum		23,00	48,00
Maximum		78,00	98,00
Sum		2037,00	2950,00

a. Multiple modes exist. The smallest value is shown

Note: a. Multiple modes exist. The smallest value is shown.

The results of the descriptive statistical analysis in the study "Development of a Fraction Operations Diagnostic Test and Its Implementation on PGSD Students' Conceptual Understanding at STKIP Melawi" show the effectiveness of the diagnostic test in improving students' understanding. The average score before the test (X) was 55.05, while the average after applying the test (Y) was 79.73, indicating a significant increase. The median for X was 53.00, while the median for Y was 81.00. The mode for X was 48.00, and the mode for Y increased to 88.00, indicating an improvement in the most frequent scores.

The standard deviation for X was 11.53 with a variance of 132.94, while the standard deviation for Y was 9.38 with a variance of 87.98, showing less variation after the test was implemented. The skewness for X was -0.057, and for Y, it was -0.935, indicating that the Y data distribution was more left-skewed. The kurtosis for X was 0.475, while for Y, it was 2.354, indicating that the Y data distribution was more peaked. The range for X was 55.00 (from 23.00 to 78.00), and for Y, it was 50.00 (from 48.00 to 98.00). The higher minimum and maximum values for Y indicate significant improvement in both the lowest and highest student scores. This data provides evidence that the diagnostic test is highly effective in improving and leveling the understanding of fraction operations among PGSD students at STKIP Melawi, supporting the hypothesis that this test can be an effective tool for mathematics learning at the elementary education level.

N-Gain Test

The function of the N-Gain test in this study is to measure the effectiveness of the Fraction Operations Diagnostic Test and its implementation on the conceptual understanding of PGSD students at STKIP Melawi. The intervention in this study involved the administration of the diagnostic test to students and the collection of their responses via a questionnaire after completing the test.

Following this intervention, data from the diagnostic test were analyzed using the N-Gain test through SPSS software. The N-Gain test was used to determine the students' conceptual understanding of fraction operations after taking the diagnostic test. The results of the N-Gain test analysis are presented in Table 4.11, providing an overview of the average N-Gain and the effectiveness of the diagnostic test implementation in describing the conceptual understanding of PGSD students at STKIP Melawi.

Table 7. N-Gain Test Analysis

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
N-gain_Score	37	0.32	0.93	0.5610	.13300
N-gain_Percent	37	32.47	93.33	56.0993	13.29962
Valid N (listwise)	37				

Based on the N-Gain test analysis presented in Table 7, this study shows that the application of the Fraction Operations Diagnostic Test was effective in improving the understanding of PGSD students at STKIP Melawi.

- Student Understanding: Among the 37 participating students, the minimum N-Gain score was 0.32 (a 32% improvement) and the maximum score was 0.93 (a 93% improvement), with an average of 0.5610 (a 56.10% improvement). This indicates a significant improvement in understanding, although it varies between individuals.
- Comparison of Improvement: The variation in improvement, ranging from 32.47% to 93.33%, shows that while the results vary, the test provided consistent benefits to most students. The average improvement of 56.10% highlights the effectiveness of the diagnostic test in enhancing students' understanding of fraction operations.
- Effectiveness of the Intervention: With an average N-Gain score of 0.5610, this intervention falls into the medium to high effectiveness category. The average improvement of 56.10% suggests a significant overall impact on students' understanding, despite individual differences.
- Identifying Individual Differences: The standard deviation of the N-Gain score, 0.13300, shows moderate variation in the improvement of understanding among students. While individual differences exist, most students experienced a significant increase in understanding. The standard deviation of the percentage improvement, 13.29962%, also indicates that although there are individual variations, the majority of students showed meaningful improvement.
- Determining the Effectiveness Category: With an average N-Gain score of 0.5610, this intervention is categorized as having medium effectiveness. Some students, with N-Gain scores as high as 0.93, demonstrate the potential for the intervention to yield very high results for certain individuals.
- Basis for Decision-Making: The results of the N-Gain analysis can be used to improve the curriculum and teaching methods. Additionally, these findings can help develop more personalized training programs and guide academic policies that prioritize the use of diagnostic tests to enhance students' understanding of basic mathematical concepts.

Overall, this study indicates that the Fraction Operations Diagnostic Test is an effective evaluation tool and can be integrated into the curriculum to achieve optimal learning outcomes.

Discussion

Based on the descriptive analysis and statistical tests conducted on the results of the fraction operations diagnostic test and the survey on the test's implementation, several key findings were identified. First, there was variation in the validity levels across the diagnostic test items, with four items showing moderate validity and four others showing high validity. Despite this, the overall reliability of the diagnostic test indicated a high level of reliability (Cronbach's Alpha score of 0.866), confirming that the instrument is valid and reliable for measuring the understanding of fraction operations among PGSD students at STKIP Melawi. This is consistent with the findings of Shin & Kim (2024),

who demonstrated that diagnostic tests can provide good reliability in assessing basic mathematical skills.

Second, the descriptive statistical analysis of the diagnostic test results showed significant score variation. The average initial student score was 55.05, with the score distribution following a normal curve, indicating significant differences in students' initial abilities. After the implementation of the diagnostic test, the average score increased to 79.73, showing a significant improvement. The distribution of scores after the test was more focused, suggesting that the test not only improved concept understanding but also helped align the understanding of students with different levels of ability. This improvement aligns with the findings of Asnawi et al. (2023) and Dewi et al. (2022), which stated that diagnostic tests help reduce learning gaps in learning.

This study also found that the fraction operations diagnostic test was effective in improving students' understanding, as shown by the results of the N-Gain test. Among the 37 students, N-Gain scores ranged from 0.32 to 0.93, with an average of 0.5610. Although the improvement varied between individuals, there was a significant overall increase, with an average improvement of 56.10%. The variation in improvement, as reflected by the N-Gain standard deviation of 0.13300, showed that most students experienced meaningful improvement. These findings support previous research by Kırbulut & Geban (2014), which demonstrated that diagnostic tests can effectively identify students' weaknesses and help them address areas they do not fully understand. The diagnostic test results also revealed that most students struggled to apply fraction operations across various forms of representation, whether verbal, figural, or symbolic. No students achieved the highest score (5), and only a small percentage managed to score 4, indicating that their ability to express understanding in different representations remains limited. This finding aligns with Flores et al. (2018), who noted that one of the key challenges in fraction operations is students' ability to visualize and translate abstract concepts into concrete forms. These findings highlight the need for a more intensive and targeted approach to teaching fraction operations, especially in helping students master different forms of representation. Additionally, using more varied teaching strategies, including visual and contextual approaches, could help students better understand fraction concepts.

Overall, the findings of this study indicate that the fraction operations diagnostic test is an effective evaluation tool that can be integrated into the curriculum to improve students' understanding of basic mathematical concepts. This instrument not only helps students grasp fraction operations but also provides valuable feedback for curriculum development, teaching methods, and better academic policies. This study opens up opportunities for further development in the design and implementation of more holistic and effective diagnostic tests within the context of mathematics education.

CONCLUSIONS

The fraction operations diagnostic test developed in this study showed varying levels of validity, with some questions having moderate validity and others high validity, while

the overall reliability of the test was high, indicating that the instrument is reliable for measuring students' understanding of fraction concepts. The results from the diagnostic test analysis revealed that most students struggled to understand and correctly apply fraction concepts in different forms of representation, such as verbal, figural, and symbolic. Although some students answered correctly, many were still inaccurate in writing and understanding the solution steps. No student achieved the highest score, which suggests the need for further improvement in understanding and applying these concepts. The N-Gain test results indicated a significant improvement in students' mathematical understanding, with an average N-Gain score of 0.5610, which falls into the medium to high effectiveness category, with scores ranging from 0.32 to 0.93, showing that the test had consistent but varying benefits across individuals. Therefore, this diagnostic test has proven to be effective and can be integrated into the curriculum to improve overall mathematics learning outcomes, particularly in fraction operations. A more intensive learning approach, with varied strategies, deeper practice, and the development of representational skills, is crucial to help students better understand fraction concepts and improve their application skills in various contexts.

AUTHOR CONTRIBUTION STATEMENTS

DPJ contributed to the conceptualization, drafting of the original manuscript, editing, and visualization. AYT contributed to reviewing, editing, formal analysis, and methodology. YND contributed to validation and supervision.

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