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Exploring the relationship between students' attitudes and fraction sense proficiency across lower secondary grades

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ABSTRACT

Understanding fractions is a critical mathematical skill necessary for more advanced mathematical concepts and applications. However, many students struggle with fraction sense, which is the foundational understanding and flexible use of fractions. This study aims to explore the relationship between students' attitudes toward learning fractions and their proficiency in fraction sense in lower secondary grades. Using a descriptive-correlational design, data were collected from 296 students aged 13 to 15 using the Fraction Sense Test (FST) and the Attitudes Towards Learning Fractions Questionnaire (ATLF). The study found that students consistently struggled with fractional concepts, achieving low scores across all grades. Nevertheless, a significant, though diminishing, relationship was observed between positive attitudes towards fractions and fraction sense proficiency from Secondary One to Secondary Three. These findings suggest the need to integrate meaningful fraction learning approaches to maintain students' positive attitudes, thereby improving their overall mathematical competence.

Mengeksplorasi hubungan antara sikap siswa dan kemahiran pemahaman pecahan di kelas menengah pertama

Kata Kunci:

Sikap
Pemahaman pecahan
Pembelajaran
Masuk akal
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ABSTRAK

Memahami pecahan adalah keterampilan matematika kritis yang diperlukan untuk konsep dan aplikasi matematika yang lebih lanjut. Namun, banyak siswa kesulitan dengan pemahaman pecahan, yang merupakan pemahaman dasar dan penggunaan fleksibel pecahan. Penelitian ini bertujuan untuk mengeksplorasi hubungan antara sikap siswa terhadap pembelajaran pecahan dan kemahiran siswa dalam pemahaman pecahan di kelas menengah pertama. Menggunakan desain deskriptif-korelasi, data dikumpulkan dari 296 siswa berusia 13 hingga 15 tahun menggunakan *Fraction Sense Test* (FST) dan *Attitudes Towards Learning Fractions Questionnaire* (ATLF). Penelitian menemukan bahwa siswa secara konsisten kesulitan dengan konsep pecahan, meraih nilai rendah di semua kelas. Meskipun demikian, terdapat hubungan yang signifikan, meskipun semakin berkurang, antara sikap positif terhadap pecahan dan kemahiran pemahaman pecahan dari Tingkat Satu ke Tingkat Tiga. Temuan ini menunjukkan perlunya mengintegrasikan pendekatan pembelajaran pecahan yang bermakna untuk mempertahankan sikap positif siswa, sehingga meningkatkan kompetensi matematika mereka secara keseluruhan.

1. INTRODUCTION

As a content mastery subject taught in schools, mathematics greatly influences contemporary education. Its integral position in contemporary education underscores that it is more than an academic subject to be learned. It enables the cultivation of logical reasoning and analytical problem-solving skills. The impact of mathematics transcends disciplines. It honed cognitive abilities, enabling preparedness that ensures students meet the plethora of academic and real-life challenges that await them. Mathematics is much more than mere intellectual worth, for it is also a cognitive triage that underpins Science, Technology, Engineering, and Mathematics (STEM) education, which has declined because of mathematics avoidance. In recent times, the enthusiasm for STEM education has dropped [1], [2]. The fall in interest in STEM necessitates a thorough investigation and deliberate action. There is an underlying need to bridge the gap between theory (learn mathematics content in classrooms) and practice (applying the content for understanding and sense-making) for a comprehensive and practical approach to mathematical education, especially in the context of modern schooling. This research investigates the relationship between students' attitudes and fraction sense proficiency across lower secondary levels. It sheds light on the importance of attitude as a potential predictor in mastering fraction sense skills, offering valuable insights into mathematics education.

One of the fundamental contents of mathematics that is applied across disciplines is fractions. Proficiency in fractions is a prerequisite for learning more advanced mathematics [3]–[5]. Its competence is a "gatekeeper" topic for secondary-level mathematics [4]. Elementary school students' knowledge of fractions and division predicted their understanding of algebra and overall mathematics achievement in high school [3]. The critical crossroads developed in learning this content is the fraction sense which relates from theory to practice [6], [7]. Fraction sense refers to a learner's fundamental comprehension of fractions and operations and the ability and inclination to use this comprehension flexibly [6], [8]. It involves understanding what fractions mean, the relationship between fractions and various representations of fractions, and flexible skills for working with fractions.

The importance of fractional sense lies in its efficient use, converting learned knowledge of fractions into a deep understanding. Learners with a strong sense of fractions will have a more profound comprehension of fraction concepts and will be able to operate in ways that go beyond simply adhering to a set of rules. Good fractional senses use various problem-solving methods, many of which do not require written or computational procedures [6], [9], [10].

It is the critical bridge between mathematical theory and practical reality [6]. It involves a deep understanding of mathematical concepts connected to fractions, allowing for efficient problem-solving and well-informed mathematical decision-making. Beyond its significance as a subject matter, fractional sense opens opportunities for real-world problem-solving, influencing everything from cooking and carpeting to banking and engineering sectors [6], [10]. Nonetheless, students often face challenges and struggle to develop fraction sense, which presents considerable challenges in their higher mathematical endeavours [11], [12].

The rationale for learners' difficulties in making sense of the content learned in the classroom is usually due to the emphasis on year examination grades rather than the knowledge to be developed in the learning process [13]. This emphasis that is devoid of constructive and meaningful learning among students develops anxiety and results in the phenomenon of mathematics avoidance [14]. As the focal point of the study, we firmly believe that the obstacles faced in making sense of fraction learning will also be related to

their attitude toward learning it. This issue will have a long-term impact because mathematics is a subject that cuts across the core of STEM-related fields. If mathematics learning, such as making sense of fractions, creates a negative connotation among students, it will directly impact students' interest in STEM education. Studies [1], [2] have suggested that low enthusiasm and interest in mathematics learning will impact students' interest in STEM-related fields. To address these concerns, there is a need to investigate the relationship between these variables, namely attitude and mathematics proficiency, focusing on fractional sense. Thus, the objectives of this study are to assess fractional sense proficiency, to examine attitudes towards learning fractions, and to explore the relationship between fractional sense and attitudes towards learning it.

The findings of studies have elucidated the challenges and issues students face in understanding the concept of fractions [7], [15], [16]. Attitudes encompass how individuals express their views about a topic through actions, feelings, or thoughts. Unlike emotions, attitudes are considered more enduring and cognitive, yet less enduring and cognitive than beliefs [17]. Student attitudes have emerged as a focal point in mathematics education research spanning the last two decades, especially in the context of their achievement [18], [19]. There is a discrepancy in the information surrounding these effects. Most previous studies have depicted a strong relationship [19]–[21]. However, a growing body of current literature has depicted very low or no significant association between attitude and achievement [18], [22]. This discrepancy highlights the need for further study to understand better the relationship between students' attitudes and mathematics achievement.

In conclusion, the study corroborated the suggestions by researchers, encouraging a deeper examination of attitudes towards mathematics [23], [24]. Examining the connection between attitudes (motivation, confidence, and interest) and students' proficiency in fractional sense during fractions learning offers insights into crucial areas needing interventions for enhanced performance in fractions. These factors have consistently demonstrated a significant influence on academic success. However, recent studies have also shown that attitude is not related to achievement, which necessitates a rationale for the study at the current time.

Research on student attitudes has been widely conducted, including the impact of students' digital technology attitudes on online learning engagement [25], the improvement of student outcomes and attitudes towards mathematics [26], the influence of students' attitudes on mathematics lessons [27], and the effect of memorizing the Quran and students' attitudes on mathematics learning outcomes [28]. However, no studies have specifically explored the relationship between students' attitudes towards learning fractions and their proficiency in fraction sense at the lower secondary level.

Based on this issue, this study aims to explore the relationship between students' attitudes towards learning fractions and their proficiency in fraction sense at the lower secondary level. This study differs from existing research, which mostly focuses on computational aspects and concept understanding without fully integrating the attitude factor. This study is novel in combining attitude analysis with fraction sense proficiency and providing empirical evidence from an educational context that has not been widely explored before.

This research is expected to provide new insights into the importance of positive attitudes in enhancing fraction understanding and offer a foundation for the development of more effective educational interventions. Additionally, this study provides practical recommendations for educators to integrate more meaningful and engaging fraction

learning approaches, which can increase students' interest in mathematics and STEM fields overall.

Contribution to the literature

This research contributes to:

- Identifying specific challenges faced by students in understanding fraction concepts.
- Demonstrating the relationship between students' attitudes towards learning fractions and their proficiency in fraction sense.
- Providing new perspectives on how attitudes and mathematical understanding are interrelated and influence each other.

2. METHOD

This study employed a descriptive-correlational design to attain the objective of the study. The two variables were the fraction sense proficiency and attitudes toward fraction learning. This design allowed for a thorough assessment of the relationship between attitudes and fraction proficiency, resulting in a comprehensive understanding of their relevance to fundamental mathematics learning [29]. A total of 296 students (ages 13 to 15) from three public schools in a district in Selangor participated in this study. These samples were selected using stratified random sampling based on the strata of Grade levels and Gender. The sample size requirement of two hundred and ninety-six met the requirement based on specifications [30]. The demography representation of the students involved is shown in Table 1.

Table 1. Distribution of Samples by Grade Level and Gender

Gender	Secondary 1	Secondary 2	Secondary 3	Total
Male	46	51	44	141 (47.6%)
Female	47	50	58	155 (52.4%)
Total	93 (31.4%)	101 (34.1%)	102 (34.5%)	296 (100%)

In this research, two instruments, namely the Fractions Sense Test (FST) and the Attitudes Towards Learning Fractions Questionnaire (ATLF) were used for the data collection. The FST, adapted from [8], comprised 28 items from seven indicators. The distribution of these items is shown in Table 2.

Table 2. FST Items

Indicator	Items	N
Density	1, 7, 14, 21	4
Part-to-whole	2, 9, 15, 22	4
Magnitude	3, 10, 16, 23	4
Equivalence	4, 11, 17, 25	4
Addition	5, 12, 18, 27	4
Multiplication	6, 13, 20, 28	4
Number Line	8, 19, 24, 26	4
Total		28

The scorings for the FST were based on a dichotomous outcome of correct and incorrect responses, with 1 for the former and 0 for the latter, totalling a maximum score of 28. ATLF was adopted from existing research [31], [32]. The three constructs for attitude adopted from these studies were interest, confidence, and motivation. The scores from each of these constructs were computed into a composite score for attitude as the

variable of study following Ajzen technique [33], reflecting the multidimensional nature of attitudes and optimizing measurement reliability [34]. This Questionnaire comprised three constructs with 15 items. The distribution of these items according to the constructs is shown in Table 3.

Table 3. Items According to the Attitude Indicators

Indicator	Items	N
Interest	1, 3, 4, 6, 14	5
Confidence	5, 7, 11, 12,13	5
Motivation	2, 8, 9, 10, 15	5
Total		15

The content validity of the FST was established by a review of three panels of experts whose job was to evaluate how well items assess what they are made to measure based on the constructs. All the suggestions based on the feedback were incorporated into the final version. For the FST's reliability, the test-retest analyses were conducted among 12 respondents (similar characteristics of the actual study sample) tested twice, six days apart. The paired sample t-test displayed internal consistency within the FST items (pre-test M=12.27, SD=5.63; post-test M=12.67, SD=5.79), affirming the instrument's reliability (Table 4).

Table 4. Reliability Analysis for FST

		Mean	N	S. D	t	df	Sig
Pair 1	Pre-Test	12.27	12	5.63	-.196	22	.847
	Post-Test	12.67	12	5.79			

Max score: 28

High test-retest reliability (r =.915, p<.05) in Table 5 confirms the FST's consistency over time, bolstering its reliability.

Table 5. Test-retest Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-Test and Post-Test	12	.915	.000

Content validity for the Attitude Towards Fractions Learning questionnaire was established through expert reviews, including those of teachers and a university lecturer. Their feedback enhanced the content validity of the questionnaire.

Table 6. Reliability Analysis According to Indicators

Indicator	No of Items	Cronbach Alpha
Interest	5	.861
Achievement	5	.782
Motivation	5	.856
Total	15	

Reliability analysis (refer to Table 6) for the questionnaire, measured using Cronbach's alpha, yielded coefficients of .861, .782, and .856 for Interest, Achievement, and Motivation, respectively, all exceeding .70, indicating the questionnaire's reliability. Both validity and reliability processes ensure the instruments' accuracy in measuring students' Fraction Sense and attitudes toward Fractions learning.

3. RESULTS

This section presents the study's findings. It entails students' proficiency in the Fractional Sense Test, their attitudes toward learning fractions, and the relationship between these variables.

3.1 Proficiency in the Fractional Sense Test

Secondary 2 students attained the highest (mean = 12.54, SD = 5.57), followed by Secondary 3 (mean = 12.30, SD = 4.90) and Secondary 1 (mean = 11.65, SD = 5.48). In terms of percentage scores relative to the total, Secondary 2 had the highest (35.1%), followed by Secondary 3 (34.8%), and Secondary 1 (30.0%). These collectively show that students scored relatively low on the FST. A One-Way ANOVA test was performed to explore differences in grade-level performance.

Table 7. Descriptive Statistics for FST by Grade Levels

Grade Level	N	Mean	Std. Deviation	% of Total Sum
Secondary 1	93	11.65	5.48	30.0%
Secondary 2	101	12.54	5.57	35.1%
Secondary 3	102	12.30	4.90	34.8%

Max = 28

Hypotheses:
H_0: There is no significant difference among grade levels in the FST Scores.
H_1: There is a significant difference in grade levels among the FST Test Scores.

Table 8. One Way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.59	2	20.796	.73	.48
Within Groups	8291.918	293	28.300		
Total	8333.510	295			

Table 8 displays results showing no significant difference in the FST mean scores [F(2, 293) = 0.73, p > .05] among different grade levels. This analysis implies that scores did not significantly vary across grades, and the null hypothesis failed to be rejected, indicating no substantial evidence for significant differences in FST scores among grade levels.

3.2 Relationship between Attitude towards Fractions and FST Performance as a Predictor

This section uses linear regression to detail the correlation between students' attitudes and Fractional Sense Test performance across different grade levels. Descriptive item analysis, correlation, and linear regression analyses were carried out separately for Secondary 1, 2, and 3 students. Students' attitudes were evaluated as a composite score from the Motivation, Confidence and Interest constructs, accentuating the overall attitude variable. This approach aligns with the broader objectives of the study, aiming to comprehend students' attitudes within the research framework.

The data in Table 9 shows that Secondary 1, 2, and 3 students generally have an intermediate attitude toward fractions learning. The mean scores for each group indicate moderately positive dispositions, ranging from 3.31 to 3.50 on a scale of 1 to 5. The data also indicates a decrease in attitude scores by grade level, with scores of 3.50 (0.66), 3.48 (0.62), and 3.31 (0.60) for Secondary 1, Secondary 2, and Secondary 3, respectively. Among the three constructs, motivation to learn depicts the lowest scores across the grade levels (M1=3.28, M2=3.31 and M3=3.19)

Table 9. Attitude toward Fractions Across Grade Levels

Attitude Toward Fractions Learning		SEC 1 (N=93)		SEC 2 (N=101)		SEC 3 (N=102)	
		M	SD	M	SD	M	SD
	Motivation	3.28	0.72	3.31	0.73	3.19	0.72
	Confidence	3.45	0.70	3.36	0.72	3.28	0.64
	Interest	3.75	0.85	3.74	0.84	3.46	0.86
Scale 1 to 5	Overall	3.50	0.66	3.48	0.62	3.31	0.60

H_1: Attitude as a Predictor in Secondary 1

This hypothesis (H_1) examined whether a positive attitude predicts better Fractional Sense Test performance in Secondary one student.

Tabel 10. Linear Regression of Fraction Scores by Attitude towards Mathematics among Secondary One Students

	Predictor Variable	B	Std. Error	Beta	t	p
1	Constant	-1.913	2.589		-.739	.462
	Attitude towards math	.254	.048	.488	5.337	.000
	R= .488					
	F= 28.485					
	N=93					

Table 10 shows a significant relationship between Secondary one students' attitude towards fractions and Fractional Sense Test scores [$R = .488$, $R^2 = 0.238$, $F = 28.485$, $p < .001$]. This data implies that 23.8% of the variance in Secondary one students' attitude contributes to explaining their Fractional Sense Test scores.

The standardized coefficient and t-value confirm that attitude towards fractions significantly predicts [$t(93) = 5.337$, $p < .001$] Secondary one students' performance in the Fractional Sense Test. In sum, these findings underscore the significant influence of a positive attitude toward fractions on Secondary one student's Fractional Sense Test performance.

H_2: Attitude as a Predictor in Secondary 2

Hypothesis (H_2) examines whether a positive attitude towards fractions predicts better Fractional Sense Test performance in Secondary two students.

Table 11. Linear Regression of Fraction Scores by Attitude towards Mathematics among Secondary two Students.

	Predictor Variable	B	Std. Error	Beta	t	p
1	Constant	.161	2.598		.062	.951
	Attitude towards math	.231	.048	.439	4.857	.000
	R= .439					
	F= 23.586					
	N=101					

In Table 11, the data shows a significant and positive correlation between attitudes toward fractions and Fractional Sense Test performance among Secondary two students [$r(101) = 0.439$, $p < .001$]. This data implies that 19.3% of the variance in Fractional Sense Test scores ($R^2 = 0.193$) can be explained by their attitudes.

Additionally, the data significantly indicate [$t(101) = 4.857$, $p < .001$] that for each additional percentage increase in attitude toward fractions, students can expect an average increase of 0.231 in their FST scores. This underscores the valuable role of a positive

attitude towards fractions in predicting enhanced performance in the Fractional Sense Test for Secondary two students.

H_3: Attitude as a Predictor in Secondary 3

Hypothesis (H_3) investigates whether a positive attitude towards fractions predicts improved Fractional Sense Test performance in Secondary three students.

Table 12 presents data showing a significant positive correlation [r (102) = 0.231 and p = .02] between Fractions Attitude and Fractional Sense Test performance among Secondary three students. This indicates that 5.33% (R^2 = 0.0533) of the variance in Fraction Test scores can be attributed to their attitudes.

Table 12. Linear Regression of Fraction Scores by Attitude towards Mathematics among Secondary Three Students

	Predictor Variable	B	Std. Error	Beta	t	p
1	Constant	6.020	2.693		2.236	.028
	Attitude towards math	.113	.048	.231	2.371	.020
	R= .231, F= 5.621 N=102					

Additionally, the data signifies [t(102) = 2.371, p = .02] that with each additional percentage increase in attitude toward fractions, students can anticipate an average increase of 0.113 in their FST scores. These results emphasize the valuable predictive role of a positive attitude towards fractions in enhancing the performance of Secondary Three students in the Fractional Sense Test.

The findings show that students from various grade levels performed poorly on the FST, reinforcing that algorithmic skill in fractions does not always imply profound conceptual knowledge. The conclusion aligns with [4] suggestion that excessive emphasis on procedural knowledge can hinder the formation of a holistic grasp of fractions [35]. This perspective underscores the need to redirect attention in education towards fostering a proper understanding and intuitive sense of fractions in students. Such a change is particularly relevant as educational reform increasingly emphasises higher-order thinking skills and conceptual knowledge despite the implications of these findings suggesting otherwise.

The One-way ANOVA data showed no statistical difference in FST scores when students proceeded from Secondary 1 to Secondary 3. This result calls into question cognitive development theory, which claims that cognitive structures should grow with age [36]. Surprisingly, the expected developmental trend is less evident in the fractional sense performance setting. Despite earlier research demonstrating continuous cognitive growth in lower secondary years [37], [38], consistent FST scores across grade levels suggest that learners' conceptual grasp of fractions is not improving as expected.

The findings in Table 9 reveal a significant relationship between competency in FST and Attitude towards Fraction Learning among Secondary students. These outcomes align with some previous studies [24], [39] supporting the notion of a positive attitude towards mathematics in education. They have argued that students with a positive attitude are more involved and engaged in learning. This association inadvertently relates to students having a comprehensive grasp of fractions learning.

The output from the regression analysis (refer to Table 9) highlights the positive association between attitudes and academic achievement in mathematics among Secondary One respondents. However, we found a declining association, in terms of the coefficients,

between Attitude and FST Scores among the Secondary Two and Secondary Three respondents. [40] emphasises that fractions learning is complex and might affect students' attitudes and performances. With the rising complexity of mathematics in higher grades, students may need to change their attitudes, which could explain the declining relationship. This indicates the need for further investigation.

This study explores the relationship between students' attitudes towards learning fractions and their proficiency in fraction sense. The results indicate a significant positive correlation between a positive attitude towards learning fractions and proficiency in fraction sense. These findings are consistent with previous research suggesting that a positive attitude towards mathematics can generally enhance understanding and academic performance in the subject [41].

The results show that students with a positive attitude towards learning fractions tend to have a better understanding of fraction concepts. This positive attitude includes high interest, confidence, and motivation towards the fraction material. Such attitudes can increase students' engagement and effort in learning complex mathematical concepts. These findings underscore the importance of developing a positive attitude towards mathematics from an early age to improve learning outcomes.

This research extends previous findings that a positive attitude towards mathematics can influence academic performance [6], [12]. However, this study makes a novel contribution with a specific focus on fractions at the junior secondary level and provides empirical data from the educational context in Malaysia, which has not been widely explored in previous literature.

This research delves into a significant gap highlighted by the apparent challenges in students' low FST scores, indicating notable difficulties. Specifically, students face hurdles in grasping crucial mathematical aspects linked to fractions, hindering their effective problem-solving and capable mathematical decision-making. Notably, those with a good grasp of fractional sense use varied problem-solving methods, often bypassing written or computational steps and using mental computations [6], [9], [10]. This gap emphasises the need to address these challenges in students' understanding of fractions.

The study also revealed a decline in the relationship between attitudes and mathematics ability when they go to higher grades, challenging prior findings in lower grades [24], [39]. It elucidates the significance of inculcating positive attitudes across the upper secondary, prescribing specific interventions as mathematics topics become more complex. Consequently, the findings imply the development of measures by educators and policymakers to ensure a sustained and enjoyable mathematics learning experience as the relationship evolves.

Although this research provides important insights, there are several limitations to consider. First, the study only includes a sample from three schools in Selangor, Malaysia, so the results may not be generalizable to a broader population. Second, this study uses a descriptive-correlational design that cannot establish causal relationships between the variables studied. Future research is recommended to expand the sample to various regions and different educational contexts to improve the generalizability of the findings. Additionally, experimental research could be conducted to explore the causal relationship between attitudes towards fractions and proficiency in fraction sense. Further studies could also explore other factors that may influence this relationship, such as teaching methods, learning environments, and family support.

6. CONCLUSION

This study examined the relationship between students' attitudes towards fractions and their Fractional Sense Proficiency at various secondary school grade levels. While a moderately high positive relationship was found among Secondary One students, demonstrating the relevance of a positive attitude in mathematics education, this relationship steadily declined as students progressed to Secondary Three. Addressing these problems, particularly among early secondary students, is critical for attracting them to STEM education as they transition to High school. While context-specific and limited, these findings provide a foundation for future research in broader settings, considering additional factors, instructional methodologies, and cultural dimensions. This underscores the importance of keeping students engaged and maintaining a positive attitude towards learning, particularly in areas such as fractions. Teachers need to find ways to make learning about fractions more meaningful and enjoyable while ensuring that students maintain a positive view of mathematics as a whole. The results of this study have significant practical implications for educators and policymakers. Teachers can use these findings to develop more effective teaching strategies that not only focus on teaching fraction concepts but also on fostering positive attitudes towards mathematics.

AUTHOR CONTRIBUTION STATEMENT

PS contributed to the fieldwork, prepared the background, and oversaw the write-up of the entire article. NAABS contributed to the fieldwork and data entry. TSH contributed to the methodology section and reviewed the first draft. NAMN contributed to the literature review and conducted the statistical analysis.

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