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Impact of differentiated instruction on pupils' performance in fractions among junior high school pupils in the Tamale metropolis of Ghana

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ABSTRACT

This study investigated the effect of differentiated instruction (DI) on students' achievement in mathematics using a quasi-experimental, pretest–posttest control group design. The study was grounded in Vygotsky's sociocultural theory, which emphasizes learning through social interaction and scaffolding within the zone of proximal development. The target population for this study comprises all basic school pupils within public schools in the Tamale Metropolis of Ghana. A sample of 102 students was drawn from intact classes using cluster random sampling and assigned to experimental and control groups. An achievement test served as the primary data collection instrument. Data were analyzed using descriptive statistics and inferential statistics. The results indicated a significant difference in post-test performance between the two groups. The experimental group exposed to differentiated instruction obtained a higher mean score than the control group. The difference was statistically significant indicating a strong effect of the intervention on students' mathematics achievement. The study concludes that differentiated instruction significantly enhances students' performance in mathematics. It is recommended that mathematics teachers integrate differentiated instructional strategies to better address learner diversity and improve academic achievement in secondary school Mathematics classrooms.

Key words: Differentiated Instruction, Fractions, Impact, Performance, Pupils

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I. INTRODUCTION

Mathematics education continues to evolve in response to the need for more effective approaches to student learning (Thomasenia, 2000). Learning mathematics extends beyond the manipulation of symbols; it involves understanding relationships among mathematical concepts, reasoning through problems, developing solutions, and applying appropriate tools to different situations. In this context, differentiated instruction has emerged as a promising approach for addressing diverse learning needs and reducing achievement gaps in mathematics.

Differentiated instruction is grounded in the belief that all students can succeed when teaching is responsive to their individual learning needs (Tomlinson, 2014). It involves adapting instruction according to students' readiness levels, interests, and learning profiles (Taylor, 2010). Unlike traditional one-size-fits-all approaches, differentiated instruction provides multiple pathways through which students can achieve common learning objectives. These adaptations may involve modifications to content, instructional methods, learning materials, and assessment practices, thereby promoting inclusive and equitable learning opportunities (Lindner & Schwab, 2020). Teachers implementing differentiated instruction employ a variety of strategies to accommodate learner diversity while supporting individual growth and achievement (Strobel & van Barneveld, 2009; Tomlinson, 2014). Such approaches enable students to work toward shared learning goals through tasks and experiences tailored to their needs (Coubergs et al., 2017). Although differentiation and personalized instruction are widely recognized as effective practices, they are often implemented informally or unintentionally in classroom settings (Kratochvílová & Havel, 2013; Westwood, 2001). The need for differentiated instruction is particularly important in mathematics, where concepts are cumulative and mastery of foundational skills is essential for future learning (Boaler & Staples, 2008). When all students are taught using the same instructional methods and pace, struggling learners may fall further behind, while advanced learners may receive insufficient challenge (Tomlinson, 2014). Similarly, instructional approaches that rely heavily on lectures and routine seatwork may fail to address the diverse ways in which students learn (Neuwirth et al., 2021).

Research suggests that students learn mathematics more effectively when they are provided with choices and learning experiences that align with their individual needs and preferences (Kazemi et al., 2009). Consequently, differentiated mathematics instruction offers opportunities to tailor learning experiences to students' backgrounds, abilities, and learning preferences, thereby enhancing engagement, understanding, and achievement (Riener & Willingham, 2010; Allen et al., 2011; Njagi, 2014). Through addressing individual learning needs and reducing instructional barriers, differentiated instruction can help close learning gaps and promote equitable access to quality mathematics education (Swanson et al., 2020; Tomlinson & Imbeau, 2023).

1.1 Statement of the Problem

Mathematics education plays a critical role in students' cognitive and academic development; however, learning fractions remains a persistent challenge for many learners. Research indicates that fractions are among the most difficult mathematical concepts for students to understand because instruction often emphasizes procedural rules and algorithms rather than conceptual understanding (Cramer et al., 2002; Lortie-Forgues et al., 2015). Consequently, many students learn how to perform fraction operations without fully understanding the underlying concepts.

The continued reliance on traditional teaching approaches may contribute to disparities in mathematics achievement, as such methods often fail to accommodate learners' diverse needs, abilities, and learning styles. This challenge is reflected in the Chief Examiner's Report for the 2019/2020 Basic Education Certificate Examination (BECE) in the Tamale Metropolis, where only 46.4% of students achieved a passing grade, indicating persistent difficulties in mathematics, including fractions.

Although fractions form a foundational component of mathematical learning, their abstract nature and the predominance of teacher-centered instructional approaches often hinder students' conceptual understanding (Cramer et al., 2002; Lortie-Forgues et al., 2015). Furthermore, strict adherence to textbooks and standardized teaching methods may limit teachers' ability to adapt instruction to meet individual learner needs (Cramer et al., 2002). As a result, students who require alternative learning approaches may struggle to develop a meaningful understanding of fractions.

Differentiated instruction offers a potential solution to this problem by enabling teachers to adapt content, instructional strategies, and learning activities to learners' readiness levels, interests, and learning profiles (Tomlinson, 2001; Tomlinson & Imbeau, 2023). However, empirical evidence on the effectiveness of differentiated instruction in improving students' understanding of fractions within the Ghanaian context remains limited. This study therefore sought to determine the effect of differentiated instruction on students' performance in fractions in the Tamale Metropolis of Ghana.

1.2 Research Objective

The objective of this study is to measure the impact of Differentiated Instruction in fractions among Junior High School pupils in the Tamale metropolis of Ghana of Ghana

1.3 Research Question

What is the relationship between teacher's implementation of differentiated teaching strategy and pupils' performance in fractions among Junior High School pupils in Tamale metropolis?

II. LITERATURE REVIEW

2.1 Theoretical Review

There are many learning theories that support differentiated instruction. However, the primary theoretical foundations of differentiated instruction include Vygotsky's Socio-Cultural Theory, (Vygotsky, 1978).

2.1.1 Vygotsky's Socio-cultural theory

Differentiated instruction is grounded in Vygotsky's socio-cultural theory of learning, which views learning as a socially and culturally mediated process shaped by learners' prior experiences and cultural background (Vygotsky, 1978; Eun, 2019). Knowledge is constructed through social interaction and is first developed externally before being internalized by the learner, highlighting the importance of collaboration in cognitive development (Vygotsky, 1978; Clarà, 2017).

Vygotsky conceptualized learning as the appropriation of culturally developed ways of thinking through interaction with others rather than isolated discovery. As a result, learning is inherently mediated by language, tools, and social relationships, and learners must be understood within their sociocultural contexts (Clarà, 2017). Cognitive development begins with reliance on more knowledgeable others and gradually shifts toward independent performance as learners internalize knowledge through social engagement (Silalahi, 2019; Vygotsky, 1978). This process reflects the transformation of socially shared knowledge into individual understanding rather than simple imitation (Clarà, 2017). A central construct of the theory is the Zone of Proximal Development (ZPD), defined as the gap between what a learner can achieve independently and what is possible with guidance from a more knowledgeable other (Vygotsky, 1978). Learning is most effective when instruction targets this zone by providing appropriately challenging tasks supported through guidance (Eun, 2019; Wood et al., 1976). Vygotsky further distinguishes between actual developmental level (independent performance) and potential developmental level (supported performance), emphasizing that instruction should align with learners' readiness to avoid both under-challenge and overextension (Scott & Palincsar, 2013; Eun, 2019).

To maintain learning within the ZPD, teachers are expected to assess learners' developmental levels and provide instruction slightly above their current ability, often through pre-assessment and adaptive instructional planning (Murphy et al., 2015; Wood et al., 1976). This aligns directly with differentiated instruction, which responds to learner variability in readiness. Mediation and scaffolding further explain how learning occurs within the ZPD. Mediation refers to the role of teachers, peers, and instructional tools in guiding learning and structuring cognitive development, while scaffolding involves temporary, adaptive support that is gradually withdrawn as learners gain independence (Wood et al., 1976). Through these processes, learners actively construct and transform knowledge into meaningful understanding (Vygotsky, 1978).

In summary, socio-cultural theory provides the conceptual foundation for differentiated instruction by emphasizing socially mediated learning, developmental readiness, and guided support. The principles of ZPD, mediation, and scaffolding collectively explain how learners develop, while differentiated instruction operationalizes these principles by tailoring teaching strategies to individual learner needs and ensuring instruction is appropriately challenging and developmentally responsive.

2.2 Empirical Review

2.2.1 Impact of Differentiated Instruction on Pupils' Performance in Mathematics

Differentiated Instruction (DI) is grounded in the principle that learners vary in readiness, interest, and learning profiles, necessitating adaptive instructional approaches within inclusive mathematics classrooms. Contemporary scholarship positions DI as a learner-responsive pedagogy that seeks to optimize learning by aligning content, process, and product with individual learner characteristics. Within mathematics education, DI has gained prominence due to persistent heterogeneity in learners' prior knowledge and the abstract nature of core concepts, which often exacerbate achievement disparities and disengagement. A substantial body of evidence suggests that DI enhances student engagement in mathematics by increasing relevance, autonomy, and participation. Studies consistently report that when instruction is adapted to learner needs, students demonstrate higher levels of cognitive and affective engagement (Tomlinson & Imbeau, 2023; Lopez & Schroeder, 2008). The inclusion of multiple instructional pathways—such as collaborative learning, project-based tasks, and learner choice has been shown to increase ownership of learning and intrinsic motivation (Hall et al., 2004). However, while these studies highlight affective gains, they often rely on short-term classroom interventions, limiting generalizability to sustained instructional contexts.

Beyond engagement, DI is widely associated with improved conceptual understanding in mathematics. Evidence indicates that targeted instructional adaptation benefits both low- and high-achieving learners by providing appropriate levels of support and cognitive challenge (Allor et al., 2010; Reis & Renzulli, 2010). From a constructivist perspective, these gains are attributed to instruction that aligns with learner readiness, enabling knowledge restructuring rather than rote acquisition. Vansteenkiste et al. (2012) further argue that when learning tasks are aligned with learners' interests and competencies, deeper cognitive processing is facilitated. Nevertheless, a critical limitation in this body of research is its limited interrogation of conceptual coherence across differentiated pathways, raising concerns about whether individualized learning trajectories may fragment shared disciplinary understanding. The literature also underscores the role of DI in addressing learner diversity through multiple representation modalities, often framed in relation to learning styles (Felder & Silverman, 1988). Visual, auditory, and kinesthetic adaptations have been widely reported to enhance comprehension and engagement in mathematics (Lopez & Schroeder, 2008; Johnson & Johnson, 2015). However, the learning styles paradigm has been increasingly critiqued for limited empirical validity, suggesting that its continued use in DI research may oversimplify complex cognitive processes. A more defensible interpretation is that multimodal instruction enhances learning by reducing cognitive load and increasing representational flexibility rather than matching fixed learner types.

A recurring finding in the literature is that DI contributes positively to learners' self-efficacy, motivation, and growth orientation. Learners exposed to differentiated environments tend to demonstrate higher confidence and persistence, particularly when instruction supports incremental success and autonomy (Boaler, 2002; Hattie & Timperley, 2007). This aligns with motivational theories emphasizing competence, autonomy, and relatedness as key drivers of engagement. However, much of this evidence is correlational, and the causal mechanisms linking DI to motivational outcomes remain under-theorized. Importantly, DI has been shown to reduce achievement gaps by supporting struggling learners through scaffolded instruction while simultaneously extending high achievers (Tomlinson, 2014). Inclusive adaptations, particularly for learners with disabilities, further demonstrate DI's potential to improve access and equity in mathematics education (Friend & Bursuck, 2018). Yet, while equity gains are well documented, fewer studies critically examine whether such gains are sustained over time or whether they translate into long-term mathematical proficiency.

Despite these benefits, a critical strand of literature highlights potential limitations of DI in mathematics instruction. Highly differentiated environments may inadvertently fragment instruction, reducing opportunities for cumulative knowledge building and conceptual coherence (Schmidt et al., 2005). Similarly, concerns have been raised regarding reduced opportunities for sustained practice, which may negatively affect procedural fluency and automaticity (Kilpatrick et al., 2001). This tension reflects a broader pedagogical dilemma between personalization and curriculum coherence: while DI enhances responsiveness to learner diversity, it may compromise systematic progression if not carefully structured. Synthesis of the literature suggests that DI is most effective when it balances adaptive instruction with coherent curricular sequencing and structured practice. Its effectiveness appears to depend not only on pedagogical design but also on teacher expertise, instructional resources, and institutional support systems. Without these conditions, DI risks becoming fragmented or overly burdensome for teachers, thus limiting its scalability.

In summary, the literature indicates that DI contributes positively to engagement, conceptual understanding, motivation, and equity in mathematics education. However, these benefits are accompanied by unresolved tensions related to conceptual coherence, fluency development, and implementation feasibility. This suggests that DI should not be viewed as a standalone instructional solution but rather as a complex pedagogical framework whose effectiveness is contingent upon careful integration with curriculum structure, teacher capacity, and systemic support

III. METHODOLOGY

3.1 Research Design

The researcher employed quasi-experimental design of non-equivalent groups as the design for this study. This is Design-Based Research. Design-Based Research (DBR) is a design-based research methodology that involves developing an instrument or treatment to enhance and deepen the understanding of learning (Kennedy-Clark, 2013). Design-Based Research utilizes the term "treatment" to refer to an activity or process that may be a viable solution to meet a specific identified need. A quasi-experiment is an empirical study that is used to assess the causal impact of an intervention on the target population (Vanderstoep & Johnson, 2009).

3.2 Target Population

The target population for this study comprises all basic school pupils within public schools in the Tamale Metropolis of Ghana. This includes learners at the primary and junior high school (JHS) levels who are exposed to mathematics instruction. The population is relevant because it reflects the group directly affected by differentiated instruction (DI) strategies, allowing the study to assess how DI influences diverse learners' academic performance, participation, and inclusivity within the classroom.

3.3Sampling and Sample size

The study was conducted in Tiyumba and Zosimli Junior High Schools in the Tamale metropolis in the northern region of Ghana. Simple random sampling was employed to select one intact class from both schools and randomly assign them to control and experimental groups with a total sample size of 102 students from both schools, which comprised 52 students from School A and 50 students from School B. According to Creswell and Creswell (2018), when you select groups of individuals that have the same background, i.e., the same district or education system, you can minimize the effects of external variables and maximize the internal validity of your study.

Table 1

The Number of Pupils in the Experimental and Control Groups

Groups	Male	Female	Total
Control – Class "A"	25	27	52
Experimental– Class "B"	21	29	50
Total	**46**	**56**	**102**

3.4 Validity and Reliability

The test instrument used to collect data for this study was made up of ten (10) items carefully drafted from the JHS three curriculum to ensure reliability. The test items were also submitted to a mathematics lecturer at the University for Development studies for expert judgement. The items were also piloted in two nearby schools in the Sagnarigu municipality. Twenty (20) pupils along with their respective mathematics teacher from two (2) different schools were selected to participate in the pilot study. The pupils were divided equally between the experimental group and the control group to support the piloting. The two schools selected for the pilot study contained features like the school selected for the study. The piloting lasted for one (1) week. The pilot study was designed to assess the content validity and reliability of the test items. After the pilot study, the reliability of the test items was assessed using Cronbach Alpha Coefficient. A Cronbach Alpha Coefficient of .70 or higher is a reliable coefficient and indicate the test items and questionnaires are reliable (Field, 2009). The reliability of the achievement test items (pretest-post-test) and the questionnaires were 0.76, 0.78, and 0.80 respectively. Each of the values were higher than 0.70; therefore, each of the test items and questionnaires were determined to be reliable.

Since the researcher was responsible for instructing both groups, a separate independent observer monitored the fidelity of the experimental group's instructional process to reduce bias and promote objectivity in assessing the treatment's effectiveness. The independent observer, a trainee teacher who was not involved in either the instructional processes for the control or experimental groups, received training on the use of the fidelity checklist prior to conducting the data collection (Carroll et al., 2007).

Fidelity of implementation was measured by assigning each checklist item a score: Yes = 1, No = 0. The total yes score was then divided by the total number of applicable items and multiplied by 100% to generate a percentage as recommended by Carroll et al. (2007).

3.5 Data collection Procedure

Using a combination of instructions for both groups, the treatment and traditional instructional lessons were conducted over a period of eight (8) weeks (Creswell, 2018). Consequently, the control group was instructed by the researcher utilizing a traditional teaching methodology while the experimental group was instructed by the researcher agian utilizing a differentiated instruction methodology that is considered the treatment. To ensure the fidelity of the treatment and to minimize the possibility of cross-contamination of the treatment (Shadish et al., 2002).

3.6 Description of treatment

In implementing the treatment for the experimental group, the researcher incorporated a structured set of differentiated instructional techniques tailored to address the diverse readiness levels, learning profiles, and interests of pupils. These techniques were applied consistently throughout the eight-week intervention period to ensure fidelity to differentiated instruction principles. The following approaches were used:

3.6.1 Ability-Based Flexible Grouping

Pupils in the experimental group were organized into small, flexible groups based on their pre-test results, classroom observations, and ongoing formative assessments. Groupings were not fixed; pupils moved between groups depending on their progress and demonstrated understanding. Support groups received additional scaffolding and direct modeling on foundational fraction concepts. Intermediate groups engaged in guided practice, peer explanation, and teacher-led questioning. Advanced groups worked on extension tasks involving complex fraction operations and real-life applications. This approach enabled the teacher to offer intensified support to struggling learners while providing adequate challenges for higher-achieving pupils, aligning with the differentiation principles noted in the literature

3.6.2 Use of Visual and Concrete Manipulatives

To make abstract fraction concepts more accessible, the researcher integrated manipulatives such as fraction tiles, number lines, paper strips, and diagrammatic models. These tools were used during demonstrations, group work, and independent practice. Visual supports helped learners who benefitted from concrete representations, consistent with evidence that visual tools enhance conceptual understanding in fraction learning

3.6.3 Tiered Assignments

Learning tasks were designed at varying levels of complexity to match pupils’ differing readiness levels. Tier 1 tasks emphasized foundational skills such as identifying fractions and visualizing part–whole relationships.Tier 2 tasks required application of skills to solve addition and subtraction of like fractions. Tier 3 tasks extended learning by combining unlike fractions and applying fraction concepts to word problems and real-life scenarios. All pupils worked toward the same learning objectives, but the pathway and level of support differed.

3.6.4 Scaffolded Instruction

Instruction for the experimental group progressed through structured scaffolds including guided steps, think-aloud strategies, worked examples, and gradual release Struggling learners received additional prompts, simplified tasks, and structured worksheets, while advanced learners engaged in independent or collaborative problem-solving tasks. This scaffolded progression supported pupils within their Zone of Proximal Development, a principle underpinning DI and aligned with Vygotsky’s learning theory discussed earlier.

3.6.5 Varied Modes of Representation and Explanation

Lessons were delivered using multiple instructional formats, verbal explanations, diagrams, physical manipulatives, storytelling, and real-life fraction examples. This multimodal approach accommodated a wide range of learning profiles and preferences, ensuring that pupils accessed concepts through pathways that aligned with their strengths.

3.6.6 Continuous Formative Assessment

Throughout the intervention, quick checks for understanding such as exit tickets, mini-quizzes, oral questioning, and observation checklists were used to monitor progress. The results guided the regrouping of pupils, the level of scaffolding required, and the adjustment of tiered tasks to ensure that instruction remained responsive to learners' evolving needs.

3.6.7 Individualized Feedback and Support

Pupils received personalized feedback during classwork and small-group sessions. The feedback focused on clarifying misconceptions, strengthening reasoning steps, and reinforcing correct procedures.Learners who needed additional support were given brief, targeted reteaching sessions, while advanced learners received enrichment questions to deepen conceptual understanding

IV. FINDINGS & DISCUSSION

4.1 Findings

4.1.1 Level of pupils' performance in fractions

Table 2

Tests of Normality

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Control group score	0.926	50	0.104
Experimental group score	0.910	50	0.163

The assumption of normality was examined using the Shapiro-Wilk test for both the control and experimental group scores. The results in Table 2 indicates the distribution of scores for each group did not significantly deviate from normality. Specifically, the control group scores yielded a Shapiro-Wilk statistic of $W = 0.926$, $p = .104$, and the experimental group scores yielded $W = 0.910$, $p = .163$. Since both p-values were greater than .05, the assumption of normality was satisfied for both groups.

Table 3

Two-sample T-Test of control group and experimental group pre-test level

								95% CI for		
Pretest assessment	**Mean**	**St.D**	**SE**	**Mean Dif.**	**t**	**df**	***P***	**LB**	**UB**	**Hypothesis**
Control group score	8.92	6.31	0.89	0.54	0.39	95	0.695	-2.18	3.26	null accepted
Experimental group score	8.38	7.37	1.00							

$P < 0.05^*$, $P < 0.001^{**}$

From Table 3, a paired-samples t-test was conducted to compare the pre-test assessment scores between the control group and the experimental group. The control group had a mean score of (M=8.92, SD =6.31), while the experimental group had a mean score of (M=8.38, SD=7.37). The results indicated no significant difference between the two groups [(t (95) =0.39, *p*=0.695, 95% CI= (-2.18, 3.26)]. Since the p-value exceeded 0.05, the null hypothesis failed to reject, suggesting that the pre-test scores for the control and experimental groups were not significantly different.

Table 4

Impact of the use of differentiated instruction on pupils' performance in fractions at the post-test stage Tests of Normality

	Shapiro-Wilk		
	Statistic	**Df**	**Sig.**
Control group score	0.971	50	0.266
Experimental group score	0.955	50	0.055

The Shapiro-Wilk test was conducted to assess the normality of score distributions for both the control and experimental groups. The control group scores were normally distributed, W(50) = 0.971, *p* = .266, as the p-value exceeded the .05 threshold. The experimental group scores showed a borderline result, W(50) = 0.955, *p* = .055, which is slightly above the conventional cutoff for significance. Therefore, the assumption of normality was reasonably met for both groups, allowing for the use of parametric tests in subsequent analyses.

Table 5

Two-sample T-Test of control group and experimental group post-test assessment

								95% CI for		
Post-test assessment	**Mean**	**St.D**	**SE**	**Mean Dif.**	**t**	**df**	***P***	**LB**	**UB**	**Hypothesis**
Control group score	9.52	4.99	0.71	-11.8	-10.43	93	0.001	-14.05	-9.55	null rejected
Experimental group score	21.32	6.26	0.88							

P < 0.05, P < 0.001***

From Table 5, a paired-samples t-test was conducted to compare the post-test assessment scores between the control group and the experimental group. The control group had a mean score of (M=9.52, SD=4.99), while the experimental group had a significantly higher mean score of (M=21.32, SD=6.26). The results showed a statistically significant difference between the groups, [t (93) =−10.43, *p* =0.001, 95% CI= (−14.05, −9.55)]. Since the p-value was less than 0.05, the null hypothesis was rejected, indicating that the experimental group outperformed the control group in the post-test assessment, suggesting that the intervention implemented in the experimental group had a significant and positive impact on their performance compared to the control group.

4.2 Discussion

4.2.1 Impact of the use of Differentiated Instruction on pupils' performance in Fractions

This study indicates a substantial difference between the experimental and control groups' test results, providing strong evidence for the effectiveness of Differentiated Instruction (DI) in improving students' achievement in fractions. The findings show that DI has significant potential as an instructional approach for addressing the diverse learning needs of students, particularly in a topic widely regarded as difficult due to its abstract nature and requirement for conceptual understanding. The results are consistent with previous research indicating the positive effects of DI on learners' engagement, understanding, and achievement (Suprayogi et al., 2017; Tomlinson & Imbeau, 2023). Both learners and teachers reported that prior to the intervention, fractions were challenging to teach and learn. Pre-test results further showed that the experimental and control groups did not differ significantly, suggesting comparable levels of difficulty in understanding fractions. This aligns with evidence that fractions are among the most difficult mathematical concepts for learners due to their abstract nature and demand for conceptual reasoning (Siegler et al., 2012). Learner comments such as "Fractions were always confusing to me" reflect the frustration and anxiety often associated with this topic, which can negatively affect both achievement and attitudes toward mathematics.

Post-test results indicated that learners in the experimental group demonstrated significantly better understanding of fractions than those in the control group. The experimental group achieved higher mean scores (M = 21.32) compared to the control group (M = 9.52). These findings support previous research showing that DI positively influences student performance, particularly in mathematics (Heacox, 2021). The main components of DI implemented in this study included ability-based grouping, visual aids, and customized tasks. Ability grouping enabled teachers to provide additional support to learners struggling with foundational concepts while offering enrichment to more advanced learners. Prior research highlights the importance of individualized instruction and scaffolding in promoting conceptual understanding (Vygotsky, 1978).

Visual aids such as fraction tiles and diagrams helped learners visualize abstract fraction concepts, making them more concrete and accessible. This is consistent with research demonstrating the effectiveness of manipulatives and visual representations in enhancing mathematical understanding (Moyer et al., 2002). Learner feedback, such as "Fraction tiles and diagrams helped me to visualize concepts," indicates that these tools improved comprehension. Similarly, comments such as "My new teacher started doing different things for different groups and I finally realized how to add and subtract fractions" show that DI not only facilitated understanding but also enhanced learners' confidence and motivation in learning fractions.

Although the study produced positive outcomes, it also identified several challenges in implementing DI. Major barriers included limited instructional resources, time constraints, and classroom management difficulties. These findings are consistent with previous research on the practical challenges of implementing DI in classroom settings (Santangelo & Tomlinson, 2009). The qualitative data further revealed that DI is time-consuming and difficult to sustain throughout a full school day. In addition, the lack of instructional resources such as digital tools and manipulatives was identified as a significant constraint. These findings highlight the need for systemic support to enable effective implementation of DI.

Professional development and collaborative planning were found to support the implementation of DI. Collaborative planning helped reduce teacher workload and improved communication among educators. This aligns with research emphasizing the importance of Professional Learning Communities in supporting innovative instructional practices (Darling-Hammond et al., 2007). Through collaboration and continuous professional growth, teachers can enhance instructional strategies and better address diverse learner needs.

The findings also have important implications for instructional practice. They suggest a need to move away from one-size-fits-all approaches toward more flexible, learner-centered instructional strategies. Such approaches should include opportunities for collaborative planning, ongoing professional development, and improved access to instructional resources. The results of this study also align with Vygotsky's socio-cultural theory, particularly the concepts of social interaction, scaffolding, and the Zone of Proximal Development (ZPD). Through DI strategies such as ability grouping and individualized tasks, teachers were able to provide appropriate scaffolding to support learners within their ZPD. As Vygotsky (1978) emphasized, learning is enhanced through interaction with more knowledgeable others; accordingly, DI enabled teachers to challenge high-achieving learners while providing additional support to lower-achieving learners. Furthermore, collaborative planning and professional development reflect Vygotsky's view that learning is socially mediated and strengthened through shared knowledge (Darling-Hammond et al., 2007).

Finally, the findings are consistent with Gardner's Multiple Intelligences theory (Gardner, 2011), which emphasizes the existence of diverse cognitive strengths among learners. The use of visual tools such as fraction tiles and diagrams, along with real-world examples, reflects recognition of spatial, logical-mathematical, and interpersonal intelligences. Collaborative activities demonstrated interpersonal intelligence, while visual tools supported spatial reasoning in understanding fractions. However, the findings also suggest that some teachers may require further training to effectively integrate multiple intelligences into classroom practice.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The study concludes that differentiated instruction enhances students' comprehension of fractions by promoting deeper conceptual learning. This improvement in understanding contributes to stronger content mastery and ultimately better performance in mathematics. The findings underscore the value of adopting differentiated instructional strategies in mathematics classrooms to support diverse learners and improve learning outcomes..

5.2 Recommendations

The study recommends the adoption of differentiated instructional strategies in mathematics classrooms, particularly when teaching complex topics such as fractions. Furthermore, educational stakeholders should ensure the provision of adequate instructional resources, including manipulatives, visual representations, and digital learning tools, to support the effective implementation of differentiated instruction and promote meaningful mathematics learning. In addition, teachers should incorporate collaborative learning strategies that encourage peer explanation and discussion of mathematical concepts, enabling learners to benefit from shared understanding and collective problem-solving.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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