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Research Article

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Learning to add fractions the Ghanaian way: The impact of 'kyempe' game on learners' academic performance

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ABSTRACT

Teaching and learning fractions in school mathematics pose significant challenges for both learners and teachers. However, little is known about how sociocultural games can be utilized to boost learners' academic performance. In this context, this study investigated the effect of using the Ghanaian indigenous game of 'kyempe' to enhance the academic performance in fraction addition among basic six learners in the Effutu Municipality. The study employed a one-group pre-/post-test quasi-experimental design. A total of 80 learners were selected through purposive sampling. Data were collected using an adapted fraction test and analyzed using frequencies, percentages, and paired-samples t-tests. The findings indicated that the initial academic performance of the basic six learners in adding fractions was low (N=65%). However, after the intervention, the academic performance of learners improved from low to moderate (N=47.5%) and high (N=42.5%). A statistically significant difference was observed between their pre- and post-test results ($t[79] = -9.45$, $p < .001$). This difference, attributed to the game, resulted in a very large effect size ($d = 1.06$). Based on these findings, it was concluded that the intervention significantly enhanced learners' ability to add fractions. Consequently, teachers in the Effutu Municipality should consider integrating the game into their fractions lessons. Future research should explore its application to other areas of mathematics where learners often struggle, such as subtraction or multiplication of fractions.

Keywords: addition of fractions, Effutu, kyempe, quasi-experiment, sociocultural game

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INTRODUCTION

Fractions play a crucial role in mathematics education and are included in the curricula of many countries worldwide (Flores et al., 2020). In Ghana, the primary school mathematics curriculum places strong emphasis on the teaching and learning of fractions. According to Ministry of Education (2020), fractions are one of the three key sub-strands, alongside *counting*, *representation and cardinality*, and *number operations*, under the broader strand called "*number*." This strand is taught from grade 1 through grade 6, reflecting the importance of building a strong foundation in fraction concepts from the early years. Fractions are not only important on their own, but they also serve as a building block for more advanced mathematical topics, including algebra, ratios, proportions, decimals, and percentages (Makhubele, 2021). This suggests that a good knowledge of fractions seem prerequisite for proficiency in other mathematics content areas. This may have informed the decision of the Ghanaian mathematics curriculum developers to introduce fractions as early as grade 1, with the hope that learners would gradually build competence and confidence as they progress through school.

Despite its early introduction and importance, empirical studies show that it remains one of the most challenging topics for both students and teachers. For instance, Ricks (2019) and Deringöl (2019) found that fractions remain among the hardest topics for students to master, with many struggling to grasp the fundamental concepts. Goswami (2018) observed that the difficulty increases when learners are asked to add fractions with different denominators, a concept that many primary school pupils find confusing and frustrating. In the Ghanaian context, this issue has been confirmed by various national assessment reports. Chief Examiner's Report (2016, 2018, 2019) on the basic education certificate examination (BECE) consistently identified weaknesses among candidates in answering questions related to fractions, indicating a nationwide struggle with

this topic (Amuah, 2020). Chief Examiner's Report (2016) highlighted difficulties in converting mixed numbers into improper fractions and simplifying them. The main challenge was solving word problems involving adding and subtracting fractions in 2018 (Chief Examiner's Report, 2018). Chief Examiner's Report (2019) revealed that many learners were unable to correctly simplify fractions, resulting in flawed answers.

Additionally, a study by Amuah et al. (2019) revealed that while many junior high school (JHS) students in Ghana understand the part-whole representation of fractions, they often struggle with more complex concepts such as fraction equivalence, which is essential for performing operations like addition and subtraction. These gaps in understanding hinder learners from effectively applying their knowledge of fractions when solving real mathematical problems. Moreover, Mills and Mireku (2016) conducted a study in the Effutu Municipality and found that JHS 2 learners faced significant difficulties in meeting the national minimum standards in mathematics. Their findings specifically pointed to challenges with understanding fractions and performing operations involving fractions as primary reasons for the learners' poor performance. The study highlighted that, among all areas of mathematics, fractions were a key area of difficulty. Similarly, studies (Baidoo & Ali, 2023; Baidoo & Bondzie, 2024; Baidoo et al., 2025) found that learners in Effutu demonstrated flawed reasoning and frequent computational errors when solving algebraic word problems involving fractions. Likewise, Baidoo et al. (2025) reported widespread struggles with fractions, including issues such as spelling pluralized fraction names and ensuring equal object partitioning among learners in pilot inclusive settings in Effutu. Taken together, these findings imply that, although fractions are crucial for students' success, they remain challenging for many students in Effutu.

It is therefore important for teachers to find innovative and engaging ways to help learners understand the concept more deeply. In this regard, Davis (2016) argued that although fractions may be challenging to teach, they are deeply rooted in Ghanaian culture, supporting the assertion by Babbitt et al. (2015) that Ghana, despite economic challenges, is culturally rich. Wulandari and Amir (2022) suggested that children unconsciously learn about fractions through activities such as sharing, sewing, farming, and trading, which are common in their daily lives. Okyere (2021) added that even in the design of fabrics and cultural Adinkra symbols of Ghana, fractions are applied and embedded. The recent 2020 education reform policy in Ghana takes a further step by explicitly highlighting the inclusion of indigenous knowledge and artefacts, including games, in the teaching and learning of mathematics, with the aim of making mathematics more meaningful and relevant to learners.

'Kyempe' is a cultural game that has not yet been fully utilized. The name 'kyempe' originates from two Akan words: 'kyem' or 'kyemu', meaning "to divide," and 'pe', meaning "equally." Together, it signifies "to divide what you have equally." The main rule of the game is that players must split items into equal parts (Boateng, 2015; HisExcellency, 2021). Owusu and Obuo-Addo (2023) explained that 'kyempe' is typically played by children aged between 10 and 15. It is played by both boys and girls (Boateng, 2015). Unlike other games, 'kyempe' can last for a long time, sometimes continuing for days, weeks, or even months. To start the game, players link their index fingers together. After this, each player must remain alert. If one player has food or something else and another player approaches, the owner must quickly shout 'no kyempe' loudly enough for all to hear. This shout indicates the owner does not want to share at that moment and is adhering to the rules of the game. However, if the owner forgets or does not say 'no kyempe' in time, and another player says 'kyempe,' the owner must share what they have. The items must be divided equally among the players who called out 'kyempe.'

However, the game of 'kyempe' remains largely unexplored in teaching fractions within real classroom settings. While learners' difficulties with fractions have been addressed through interventions such as multiple representation (Mahama & Kyeremeh, 2023), the butterfly method (Laidin & Tengah, 2021), paper folding manipulatives (Mensah & Yankson, 2020), Cuisenaire rods (Togah, 2020), and computer games (Japar et al., 2022), the use of the game of 'kyempe' appears absent from available literature. The suggestion to use 'kyempe' to support learning of fractions, specifically the addition of like fractions in the Ghanaian context, was made by Owusu and Obuo-Addo (2023), but no empirical study has been conducted to verify its applicability and effect.

Furthermore, Owusu and Obuo-Addo (2023) recommended its use only for teaching the concept of adding like fractions. These points raise important questions about the wider applicability of the game in teaching other fraction concepts, including unlike and mixed fractions. To address these concerns, this study employed the game of 'kyempe' as an instructional tool to improve the academic performance in fractions among the basic six learners in Effutu. The game was used to facilitate lessons in addition to like, unlike, and mixed fractions in a real classroom setting.

To this end, the study sought to answer the following research questions:

1. What is the level of academic performance of basic six learners in the addition of fractions before the intervention?
2. What is the level of academic performance of basic six learners in the addition of fractions after the intervention?
3. What difference, if any, exists in the academic performance of basic six learners in addition of fractions before and after the intervention?

LITERATURE REVIEW

This study adopted Lev Vygotsky's (1934/1987) socio-cultural learning theory to explain the role of social interactions, cultural tools, and collaborative learning in the cognitive development of learners. The theory posits learning as a socially mediated process where interactions with peers, teachers, and cultural artefacts shape an individual's understanding and knowledge. Key tenets of this theory are the concepts of the zone of proximal development (ZPD), more knowledgeable other (MKO), and scaffolding. In this study, the game was used as a cultural tool to foster interaction and collaboration, enabling learners to actively engage in learning fractions. Similarly, MKO was the teacher who utilized the game as a cultural tool to provide support as form of scaffolding to learners in achieving higher levels of understanding of addition of fractions and in bridging their zones of proximal development.

Indigenous or cultural games are described as contests or playful activities shared by community members over several generations (Nabie, 2015, p. 219). This definition aligns with Obeng et al. (2022), who assert that these indigenous games have been passed down through generations since ancient times, reflecting the continuity of cultural practices. According to Nadziroh et al. (2019), these games have their roots in the cultural processes of our ancestors and are rich in local wisdom values. The use of cultural games has proven effective in various studies. Akayuure and Ali (2016), in a teaching experiment, used the Bukre game to teach mathematics among the JHS 2 learners at Vea Junior School in the Bongo District of the Upper East Region of Ghana. The study demonstrated how the indigenous game called Bukre can be used to reinforce the understanding of the probability concept in mathematics among learners. Ali and Tangkur (2023) have described how the game Gollaa can be used to teach various mathematical concepts including numbers and numerals, fractions, shapes and space, lengths and area, angles, probability, and vectors. Owusu and Obuo-Addo (2023) have demonstrated how playing Oware can enhance a child's cultural numeration system, as the game involves counting seeds on a board with rows of holes, providing a fun way to learn counting in their own language. Hence, this study investigates the effect of using the 'kyempe' game in improving students' academic performance in the addition of fractions among basic six learners in Effutu.

METHODS AND MATERIALS

Figure 1 illustrates the flow chart of the research design employed in the study. This research adopted a one-group pre-test post-test design. According to Creswell and Clark (2017), this design is a type of quasi-experimental method used to assess the effect of an intervention on a single group. Creswell and Creswell (2017) explained that this design involves collecting baseline data through a pre-test, administering an intervention, and subsequently conducting a post-test to identify any changes. In this study, the group initially completed a pre-test. After three weeks of intervention, the same group took a post-test. The aim was to determine whether using the 'kyempe' game would improve performance. The group consisted of an intact class of 80 learners, selected through purposive sampling. This particular school was chosen because a general pre-test administered to basic six learners across several schools in the area indicated that this school faced the most challenges. Specifically, the learners in this school scored an average of 6.64 out of 22, highlighting the need for intervention to enhance their performance. Basic six learners were also selected because this is the level where unlike and mixed fractions are introduced. It is a crucial stage in equipping learners with the foundation necessary to understand more advanced fraction concepts in JHS. Supporting learners at this stage is essential for their future success in mathematics.

Figure 1. Flow chart of quasi-experimental single group pre-/post-test design (the authors' own creation)

The intervention took place over a period of four weeks. The first week involved conducting a pre-test to assess learners' prior knowledge of fractions. The remaining three weeks were dedicated to implementing lesson activities that involved the game. The lessons concentrated on adding fractions: like, unlike, and mixed. Each session targeted a specific aspect of fractions. During the second week, lessons focused on adding fractions. The teacher asked learners to identify given fractions based on shaded portions shown on the board. Learners then wrote their symbolic forms on the board, using different colors for the denominators. Subsequently, a similar activity was repeated using fractions created by the learners, followed by class discussions of their responses. The teacher grouped the fractions based on having identical denominators and introduced them as 'like fractions'. In the game of 'kyempe', this concept was related to sharing objects among the same number of players. Learners used the game to add two fractions. For example, Adam had two other players in his group, and Fati also had two. Adam divided a cup of gari into three equal parts, and Fati did the same. Afterwards, the class named the shares and found the sum by viewing fractions as a family. For instance, 3/5 + 1/5 was explained as adding one member of the fifth's family to three members of the same family, making four.

During the third week, learners were introduced to the addition of unlike fractions using the game of 'kyempe'. To start the lesson, the teacher presented fractions with different denominators on the board for learners to add:

(a) 2/3 + 3/5 and

(b) 2/5 + 3/10.

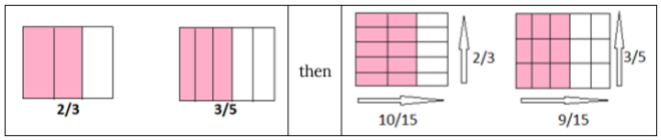

Figure 2. Sharing objects (the authors' own creation)

Next, the teacher cautioned learners against solving the task using the procedure for like fractions. The teacher explained that fractions with different denominators are called 'unlike fractions', meaning they belong to different fraction families and therefore cannot be treated the same way as fractions. To add such fractions, the teacher introduced the game of 'kyempe'. Two learners were called to the front of the class to share objects among their respective players, one with 1 player, the other with 2 players. To add their respective shares, ½ and 1/3, the teacher asked learners to think-pair-share what could be done to make the two shares equal, as the game of 'kyempe' demands. Responses were invited and illustrated on the board. Then, the teacher demonstrated this by dividing the share of each player in the first team by the number of players in the second team, and vice versa. To make this more visual, the teacher used A4 sheets. For example, for 2/3 + 3/5, two learners were called forward to share a sheet of paper by folding it into equal parts. The class shouted 'kyempe' as each learner folded and shaded their shares: one folded the sheet into three parts and shaded two; the other folded his into five parts and shaded three. To make the divisions on each sheet look the same, the class shouted 'kyempe' again. This time, the first learner divided his sheet by the total number of players in the second learner's team. The class shouted once more, and the second learner divided his sheet by the number of players in the first learner's team. By doing this, they ensured that the same number of players shared each of the objects, as shown in **Figure 2**.

The last week was used to implement lesson activities in the addition of mixed fractions, as outlined below. To begin the lesson, the teacher guided learners to sing "Yaaba yebedi agoro", meaning "We are here to play," as they used the "Do the dance" walk to move in circles around the classroom. The teacher then asked the learners, "What is the agoro (game) here?" and they chorused, "Kyempe!" Next, the teacher introduced mixed fractions as fractions that include both whole objects and fractional parts. In the context of the game, this referred to a player having both 'kyempe' shares and 'no kyempe' shares, meaning a combination of divided and whole portions. The teacher explained that this was like having both whole items and shared parts. To help ease learners understand, the teacher guided them to add whole objects along with 'kyempe' shares from two different, but equally sized, groups of players. The teacher then wrote the following examples on the board:

(a) $2\frac{1}{3} + 1\frac{1}{3}$

(b) $7\frac{1}{2} - 3\frac{1}{2}$

(c) $3\frac{3}{4} + 2\frac{1}{4}$.

In solving this, the teacher asked learners to first group the fractions into whole shares and 'kyempe' shares and then add them. For example:

$8\frac{3}{4} + 4\frac{1}{4}$ = (8+4) whole = 12 wholes and $(\frac{3}{4} + \frac{1}{4})$ =

Interpreted as 3 members of the fourth family added to another 1 member of the fourth family to give 4 members of the fourth family, making the whole family:

$(3[\frac{1}{4}] + 1[\frac{1}{4}]) = (3 + 1[\frac{1}{4}]) = 4(\frac{1}{4}) = (\frac{4}{4})$ = 1 whole.

Therefore, 12 wholes + 1 whole = 13 wholes = 13.

Lastly, the teacher invited learners to come forward and show their solutions using oranges and sheets of A4 paper. Oranges were used when the number of players involved in the game was even, as they could be easily divided into equal parts without much difficulty. However, when the number of players was odd, sheets of A4 paper were used instead. This was because dividing an orange into equal parts for an odd number of players (such as 3 or 5) would be difficult and inaccurate, while paper could be folded precisely to ensure equal divisions. This approach helped learners visually understand the importance of equal sharing in fractions, using appropriate materials for accurate representation.

Several steps were taken during the implementation of the lesson activities to mitigate threats to internal validity. Measures such as the use of equivalent test forms were employed to address instrumentation and testing effects. To further reduce the threat of repeated testing and practice effects, the test items were neither discussed nor shared with the learners before or after testing. Additionally, interesting and engaging intervention activities were implemented to reduce the threat of mortality. Short intervention activities were also used to minimize the effects of maturation. Potential confounding variables, such as prior knowledge, informal practice outside of class, and classroom environment, were carefully considered and controlled as much as possible through consistent lesson delivery. Lastly, existing classroom teachers were utilized to avoid experimenter bias. These teachers were responsible for delivering the lessons using the 'kyempe' game approach, following the lesson plans prepared by the researchers and the daily coaching given by the researchers. Their role was to ensure that the intervention was carried out in a natural classroom setting, just as they would normally teach, but incorporating the specified activities. During the process, the researchers observed the lessons, provided guidance when necessary, and ensured consistent implementation across all sessions. This helped maintain objectivity and allowed the results to reflect the intervention's actual impact, free from external influence from the researchers.

The test instrument used in this study was a teacher-made fraction-addition test. Sample items are included as **Appendix A** and **Appendix B**. The test consisted of 7 items, with a total of 22 marks, and was administered within 20 minutes. Item (a) to item (c) were worth 2 marks each. Item

Table 1. Distribution of pre-test scores

Range of scores	Description	Frequency	Percentage (%)
0-7	Low	52	65.0
8-15	Moderate	21	26.3
16-22	High	7	8.7
Total		**80**	**100**

Table 2. Distribution of post-test scores

Range of scores	Description	Frequency	Percentage (%)
0-7	Low	8	10.0
8-15	Moderate	38	47.5
16-22	High	34	42.5
Total		**80**	**100**

(d) to item (g) were allocated 4 marks each, as they were presented as word problems and scores depended on pupils' ability to translate them into mathematical form before solving. The items were developed based on the approved National Council for Curriculum and Assessment 2019 Mathematics Curriculum, Ministry of Education (2020) endorse curriculum and other mathematics textbooks. The instrument was reviewed by the researcher's supervisor, a senior mathematics lecturer at the University of Education, Winneba, and an in-service mathematics teacher at a basic school, to ensure that the items were appropriate for the learners' level and aligned with the content taught at that level. In developing the items, four were adapted from the study by Mahama and Kyeremeh (2023), while the remaining three were adopted from Norga (2004), which has an established reliability coefficient of 0. 87. A pilot test was conducted with 20 basic six learners in a different circuit within the Effutu Municipality. Using a different circuit aims to create a contact gap and prevent cross- contamination, as learners in the pilot might share details of the intervention or test items with those in the main study. The researcher provided learners with two equivalent forms of the test, one after the other. Each learner's scores on both tests were compared. The scores were analyzed for alternative forms reliability, yielding a coefficient of 0. 0.877. This indicated that the test was highly reliable, as Mertens et al. (2017) stated. It meant the instrument could be trusted to collect dependable data. An analytic scoring rubric was used, awarding one mark for each major step in the solution. The total score for each test was out of twenty- two. The scores were entered into SPSS version 25 and analyzed using frequencies, percentages, and a paired-samples t-test.

RESULTS

Research Question One: What Is the Level of Academic Performance of Basic Six Learners in Addition to Fractions Before the Intervention?

This research question determined the baseline academic performance in the addition of fractions among the basic six learners. A judging criterion, based on the division of 100% mark into three ranges of marks, was adopted to designate performance levels as: low (0-33), moderate (34-66) and high performance (67-100). The scores were analyzed using frequency and percentages as found in **Table 1**.

The data in **Table 1** indicates that the majority of the learners, 52 (65.0%), obtained scores within the low range (0-7), 21 learners (26.3%) achieved scores within the moderate range (8-15) while only 7 learners (8.7%) achieved high scores (16-22). Thus, the pre-intervention scores show a large percentage (65%) of the learners were in the low-performance category. This finding suggests that the majority of the basic six learners used in the study had difficulties with addition of fraction prior to the implementation of the intervention.

Table 3. Descriptive Statistics for pre-post performance

	N	M	SD
Pre-test scores	80	6.64	4.72
Post-test scores	80	13.41	4.59

Research Question Two: What Is the Level of Academic Performance of Basic Six Learners in the Addition of Fractions After the Intervention?

The second research question sought to ascertain the level of academic performance in addition of fractions among the basic six learners after being taught using the game of 'kyempe'. The scores were marked out of 22 and a judging criterion, based on the division of 100% mark into three ranges of marks, was adopted to designate performance levels as: low (0-33), moderate (34-66) and high performance (67-100). The results are presented using frequency and percentages in **Table 2**.

The results in **Table 2** show that only 8 learners (10.0%) obtained scores in the low range (0-7), 38 learners (47.5%) achieved moderate scores (8-15), and notably, 34 learners (42.5%) obtained scores in the high range (16-22). This indicates a significant improvement in learners' performance after the intervention, with a larger proportion achieving moderate and high scores. This further suggests that the use of the 'kyempe' game was effective in improving learners' performance in the addition of fractions, shifting from an initially high percentage of low scores to a final high percentage of moderate and high scores.

Research Question Three: What Difference, if Any, Exists in the Academic Performance of Basic Six Learners in Addition of Fractions Before and After the Intervention?

In this research question, the aim was to determine whether there is a significant difference in the academic performance of basic six learners in the addition of fractions before and after the intervention. A paired sample t-test was conducted to find the difference in the pre-post performance of the learners. The descriptive statistics of the test are shown in **Table 3**.

The result in **Table 3** shows that the mean (M) post-test scores (M = 13.41, standard deviation [SD] = 4.59) were higher than the mean pre-test scores (M = 6.64, SD = 4.72)

Table 4. Test of difference in performance before and after the intervention (paired samples test)

	Paired differences					t	df	Sig. (2-tailed)
	M	SD	Standard error mean	95% CI of the difference				
				Lower	Upper			
Pre- and post-test scores for addition	-6.775	6.416	.717	-8.203	-5.347	-9.445	79	.000

Table 5. Test of effect size on performance before and after the intervention

Effect sizes	Standardizer[a]	Point estimate	95% CI	
			Lower	Upper
Cohen's *d*	6.416	1.056	0.780	1.328
Hedges' correction	6.447	1.051	0.776	1.321

in terms of the addition of fractions. This suggests that, based on the means, the learners had improved performance when they were taught the addition of fractions using the game of 'kyempe'.

To determine whether the observed mean difference was statistically significant or not, paired samples t-test results were used to ascertain this. The paired samples t-test results are presented in **Table 4**.

The results of the paired-samples t-test in **Table 4** show a statistically significant difference in performance between the pre- and post-test, $t(79) = -9.45$, $p < .001$. Thus, the critical P-value obtained (.000, 2-tailed) is less than the alpha level of .05, indicating that the difference in mean scores between the pre- and post-test was statistically significant. The mean difference between the pre- and post-test scores was -6.775, indicating that the performance in the pre-post scores improved by an average of 6.775 points after the intervention. This suggests that the intervention had a significant positive effect on the learners' ability to add fractions.

To determine the magnitude of the difference in the pre-post test results, as accounted for by the use of the 'kyempe' game, another test of effect size was computed. The results are presented in **Table 5**.

The results in **Table 5** show the magnitude of the difference in performance before and after the intervention. The effect size based on Cohen's d was 1.056 (95% confidence interval [CI] [0.780, 1.328]), and Hedges' correction was 1.051 (95% CI [0.776, 1.321]). Both values were positive and above 1.0, indicating a large positive effect size. According to Hirose and Creswell (2023), effect size is a way to identify the strength of the conclusions about group differences. Cohen (2013) provides conventional benchmarks for interpreting effect sizes, categorizing them as small (0.2), medium (0.5), and large (0.8). However, recent research suggests that effect sizes exceeding 1.2 are considered very large (Büsch & Loffing, 2024). This implies a significant improvement in learners' performance in the post-test compared to the pre-test. The positive sign indicates that the post-test scores were significantly higher than the pre-test scores. These findings demonstrate the effectiveness of the 'kyempe' game in enhancing learners' performance in the addition of fractions and implies that learners developed a deeper understanding of fraction concepts after engaging with the game.

DISCUSSION

The Level of Academic Performance in Addition to Fractions Before the Intervention

The pre-test results indicated that, prior to the intervention, the basic six learners demonstrated generally low performance in adding fractions, with 65.0% of the learners (52 out of 80) scoring within the low range of 0-7. From a socio-cultural learning perspective, this widespread underperformance suggests that learners have not yet developed adequate conceptual understanding of fraction addition through meaningful social interaction or the use of culturally relevant learning tools. Vygotsky's theory emphasizes that abstract concepts, such as fractions, are difficult to internalize when instruction is largely teacher-centered and disconnected from learners' everyday experiences, which may explain the poor baseline performance observed. These findings are consistent with empirical studies that identify fractions, particularly the addition of fractions with unlike denominators, as one of the most challenging areas of primary mathematics. Ricks (2019) and Deringöl (2019) reported that learners often struggle because fraction instruction frequently emphasizes procedural rules rather than socially mediated conceptual understanding. Similarly, Goswami (2018) noted that adding fractions is especially confusing for young learners when taught in abstract terms without concrete or contextual support. Within Vygotsky's framework, such instructional approaches limit learners' opportunities to operate within their ZPD, as they receive insufficient scaffolding to bridge the gap between what they can do independently and what they could achieve with guided support. The poor pre-test performance also mirrors national and local trends reported in Ghana. Chief Examiner's Report (2016, 2018, 2019) from the BECE consistently identified weaknesses in candidates' handling of fractions, including converting between mixed and improper fractions, solving fraction word problems, and simplifying answers (Amuah, 2020). These persistent difficulties suggest that learners are rarely exposed to culturally meaningful tools or collaborative learning experiences that facilitate the social construction of fraction knowledge. Supporting this view, Mills and Mireku (2016) found that learners in the Effutu Municipality performed poorly in mathematics largely due to challenges with fractions, which they attributed to limited learner engagement and insufficient conceptual scaffolding. The

poor performance further reflects both the cognitive demands of fraction addition and the absence of instructional practices aligned with socio-cultural learning principles. The findings, therefore, serve as an urgent call for interventions, such as the use of the 'kyempe' game, that provide culturally grounded, interactive, and scaffolded learning experiences. Such approaches are consistent with Vygotsky's assertion that learning is most effective when new concepts are introduced through social interaction and familiar cultural practices, thereby creating conditions for improved understanding and performance in fractions.

The Level of Academic Performance in Addition of Fractions After the Intervention

The post-test results showed a substantial improvement in learners' performance in fraction addition after the introduction of the 'kyempe' game, with 88.0% of learners attaining moderate to high scores and only 10.0% recording low performance. This improvement can be explained through Vygotsky's socio-cultural learning theory, which emphasizes that learning occurs most effectively through social interaction and the use of culturally meaningful tools. The 'kyempe' game functioned as a mediating cultural artefact that enabled learners to construct mathematical understanding collaboratively rather than through isolated, abstract instruction. Consistent with Vygotsky's assertion that cognitive development is socially mediated, learners engaged in shared activities such as dividing items equally and negotiating fair distribution during gameplay. These interactions supported the internalization of fraction concepts, particularly partitioning and equivalence, which are foundational to fraction addition. Empirical evidence supports this interpretation. Davis (2016) and Okyere (2021) similarly found that when mathematics instruction is linked to learners' cultural practices, learners demonstrate improved conceptual understanding and higher achievement. The familiarity of the 'kyempe' game reduced abstraction and enabled learners to acquire new knowledge in existing cultural experiences, thereby explaining the observed rise in performance levels. The findings further align with the concept of the ZPD, as learners' improved outcomes suggest that instructional support during gameplay enabled them to move from assisted to independent performance. The teacher, acting as the MKO, provided scaffolding through guided questioning, demonstrations, and corrective feedback while learners interacted with the game. This form of structured support is consistent with Vygotsky's view that learning precedes development when learners are supported within their ZPD. Similar outcomes were reported by Wulandari and Amir (2022), who observed that children develop stronger fractional understanding when teachers guide everyday sharing activities that mirror mathematical concepts.

Moreover, the collaborative nature of the 'kyempe' game promoted peer interaction, which Vygotsky identifies as a critical mechanism for cognitive growth. Through group play, learners discussed strategies, corrected misconceptions, and learned from more capable peers. This social co-construction of knowledge likely contributed to the reduction in low scores and the overall improvement in achievement. Empirical studies by Okyere (2021) also demonstrate that collaborative, culturally grounded learning environments help narrow performance gaps by allowing less proficient learners to benefit from peer support. In addition, the findings resonate with national policy recommendations that advocate culturally responsive pedagogy. Ministry of Education (2020) emphasizes the integration of indigenous knowledge and games into classroom instruction to enhance relevance and learner engagement. The improved post-test results provide empirical support for this policy direction, showing that culturally situated instructional approaches not only increase engagement but also lead to measurable learning gains. The significant improvement in learners' performance in fraction addition reflects the combined influence of socio-cultural learning processes and culturally grounded pedagogy. Guided interaction with the 'kyempe' game, supported by teacher scaffolding and peer collaboration, facilitated learners' movement through their ZPD, resulting in enhanced conceptual understanding. These findings are consistent with both Vygotsky's socio-cultural learning theory and empirical studies that advocate for the use of indigenous cultural tools in mathematics instruction.

Effect of the Game on Performance in Addition to Fractions Before and After the Intervention

The statistically significant difference observed between the pre- and post-test scores, with a large effect size, indicates that learners' performance in adding fractions improved substantially following the intervention. Interpreted through Vygotsky's socio-cultural learning theory, this improvement suggests that the use of the 'kyempe' game created a socially mediated learning environment in which learners were able to construct mathematical understanding through interaction, collaboration, and engagement with a culturally meaningful tool. The effectiveness of the intervention supports Vygotsky's view that learning is enhanced when instruction operates within learners' ZPD. Through guided gameplay, the teacher acted as a MKO by scaffolding learners' understanding of fraction addition, particularly as learners engaged in sharing and combining fractional parts during the game. This scaffolded support enabled learners to move from procedural attempts at fraction addition to deeper conceptual understanding, which is reflected in the large effect size reported. Similar findings were anticipated by Owusu and Obuo-Addo (2023), who suggested the potential of the 'kyempe' game for teaching addition of like fractions but highlighted the absence of empirical validation. The present study extends their work by providing empirical evidence that the game is not only culturally appropriate but also pedagogically effective for teaching fraction addition. The findings also align with empirical studies demonstrating the instructional value of indigenous games in mathematics education. Akayuure and Ali (2016) found

that culturally grounded games enhance learners' engagement and conceptual understanding by situating mathematical ideas within familiar social practices. Likewise, Ali and Tangkur (2023) reported that indigenous games facilitate the learning of mathematical concepts, including fractions, by allowing learners to internalize abstract ideas through meaningful social interaction. Within the socio-cultural framework, these outcomes reflect the mediating role of cultural tools in transforming learners' cognitive processes. By engaging learners in a familiar cultural activity centered on equal sharing, the 'kyempe' game enabled learners to experience fraction addition as a practical and socially meaningful process rather than an abstract procedure. This supports Vygotsky's assertion that higher-order thinking develops through participation in culturally organized activities. The significant improvement in performance therefore illustrates the effectiveness of culturally responsive pedagogy, particularly in contexts where traditional, decontextualized teaching methods have yielded limited success. The study demonstrates that when mathematical instruction is aligned with socio-cultural learning principles and supported by culturally relevant practices, learners' understanding and achievement in fraction addition can improve significantly.

CONCLUSIONS AND RECOMMENDATIONS

This study examined the effect of the Ghanaian cultural game 'kyempe' on basic six learners' academic performance in the addition of like and unlike fractions. The results show that the use of 'kyempe' or its integration into mathematics instruction significantly improved learners' performance, with a very large effect size. Thus, the game 'kyempe' holds promise for improving learners' procedural knowledge of fraction addition and, by extension, their procedural knowledge of mathematics in general, as fractions are key to the development of numerical concepts and are linked to topics such as algebra, proportion, decimals, geometry, and percentages.

The study revealed very low pre-intervention performance among learners. This indicates that learners' prior exposure to fraction instruction did not sufficiently develop their procedural knowledge and, by implication, their conceptual understanding of fractions. Mathematics teachers in Effutu and beyond need to be mindful of this lapse and tailor their instruction to address these deficits.

The finding that the use of the 'kyempe' game reduced the proportion of low performers from 65% to 10% and increased the number of high achievers from 8.7% to 42.5%, is indicative of its effectiveness for teaching fractions. Mathematics curriculum developers in Ghana should consider 'kyempe' as another cultural game to add to the repertoire of suggested games for teachers. More importantly, Mathematics teachers in Effutu and beyond must become aware of it and be trained to employ 'kyempe', as demonstrated in this study, to teach fractions in Ghanaian schools. The game is familiar to most learners and can easily be adapted to highlight its mathematical elements.

The finding of a significant difference between pre- and post-test performance, with a very large effect size, indicates a significant positive impact of the 'kyempe' game. This calls for its immediate adoption by mathematics teachers in Ghanaian schools, including those in Effutu, to support the learning of fractions. The importance of fractions at the early stages of mathematics learning makes it imperative to scale up this research through multiple studies in different locations across Ghana to confirm the applicability and effectiveness of using 'kyempe' to improve learners' performance in fraction addition. This could also be extended to other operations involving fractions, such as subtraction and multiplication. Given the game's enjoyment among both genders, future studies could also examine how it could help bridge gender imbalances in fraction learning.

Limitations

This study used a one-group pre-/post-test design without a control group; therefore, changes in learners' post-test scores could have been affected by factors other than the intervention. Potential threats to internal validity, such as testing effects, instrumentation effects, and other external influences during the intervention period, were monitored and mitigated to some degree through measures like using equivalent test forms, standardized test administration, consistent lesson delivery, and preventing learners from accessing or practicing test items. However, despite these precautions, these factors could still have impacted the outcomes. Additionally, the study was conducted in only two schools with participants selected through purposive sampling, which restricts the generalizability of the findings to wider populations. As a result, the findings should be interpreted with caution, and any conclusions about the intervention's effectiveness are tentative rather than definitive. Future research involving experimental or quasi-experimental designs with control groups and larger, randomly chosen samples is recommended to improve causal inference and external validity.

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inclusion in the study. Consent was also obtained from the heads of the basic schools and teachers, as well as from the participating students.

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APPENDIX A: PRE-TEST

Time allowed: 20 minutes

The purpose of this test is purely to collect information for a research study. Your results will **not** be used to grade you. Please try your best to answer all questions.

Section A: Background Information

Please provide the following information (kept confidential):

1. Age: ..... years
2. Gender: Male [ ] Female [ ]

Section B: Test Items

Please answer all questions on the plain sheet provided. Show all working and leave answers in their simplest form where possible.

(a) Add $\frac{5}{14}$ and $\frac{7}{14}$. What is the sum?

(b) $\frac{2}{6}+\frac{2}{6}$

(c) $\frac{2}{3}+\frac{1}{3}$

(d) Kofi got $2\frac{1}{3}$ pieces of bread from Yaa and $3\frac{2}{5}$ pieces from Ama. How many pieces of bread does Kofi have now?

(e) Baba drank $\frac{1}{2}$ litre of water in the morning and $\frac{1}{3}$ in the afternoon. How much water did Baba drink in total that day?

(f) At UEW Basic School, $\frac{1}{5}$ of the teachers are Ashantis and $\frac{1}{2}$ are Fantes. What fraction of the teachers at the school are Akans?

(g) My mother spent $2\frac{1}{3}$ of her money on vegetables, while my father spent $3\frac{2}{3}$ on fruits. What fraction of their combined money did my parent spend that day?

APPENDIX B: POST-TEST

Time allowed: 20 minutes

The purpose of this test is purely to collect information for a research study. Your results will **not** be used to grade you. Please try your best to answer all questions.

Section A: Background Information

Please provide the following information (kept confidential):

1. Age: ..... years
2. Gender: Male [ ] Female [ ]

Section B: Test Items

Please answer all questions on the plain sheet provided. Show all working and leave answers in their simplest form where possible.

(a) Find the sum of $\frac{3}{20}$ and $\frac{5}{20}$

(b) Simplify $\frac{2}{4} + \frac{6}{4}$

(c) Add $\frac{2}{5}$ and $\frac{3}{5}$

(d) Sarah baked $\frac{1}{4}$ cake in the morning and $\frac{1}{8}$ cake in the afternoon. How many cakes did she bake in total?

(e) Michael drank $\frac{1}{2}$ litre of juice before lunch and $\frac{2}{3}$ liter after lunch. How many liters of juice did he drink that day?

(f) At a party, the first fridge contains 6 whole watermelons and 2 whole pineapples. In the second fridge, there are $\frac{3}{4}$ of a whole apple and $\frac{1}{4}$ of a whole orange. How many fruits are available for the party in total?

(g) A farmer harvested $4\frac{4}{5}$ bags of rice from field A and $7\frac{2}{3}$ bags from field B. How many bags of rice did he harvest in total?