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VIRTUAL MANIPULATIVE MODEL AND PUPILS' ACHIEVEMENT IN FRACTION, IN OSUN STATE, NIGERIA

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ABSTRACT

This research was an experimental study carried out to determine the impacts of using virtual manipulatives as an experiential learning technique and the moderating role of gender on pupils' fraction achievement in Osun State, Nigeria. The study adopted the pretest-posttest control group quasi-experimental design using a 2x2 factorial matrix. The sample group consisted of 118 boys and 120 girls from six randomly selected public primary schools. Three intact classes were randomly assigned to each of the experimental and control groups. The instruments used were pupils' achievement test in fraction and teachers' instructional guides. Data were analysed using analysis of covariance, as well as estimated marginal mean. Findings indicated that while gender did not significantly affect treatment, it did have a significant main influence on pupils' achievement in fraction. Gender and treatment did not significantly interact to affect pupils' fractional achievement. Based on the findings, it was recommended that primary school teachers should acknowledge virtual manipulative to improve pupils achievement in fraction and give boys and girls the same opportunity to engage with teachers, each other, and the resources.

Keywords: Virtual Manipulative model, Pupils' achievement in fraction, Gender

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Introduction

In Nigeria, mathematics plays a major role in the educational system. Due to the value of mathematics in fostering national development, the Federal Government of Nigeria has mandated that mathematics be taught to pupils at all educational levels (FRN, 2013).
According to the Nigerian National Policy on Education, mastery in mathematics is required for admission to all educational levels. In addition, it is one of the topics that permit a student to be admitted into any higher education institution in Nigeria because it is the basis for almost all tertiary-level disciplines of study (Ojetunde, Sule, Kemiki and Olatunji 2020). For this reason, Nigerian education mandates it for both primary and secondary students (FRN, 2013).

Primary education in Nigeria is fundamental for children ages 6 to 12 according to the National Policy on Education, and the foundation of the rest of the educational system is the knowledge gained in primary school (FRN, 2013). Early reading and numeracy skills have an impact on students' academic performance and attitude towards mathematics later in life, which has an impact on how well they learn other subjects (Hammed, 2022). The five thematic areas of mathematics in Nigeria's Primary 4 curriculum are Numbers and Numeration; Basic Operations; Algebraic Processes; Mensuration and Geometry and finally Everyday Statistics. Pupils will benefit from learning about Numbers and Numeration as they learn about operations involving whole numbers, LCM, HCF, roman numerals, place value, decimals, fractions, etc

In primary mathematics, fractions are a crucial component of numeracy and are taught to pupils right after numbers. In many nations, including Nigeria, fraction is taught at all primary school levels and is crucial to secondary and postsecondary education (Satoshi, 2021). The elementary school mathematics curriculum covers fractions in great detail because a sufficient understanding of fractions in primary school will be necessary for students to study mathematics and other subjects in the future that call for the application of fractional knowledge (Hammed, 2022).

A fraction can express concepts that fit on a number line, such as a portion of a whole, a proportion, or a size (Ndaba, 2021). Neagoy (2017) submitted that concepts like a part of a whole, a percentage, or a size that fit on a number line can all be expressed with fraction, it is a necessary component of mathematical knowledge that is taught in primary school higher classes i.e. Primary 4-6. Bruce, Chang and Flynn (2013) put forward that a weak foundation in mathematics and fraction inhibits some learners from going into advanced mathematics and keeps them from having access to many job options in the future.

Numerous studies have shown that a significant portion of students struggle to solve fraction-related problems because they lack fundamental fractional knowledge (Idris and Narayanan 2011; Yea-Ling 2005; Burler et al 2003). Tella and Sulaimon (2022) in their study on fraction, affirmed that of the three challenging topics covered in the primary school mathematics curriculum, fractions is thought to be the most challenging to teach and learn. In addition, Aliyu, Adamu and Unogwu (2018) noted that one of the mathematical concepts that teachers find difficult to teach and pupils discover confusing to learn is learning about fraction.

Tarkan (2012) discovered that the misperception that a fraction is usually smaller than one and the kind of teaching pupils receive account for the majority of their struggles with fraction. He further noted that a fraction is always worth more, according to some pupils,

when the numerator and denominator are increased. Besides, according to Adams, Bucci, McEwan, and Reinthal (2021), pupils' struggles with fraction are caused by the different definitions or interpretations that have been provided in mathematics curricula and research studies on mathematics education. To further elucidate the meaning of fractions and rational numbers, they additionally distinguish five sub-constructs or interpretations: measure, operator, quotient, part whole, and ratio. According to the first sub-construct, a fraction is a measure. This definition states that the fraction a/b can be understood as the distance on the number line between a and b units. According to the second view, a fraction is an operator. For instance, something's stretching or contracting is represented by its fraction a/b. The amount that each person receives, a, is divided by b to create a quotient in the fraction a/b. Lastly, using this definition, the fraction a/b represents, as a ratio, (a) parts of set A to (b) parts of set B.

However, the definition of a fraction as a part of whole is far more frequently used in primary school mathematics curricula than other definitions, even in Osun State, Nigeria. This is because it allows pupils to participate in activities like cutting and the art of drawing. But pupils find this explanation confusing and problematic, particularly when it comes to applying fraction to real-world scenarios (Ni and Zhou 2005; Thompson and Saldanha 2003). One of these issues has to do with using the part-of-a-whole interpretation to represent negative fractions. Furthermore, it is difficult for primary school pupils to visualise a fraction like 135/254 that has a big numerator and a small denominator. Additionally, when comparing two or more fraction, this definition may lead to ambiguities. Lastly, this interpretation suggests that pupils may become confused by inappropriate fraction. One pupil incorrectly represented the fraction 3/2 by writing that there could not be "three parts of an object that is divided into two parts," according to Mack (2000), a study that exposed pupils to errors about fraction.

The consequences of these challenges are as stated by Satoshi (2021), Namkung (2019), and Amazigo (2000): pupils who are unable to comprehend the meaning of calculation in fraction must rely on memorization to solve problems. This can result in poor achievement, particularly for those who have trouble with rote learning. They eventually come to view fraction and mathematics in general wrongly. Accordingly, these challenges start early in the primary years and continue through junior school, senior secondary school, and even postsecondary education (Tella and Sulaimon, 2022; Fazio, DeWolf, and Siegler, 2016).

For all these reasons, it is imperative that pupils be inspired to comprehend fraction in order to raise their fractional proficiency. According to researchers, algebra success requires an understanding of fraction and pupils often struggle with fraction-based problems (Ubah 2021, Booth, Newton, and Twiss-Garrity 2014). This is evident in a baseline study conducted by the researcher on primary four pupils with some sampled schools in Osun State pupils' performance in fraction in mathematics where the result reveals that pupils' average performance was below 50%.

Year	2019	2020	2021	2022
Total number of candidates	298	190	235	278
Number with at least 35marks and above	102	47	110	114
% Pass	34.23	24.74	46.8	41.01

(Source: Researcher's Fieldwork)

The causes of the poor achievement in fraction, and in mathematics generally in Nigerian mathematics classrooms are characterised by traditional, unchanging teaching and learning methods (Ukeagbu, Anulobi, and Chukwuemeka, 2020). On this, teachers, textbooks, chalkboards and conventional facilities are no longer sufficient in Nigeria including Osun State to provide the volume and variety of skills and competencies demanded of pupils, according to Abakpa and Iji (2011). As a result, Ukeagbu, Anulobi, and Chukwuemeka (2020) contend that educators require tools to help them do their jobs effectively. They go on to say that numerous attempts have been made to enhance teaching techniques through the use of instructional materials like computers, since teaching methods have evolved over time and have shown shifts from one perspective to another.

The teaching approach that a teacher employs is crucial in helping pupils acquire the knowledge and skills they need to study in a meaningful way. It has been said that teacher-centered learning approaches do not adequately equip students to achieve at a high level achievement in mathematics, particularly fraction (Emaiku, 2012). It reduces student interaction and renders them inactive. Yet, teachers in Osun State, Nigeria primarily utilise this strategy, which discourages pupil-to-pupil engagement.

In order to rectify and enhance the performance of pupils in fraction, numerous innovative and updated teaching strategies have been put out. These include video learning media strategy (Yusrizza and Kowiyah, 2023), inquiry-based instructional strategy with origami (Tella and Sulaimon, 2022), hands-on-activities (Kehinde, Adeyinka, Khalid and Abiodun, 2021), Paper folding manipulative strategy (Adom and Adu, 2020), Practical Approach Strategy (Ado and Abasi, 2014), Pictorial model (Moyer-Packenham, Ulmer and Anderson, 2012) and adopting Jigsaw instructional strategy (Areelu and Omolola, 2018) amongst others. Based on earlier research, all of these alternative fraction teaching strategies have been employed in various contexts, but have not been able to produce the anticipated outcomes. This is because, despite the strategies' claims to have improved pupils' performance in fraction, Nigerian schools continue to use the traditional fraction teaching approach regardless of a pupil's learning disability, which has not been producing the intended outcomes (Akinoso, 2013).

However, pupils can develop and interact with fractional knowledge in a variety of ways when digital tools are used in mathematics instruction. Through modelling, visualisation, manipulation, and more complicated scenarios, it could make it easier to emphasise how mathematics is used in real-world situations (Ziatdinov and Valles, 2022). It is well known in this day and age that digital devices like laptops, iPhones, iPads, video games, cell phones, and WiFi games take up a larger portion of pupils' lives when they are not in class.

Nevertheless, the use of models and manipulatives in conjunction with the experiential learning instructional strategy to teach and learn fraction has been the subject of very few studies. Activities for experiential learning have been created to enhance pupils' learning results. In an experiential learning setting, pupils actively participate in the design of educational activities as well as the collection, evaluation, and application of subject matter (Awolere, 2015). Learning, in Piaget's view, is the process by which experience becomes knowledge. The pupils gained knowledge via hands-on experience, self-reflection and active engagement with an emphasis on the individual's learning process.

Utilising technology in mathematics instruction has the ability to give pupils a range of opportunities to construct and engage with mathematical knowledge. Manipulatives are

"physical objects designed to represent explicitly and concretely mathematical ideas that are abstract," according to Akinoso (2013).

A virtual manipulative is defined as “an interactive, Web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge” (Moyer, Bolyard and Spikell, 2002). Dorward (2002) defined virtual manipulatives as “computer based renditions of common mathematics manipulatives and tools”. Virtual manipulatives are frequently dynamic visual and pictorial copies of real manipulatives (such geoboards, geometric solids, pattern blocks, base-10 blocks, or tangrams). You can find them as applets on the Internet. Through the simultaneous connection of words, pictures, and symbols, virtual manipulatives can help young ones improve their visualisation skills. Pupils can gain a strong grasp of mathematical topics such as fraction with the help of this simultaneous presentation (Moyer, Ulmer, and Anderson, 2012). There are numerous virtual manipulative collections available on the Internet, including the National Library of Virtual Manipulatives and the National Council of Teachers of Mathematics Illuminations websites. Virtual manipulation applets with a range of features are included in these collections. Applets that display dynamic electronic content can have one of the following features: (a) only visual images, (b) both visual and numerical images, (c) simulations, or (d) concept tutorials that mix visual and numerical images together with instructions and feedback.

"Work with virtual manipulatives, can allow young children to extend physical experience and to develop an initial understanding of sophisticated ideas like the use of algorithms," according to the NCTM Technology Principle (NCTM, 2000). Virtual manipulatives, then, combine some of the best aspects of many representational systems with some extra benefits arising from their technological characteristics.

Virtual manipulatives proved to be more successful than paper and pencil when Satsangi and Raines (2023) used them in their classroom study. They also emphasised how virtual manipulatives create a connection between abstract symbols and moving graphics, which is one of their advantages. According to a different study by Kembubi (2020), virtual manipulatives have an as powerful and engaging impact on mathematics knowledge as concrete ones.

In a study conducted in 2017, Ukeagbu, Anulobi, and Umamba looked into how virtual manipulatives affected students' performance and attitudes in maths. The findings demonstrated a statistically significant difference in the mean accomplishment scores of students taught mathematics using virtual manipulatives compared to students taught using traditional methods.

Ukeagbu, Anulobi and Chukwemeka (2020) conducted a quantitative study to investigate the effect of virtual manipulatives on pupil’s achievement and attitude in Mathematics. The study made use of quasi-experimental design research type adopting pretest, posttest and non-equivalent control group design. The population of the study consisted of all primary six pupils of Alvan-Ikoku College of Education Demonstration Primary School in Owerri Municipal Council Area of Imo-State. The sample of the study comprised 224 primary six pupils selected using simple random sampling technique from four classes in the school by balloting. In each class selected, two intact classes were assigned to experimental and control groups using simple balloting. The experimental group had 110 pupils while the control group had 114 pupils. The instrument used for data collection was Mathematics Achievement Test (MAT). The result showed that the experimental group has a mean achievement gain of

37.81 while the control group had 15.58, the gain difference of 21.73 in favour of the experimental groups.

One of the elements influencing learning is gender disparity, and numerous scholars have concentrated their attention on studies concerning its impact on students' mathematical achievement. Many facets of life, including education and particularly students' academic achievement, have been impacted by gender inequality (Adeosun and Owolabi, 2021). Research on how gender affects achievement hasn't yielded any clear winners. While some research revealed that there were notable disparities between male and female students' academic performance, other research revealed that gender had no bearing whatsoever on students' academic performance. According to others, there is no discernible difference between male and female students' academic achievement in science and mathematics (Owolabi, 2002; Ogunkola, 2007). Saha (2007) found that all three of the factors—gender, attitude towards mathematics, cognitive style, and mathematical achievement—contributed to a statistically significant difference in mathematical achievement.

Despite the importance of fractions, primary school pupils' attitude and performance in it have been consistently inadequate over the years. This issue has been partially linked to teachers' poor use of instructional strategies, which prevent pupils from mastering the material, and students' inadequate fractional knowledge, which shows in their poor conceptual accomplishment. This might be as a result of pupils' attitudes towards answering questions on various fractional ideas as well as the abstract character of some of the fraction themes from which the majority of the questions were derived.

Specific objectives of the study:
To investigate the effect of virtual manipulative on the academic achievement of primary four school pupils in fraction, in Osun State, Nigeria.

To find out the effect of gender on the academic achievement of primary four school pupils in fraction, in Osun State, Nigeria.

Hypotheses
The following hypotheses were tested at 0.05 level of significance.
H_{o1}: There is no significant main effect of treatment on pupils' achievement in fraction.
H_{o2}: There is no significant main effect of gender on pupils' achievement in fraction.
H_{o3}: There is no significant interaction effect of treatment and gender on pupils' achievement in fraction.

Methodology
The study adopted the pretest-posttest experimental control group quasi-experimental research design using a 2x2 factorial matrix. The study covered primary four pupils from four LGAs randomly selected out of ten LGA in Osun Central Senatorial District of Osun State, Nigeria. The topic selected for the experiment was fraction, while sub-topics included ordering of equivalent fraction; proper and improper fractions and mixed numbers; decimal fraction; and addition and subtraction of two proper and improper fractions. These were included in the primary 4 mathematics curriculum for the nine-year basic education programme. For the experimental group and control group, a total of four schools were chosen using the purposeful sampling technique from each of the chosen LGAs.

The criteria for selecting the schools were based on the followings:
The schools must be public schools and co-educational.

Availability of ICT resource materials.
Readiness and willingness of the teacher to participate in the research.

Each of the schools' intact primary 4 classes was randomly allocated to the experimental and control groups. The experimental group's participants were instructed utilising virtual manipulatives, whereas the control group was instructed using the traditional chalk-talk method.

The instruments used for the study were:
Pupils' Achievement Test in Fraction (PATF)
Teachers' Instructional Guide on Virtual Manipulatives Model (TIGVMM)
Teachers' Instructional Guide on Conventional Instructional Strategy (TIGCIS)
Evaluation Sheet for assessing teachers' performance during training. (TES)

The PATF was adapted from New Method Mathematics Textbook for primary four to measure pupils' achievement in fraction. It was divided into two sections: part A asked questions regarding the students' age, class, and name of school, while section B had thirty multiple-choice questions with answers ranging from A to D. Experts in test construction approved the PATF. The PATF was given to a sample of twenty students who were chosen at random from outside the target sample in order to assess the instrument's reliability. The experiment was deemed to be suitable for the experiment when the reliability coefficient, which was calculated using the Kuder-Richardson formula (K-R20), was found to be 0.79.

The pupils in the experimental group received lessons in fraction using teacher's instructional guide in virtual manipulatives model (TIGVMM). Expert review and face and content validity tests were used to validate the web-based visual teaching package. The instrument's final production included the experts' insightful recommendations and modifications. The package included numerous activities that were fixed. Pupils in the control group were taught fractions using a traditional approach with a teacher-centered instructional guide. Experts verified the suitability of this TIGCS. In order to assess how well the research assistants taught the fractional ideas in the study, the TES was utilised to gauge how effectively or otherwise they performed during their training. There were two portions on the sheet: A and B. In Section A, the research assistant's demographic details were requested, including the name of the school, the class and topic they taught, the number of times per week that the instructional technique was employed, and the type of group (experimental or control). Items in Section B were designed to track and evaluate each research assistant's conformity to and proficiency with the processes. Trial testing was done on the instruments to make sure they were reliable. The instruments' reliabilities were determined through the use of Scott's π statistical measure, which yielded a virtual manipulative model score of 0.76 and a conventional strategy score of 0.81. Drafts of the assessment forms were given to test construction specialists and maths educators with a focus on language, adequacy, and clarity in order to guarantee the face and content validity of the instruments. A 5-point Likert-type rating scale was used to score the items, with Very Good (VG) receiving 5 points to Very Poor (VP) receiving 1 point.

The usual maths teachers of the four intact primary classes are the research assistants who underwent a week of training. These classes, which include both male and female participants, were divided into treatment and control groups at random. Prior to the start of the treatment, the study participants finished the fractional achievement test for the pupils. The course of treatment was eight weeks long. Pupils were taught by their regular class teachers who had received training as research assistants, under the researcher's supervision.

Everyday classes lasted for forty-five minutes each. The following fractional concepts were taught during the application of the treatment; ordering of equivalent fractions; proper and improper fractions and mixed numbers; decimal fractions and addition and subtraction of two proper and improper fractions. The pupils did the Pupils' Achievement Test in Fraction (PATF), which is same to their prior pretest, as a posttest following the conclusion of the treatment phase. Analysis of Covariance was used to evaluate the data at the 0.05 level of significance.

Results and discussion

Ho1: There was no significant main effect of treatment on pupils' achievement in fraction

Table 1: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5676.949	4	1419.237	69.660	.000	.634
Intercept	2574.169	1	2574.169	126.348	.000	.440
Pre-Achievement	251.529	1	251.529	12.346	.001	.071
Treatment	4539.680	1	4539.680	222.821	.000	.581
Gender	.126	1	.126	.006	.937	.000
Treatment x Gender	.019	1	.019	.001	.976	.000
Error	3280.165	161	20.374			
Total	53887.000	166				
Corrected Total	8957.114	165				

R Squared = .63 (Adjusted R Squared = .63) * denotes significant p<.05

Table 1 revealed that there was a significant main effect of treatment on pupils' achievement in fraction ($F_{(1, 165)}$ =222.82; p<0.05, partial η^2 = 0.581). Table 4.2 indicated the effect size of 58.1%. This means that 58.1% of the total 63.0% variation observed (Adjusted R^2 = 0.63) in pupils' post-achievement scores in fraction in this ANCOVA model was due to the significant main effect of the treatment. Therefore, hypothesis 1 was rejected. In order to explore the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out and the result is presented in Table 2.

Table 2: Estimated Marginal Means for Post-Achievement by Treatment and Control group

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Virtual Manipulative Model (VMM)	23.66	.60	22.47	24.84
Conventional Model (CM)	12.377	.44	11.50	13.25

Table 2 revealed that pupils in the Virtual Manipulative Model (VMM) group had the highest adjusted mean score in their post-achievement in fraction (23.66) and the Conventional Model (CM) control group had (12.38). This order is represented VMM > CM. This indicated that the post-achievement mean score in fraction of pupils in the Virtual Manipulative Model differ significantly from those in the Conventional Model. This indicates that the significant difference observed in the ANCOVA result was due to the effect of the treatment as pupils' post-achievement scores is concerned.

Ho2: There was no significant main effect of gender on pupils' achievement in fraction

Table 1 showed that there was no significant main effect of gender on pupils' achievement in fraction ($F_{(1,165)}$ =.006; p>.05, partial η^2 = .000). Therefore, hypothesis 2 was not rejected.

This means that gender had no effect on pupils' achievement in fraction. The Estimated Marginal Mean of the analysis that determined the difference in magnitude in the achievement by gender is presented in Table 3.

Table 3: Estimated Marginal Means for Post-Achievement by Gender

			95% Confidence Interval	
Gender	Mean	Std. Error	Lower Bound	Upper Bound
Male	18.05	.55	16.97	19.12
Female	17.99	.49	17.02	18.96

Table 3 revealed that the male pupils had highest post-achievement scores (18.05) in fraction compare to female counterpart (17.99). The order is represented male>female. The male pupils though scored high than the female pupils in fraction, the difference was not significant. This implies that both gender achievement in fraction is at par.

Ho3: There was no significant interaction effect of treatment and gender on pupils' achievement in fraction

Table 1showed that the interaction effect of treatment and gender on pupils' achievement in fraction was not significant ($F_{(1,165)}$ =.001; p>.05, partial η^2 = .000). Thus, hypothesis 3 was not rejected. This indicates that treatment and gender had no interaction effect on pupils' achievement in fraction.

The discussions of the findings were as follows:
The outcome showed that the virtual manipulative model teaching technique outperformed the conventional method in terms of enhancing the performance of pupils in fractions. Pupils in the Virtual Manipulative model Instructional Strategy (VMMIS) treatment group had highest adjusted mean score in their post-achievement in fraction (23.66) than their counterpart in conventional Strategy (CS) control group (12.38). The fact that the virtual manipulative model instructional technique is learner-centered and appropriate for learners who are concrete-operators may account for its effectiveness, as suggested by Piaget. The pupils gained knowledge via hands-on experience, reflection, and active engagement with an emphasis on the individual's learning process. This finding agreed with Ukeagbu, Anulobi and Umamba (2017) who showed that virtual manipulatives improves pupils' achievement scores in mathematics than those taught using conventional method. Ukeagbu, Anulobi and Chukwemeka (2020) also revealed that the pupils in virtual manipulatives group have a higher mean achievement gain in mathematics. The result is also in line with the studies which have shown that teaching fractions with virtual manipulatives is more efficient than using paper and pencil (Satsangi and Raines, 2023), interesting and have a powerful impact on mathematical comprehension that is comparable to that of concrete ones (Kembubi, 2020), encourage low-achieving students to understand fraction concepts in a positive way (Moyer-Packenham, Ulmer and Anderson, 2012), and It creates a connection between abstract symbols and moving images (Ukeagbu, Anulobi and Chukwemeka, 2020).
The result also revealed that there was no significant main effect of gender on pupils' achievement in fraction. Though the male pupils obtained slightly higher mean achievement score than female but the difference was not significant. The result corroborates with the result obtained by Tella and Sulaimon (2022) and Al-Mustapha (2014) that revealed the main effect of gender on pupils' achievement in fraction was not significant. The result is in contrast with the findings of Kurumeh and Iji 2009 who reported a gender difference in mathematics learning where males perform better than girls. This result demonstrates how

gender-friendly and successful virtual manipulatives are when used to teach and learn fractions.

The result of this study also showed that there was no significant interaction effect of treatment and gender on pupils' achievement in fraction. This shows that virtual manipulative model used in the study imparted equally on male and female pupils based on their academic achievement in fraction. It agrees with the finding of Boakes, 2009 who found that there was no significant interaction effect between group and gender in paper folding test and surface development test; it likewise concur with Tella and Sulaimon 2022 who found out that there was no significant interaction effect of inquiry-based instruction enriched with origami activities and gender on pupils' achievement in fraction. However, this result is in disparity with Boakes, 2009 which demonstrated that a significant interaction effect exist between group and gender in card rotation test.

Conclusion

Studies have indicated that using virtual manipulatives into fractional instruction could be a highly effective strategy for preventing widespread failure and enhancing pupils' mathematical ability. Therefore, using virtual manipulatives as an educational technique will not only help pupils accomplish better academically in fraction but will also assist pupils in forming intuitive links between concepts and abstract symbols.

Contribution to knowledge

This study recommends using virtual manipulatives to help primary school teachers share knowledge with the pupils they teach. The study demonstrated how equal opportunities for boys and girls to engage with the resources, teachers, and other pupils might close the gender gap in fraction achievement through virtual manipulatives. Additionally, it offers baseline data that helps curriculum developers and mathematics teachers integrate technology into the teaching and learning of mathematics, including the study of fraction as an algebraic concept. Additionally, the study identifies a number of problems that may limit or impede the application of the recommended instructional technique and recommends suggestions for improvement. Additionally, the outcome broadens the corpus of current knowledge.

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