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# IMPROVING PUPILS' ACHIEVEMENT IN FRACTION USING INQUIRY-BASED INSTRUCTIONAL STRATEGY ENRICHED WITH ORIGAMI ACTIVITIES

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## ABSTRACT

This study determined the effects of inquiry-based instructional strategy enriched with origami activities and the moderating effect of gender on pupils' achievement in fraction in Oyo State, Nigeria. The study adopted the pretest-posttest control group quasi-experimental design using a 2x2 factorial matrix. The sample group consisted of 55 boys and 33 girls from two randomly selected public primary schools. Two intact classes were randomly assigned to 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. Treatment had a significant main effect on pupils' achievement in fraction and there was no significant main effect on gender. Treatment and gender had no significant interaction effect on pupils' achievement. It was recommended that mathematics teacher should adopt inquiry-based instructional strategy enriched with origami activities.

# MENINGKATKAN PRESTASI SISWA DALAM PECAHAN MENGGUNAKAN STRATEGI INSTRUKSIONAL BERBASIS *INQUIRY* YANG DIPERKAYA DENGAN KEGIATAN ORIGAMI

***Kata Kunci:***

Strategi Pembelajaran Berbasis Inkuiri
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Prestasi belajar pada pecahan

## ABSTRAK

Penelitian ini bertujuan untuk menentukan efek dari strategi pembelajaran berbasis inkuiri yang diperkaya dengan kegiatan origami dan efek moderasi gender terhadap prestasi siswa dalam pecahan di Negara Bagian Oyo, Nigeria. Penelitian ini mengadopsi desain eksperimen semu kelompok kontrol pretest-posttest dengan menggunakan matriks faktorial 2x2. Kelompok sampel terdiri dari 55 anak laki-laki dan 33 perempuan dari dua sekolah dasar negeri yang dipilih secara acak. Dua kelas utuh secara acak ditugaskan ke kelompok eksperimen dan kontrol. Instrumen yang digunakan adalah tes hasil belajar siswa pada pecahan dan buku petunjuk guru. Analisis data menggunakan analisis kovarians, serta estimasi marginal mean. Perlakuan memiliki pengaruh utama yang signifikan terhadap prestasi belajar siswa pada pecahan dan tidak ada pengaruh utama yang signifikan terhadap jenis kelamin. Perlakuan dan jenis kelamin tidak memiliki pengaruh interaksi yang signifikan terhadap prestasi belajar siswa. Direkomendasikan kepada guru matematika untuk mengadopsi strategi pembelajaran berbasis inkuiri yang diperkaya dengan kegiatan origami.

## 1. INTRODUCTION

Mathematics is a central part of all efforts at knowledge that human cannot live effectively without. Mathematics is described as the pillar of all knowledge showing its relevance to all disciplines. Mathematics relates to everything in the universe from the smallest to the largest [1]. Mathematics is the science of structure, order, numbers, spaces, and quantities [2]. Mathematics is a relationship that revolves around the elementary practice of counting, measuring and description of shapes and objects. Mathematics is the bedrock and indispensable tool for scientific, technological and economic advancement of any nation [3], [4]. Mathematics is intimately connected to daily life and everyone's life-long planning/experiences [3]. Emphasis on sound mathematical knowledge for pupils and students in primary and secondary schools is therefore for learners to be able to reap the benefits of acquisition of mathematical skills, live a better life and also be in a better position to directly or indirectly contribute to the development of the society and the world's economy [5].

Nigerian education curriculum sees primary education as the compulsory education given to children aged 6-12 years and the rest of the education system is built on it [6]. Teaching mathematics in primary schools will lay foundation for pupils for their future advance studies in mathematics, as well as in other school subjects that requires the knowledge of mathematics. With this assertion, it can be concluded that the knowledge of mathematics at the primary school level is of great importance, especially in the day to day life of every citizens. No matter the profession one venture into in life, one will still need mathematics. The main goal of teaching mathematics at the primary school level is to help pupils to acquire: basic skills in numeracy; ability to use these skills to solve problems; ability to estimate and make or calculate approximations and ability to interpret graphs and arrangements of numerical data.

Fraction is an important aspect of numeracy in primary school mathematics and it refers to a number that represents a measure of the relationship between two quantities, these two quantities provide information about the parts, the units and the whole. Fractions can represent different concepts such as: the part of a whole; a proportion; or a magnitude that can be placed on a number line [7]. Fractions are important for physical, biological, and social sciences and in a wide range of middle-income occupations that do not require advanced mathematics including nursing, carpentry, and auto mechanics [8], [9]. A shaky grounding in fractions can prevent individuals from pursuing advanced mathematics and shut pupils off from a significant number of career opportunities in later life [10]. Learners' competency in numeracy and literacy in early grades affects their academic achievement more generally in later years and affects how they master other subjects [11]. Knowledge of fraction is essential in understanding measurement, algebra, rational numbers and time concept, to mention a few.

Despite these importance, fraction as a concept in mathematics still poses a lot of challenges to both teachers and pupils in primary schools in Nigeria. Fractions were identified as one of the three most difficult topics to teach and learn in primary school mathematics curriculum [12]. Fractions involve difficult-to-learn and difficult-to-teach concepts that present ongoing pedagogical challenges to the mathematics education community. These difficulties begin early in the primary years [13] and persist through middle school, then into secondary and even tertiary education [14]. Historically, fractions have been one of the most difficult skill to master [15]. Students perceived fractions as parts of the sets rather than parts of the whole [16]. If students experience difficulties with fractions, they will have problems with other domains in mathematics such as algebra, measurement, and ratio and proportion concepts [17].

The observed low performance of students in fraction cum mathematics has been traced to various factors, including lack of interest [18], ineffective course-delivery strategies adopted by teachers [19], [20], weak foundation, at the formative stage of the students' education [21], reasoning and numerical abilities [22], contents the students are required to learn, as well as the instructional approach used by teachers [23]. Poor teaching methods are the main factor contributing to students' poor performance in fractions [24], [25]. Despite this, many teachers still use the traditional (conventional) mode which relies heavily on textbooks, charts and diagrams to teach mathematics including fraction. A lot of new and modified methods have been proposed to improve performance in fraction, these includes measurement approach [26], e-learning approach [27], geogebra [28] among others.

Inquiry-based Learning is learning through questions and experimentations [29]. It also creates a "culture of inquiry" as "teachers become learners, learners are self and peer-taught and everyone becomes a researcher" [30]. Inquiry-based learning is an active learning approach which gives students the opportunity to experience an authentic version of the subject and get a taste of high level mathematical work [31]. There have been many attempts to strengthen the learning of mathematics through the adoption of a teaching approach that emphasizes inquiry [32]. Inquiry-based learning is emphasizing the responsiveness, authenticity, and intellectual engagement that make this approach a useful, means of ensuring that students get the most out of their shared learning environment [33]. The strategy actively involves students in the learning process and allows them to learn the contents on their own, which provides more opportunities for them to gain a deeper understanding of the concepts and become better critical thinkers [34].

Several studies have revealed that students taught through inquiry scored higher than those taught with the traditional method [35], [36]. Inquiry based mathematics instruction improved students' achievement in mathematics [37]. Inquiry-based learning has also been found to support higher level cognitive interaction [38]-[40], longer-term knowledge retention [41], [42], and more efficient collaboration [43]. However, there are few studies on effect of Inquiry-based learning strategy enriched with origami activities on pupils' achievement in mathematics especially in fraction in Nigeria.

The importance of origami in the teaching and learning of fraction cannot be over emphasized. Origami is common word in Japanese, "*ori"* means "to fold", and "g*ami"* means "paper". It is thus known as Japanese art of paper folding. Origami is a bridge between nature and mathematics [44], [45]. Origami takes great mathematical potential when used in education [46] especially in geometry [47]. Origami activities in geometry lessons improved high school students' achievement in geometry [48], it is also helpful in students' mathematical problem solving abilities [49].

Origami-based mathematics instruction significantly increased students' spatial ability scores [50]. Aside geometry, origami can be used to learn fractions, algebra, spatial visualisation, sequence and trigonometry. However, studies using origami activities on pupils' achievement in fraction in Nigeria is replete.

Researchers have identified gender as one of the variables influencing instructional strategy. Gender difference is a recurring issue in mathematics instruction. Many research findings show that, a significant difference in mean achievement of students in mathematics is in favour of male. Such findings are seen in [51]-[55] among others. There is also argument that male superiority over female is virtual because the female only see mathematics as a domain of the male. There is no significant relationship between gender and achievement in mathematics [56], [57]. This inconsistency in gender issues calls for further investigation in this study. This study, therefore, determined the effect of inquiry-

based instruction enriched with origami activities on pupils' achievement in fraction, as well as the investigation of gender.

Despite the importance attached to fraction in everyday life activities, pupils experience difficulty in learning fraction, when compared to other aspects of mathematics. Studies have revealed that strategy adopted by teachers (which is mainly conventional strategy) is a major factor of learners' achievement. It was observed that the conventional approach did not help in improving pupils' achievement in fraction. In an attempt to remediate the recurring poor achievement in fraction, researchers have focused on different instructional strategies such as Measurement approach, Geogebra, Computer Games, E-learning approach. However, very few studies have been carried out on incorporation of origami activities into Inquiry-Based Instructional Strategy coupled with gender investigation.

Inquiry-Based Instructional Strategy is an approach to teaching and learning that places students' question, ideas and observations at the centre of the learning experience. This method is not vast in practice by mathematics teachers, but offers active learning environments that engage learners and improves their reasoning skills. This study, therefore, determined the effect of inquiry based instruction enriched with origami activities on pupils' achievement in fraction as well as examining the moderating effect of gender.

Research on learning mathematics with origami activities has been carried out several times by other researchers, including; origami boxes to explore the concepts of geometry and calculus [45], origami instructions for geometry knowledge [46], origami to improve mathematical problem solving [49], origami to learning mathematics for the deaf [1], origami to spatial intelligence [2] but, research on origami activities using instructional strategies has never been done. However, in this study, research on instructional strategies is a novelty. This study also uses inquiry-based learning, which has never been done before through origami activities. This research aims to improve student achievement with inquiry-based instructional strategies through origami activities.

## 2. METHOD

This study adopted the pretest-posttest control group quasi-experimental research design using 2 x 2 factorial matrix. This study covered basic three pupils in two public schools in Akinyele Local Government Area of Oyo State Nigeria. The topic selected for the experiment was fraction, while sub-topics included fraction of shapes, unit fractions, equivalent fractions and ordering of fractions. These were as contained in 9-year basic education curriculum: mathematics for primaries 1-3 [58]. Convenient random sampling was used to select two primary schools in Akinyele Local Government Area of Oyo state, Nigeria. Two intact Basic three classes, one from each school were used for this study. The schools were selected based on the following criteria:

a. The schools must be public schools
b. The schools must have experienced teachers who possessed teaching qualification
c. The mathematics teachers must be willing to involve in the experiment.

The instruments used for the study are;

a. Pupils' Achievement Test in Fraction (PATF)
b. Teachers' Instructional Guide on Inquiry-Based Instructional Strategy enriched with Origami Activities (TIGIISOA)
c. Teachers' Instructional Guide on Conventional Instructional Strategy (TIGCIS)
d. Evaluation Sheet for Assessing Teachers' Performance during Training (ESATPT)

The PATF was adapted from Mathematics Association of Nigeria Mathematics textbook for primary three, to measure pupils' achievement in fraction. It consisted of two sections; section A contained questions that sought personal data about pupils such as: name of school, class, sex and age while section B consisted of 15 multiple choice items with options A-D. The Pupils' Achievement Test in Fraction (PATF) was validated by experts in test Construction. The reliability of the instrument was determined by administering the Fraction Achievement Test to a sample of 40 pupils selected outside the target sample. The reliability coefficient was ascertained using Kuder-Richardson formula ($K\text{-}R_{20}$) and this yielded a value of .72 which was found suitable for the experiment/ study.

The pupils in the experimental group received lessons in fraction using inquiry-based instructional strategy enriched with origami activities. Instructional resources included origami papers, crayon, ruler and pencil. The teachers' instructional guide on inquiry-based instructional strategy enriched with origami activities was validated by experts. There were many pupils' activities embedded in the TIGIISOA. The pupils in the control group received lessons in fraction using conventional instruction only (without origami activities). This instructional guide was teacher- dominated. The TIGCIS was validated by experts for its uniformity. The ESATPT was developed to assess research assistants before enlisting them. This was designed to evaluate the trained teachers' effective use of the instructional guide during the teaching. It was divided into two sections: section A consisted of personal data of teachers; while section B is made up of different stages of instructional strategy to be assessed, with a format of a-5 point rating scale, from very-good (5) to very poor (1).

The validity of the instrument was carried out by experts in test construction and mathematics educators. The instrument was used by three raters to assess the performance of teachers on the use of the two strategies in teaching fraction. The inter-rater reliability indexes of the instruments were determined using Scott pie (Scott $\pi$) which gives .79 and .72 for inquiry-based instructional strategy enriched with origami activities and conventional instructional strategy respectively.

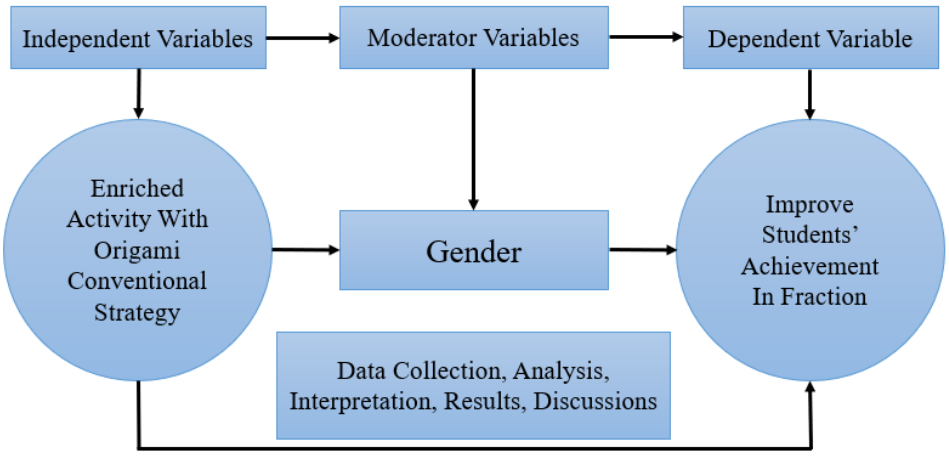


**Figure 1.** Study flowchart

The regular mathematics teachers of the two intact classes were trained as research assistants for a week. All pupils completed the pupils' achievement test in fraction as pre-test before the commencement of treatment. Application of treatment lasted four weeks. The two intact basic three classes were assigned to treatment and control group randomly. The pupils were taught by their regular mathematics teachers trained for the purpose, under the supervision of the researcher. The duration of the lesson was 45 minutes daily. The

topic used for the study was fraction and subtopic included: unit fractions, fraction of shapes, equivalent fractions, and ordering of fractions.

All pupils completed Pupils' Achievement Test in Fraction (PATF) as posttest (same as pretest) after the completion of treatment. The data collected were analysed using Analysis of covariance at .05 level of significance.

## 3. RESULTS AND DISCUSSION

$H_{o1}$: There is no significant main effect of treatment on pupils' achievement in fraction

**Table 1.** Analysis of Covariance (ANCOVA) Showing the Effect of Treatment and Gender on Achievement in Fraction

| Source | TYPE III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 85.280[a] | 4 | 21.320 | 6.010 | .000 | .225 |
| Intercept | 480.380 | 1 | 480.380 | 135.417 | .000 | .620 |
| Pretest | 0.523 | 1 | .523 | .147 | .702 | .002 |
| Treatment | 76.714 | 1 | 76.714 | 21.625 | .000* | .207 |
| Gender | 7.013 | 1 | 7.013 | 1.977 | .163 | .023 |
| Treatment x Gender | 5.037 | 1 | 5.037 | 1.420 | .237 | .017 |
| Error | 294.436 | 83 | 3.547 | | | |
| Total | 3755.000 | 88 | | | | |
| Corrected Total | 379.716 | 87 | | | | |

R Squared = .23 (Adjusted R Squared = 0.19) *denotes significant at .05 level of significance

Table 1 shows that there is a significant main effect of treatment on pupils' achievement in fraction ($F_{(1,87)} = 21.63$, partial $\eta^2 = .21$, $p<.05$). The effect size is 21%, this indicates a significant improvement in the pupils' achievement in fraction after the intervention. This implies that the null hypothesis 1 was rejected. Consequent upon the observed main effect, the marginal means is used to determine the mean post-achievement scores of pupils in each of the groups (experimental and control) as shown in Table 2.

**Table 2.** Estimated Marginal Means for Post-Achievement Scores by Treatment

| Treatment | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Experimental group | 7.17 | .29 | 6.60 | 7.74 |
| Control group | 5.22 | .31 | 4.61 | 5.83 |

Table 2 shows that the experimental group had a higher adjusted post-achievement mean score (7.17) compared to the control (5.22) group .The difference is in favour of inquiry-based instruction enriched with origami activities. This implies that pupils taught using inquiry-based instructional strategy enriched with origami activities had a higher achievement in fraction that those taught using the conventional instructional strategy.

$Ho_2$: There is no significant main effect of gender on pupils' achievement in fraction. The result from Table 2 reveals the main effect of gender on pupils' achievement in fraction was not significant ($F_{(1, 83)} = 1.98$, $p>.05$) at 0.05 level of significance**.** The null hypothesis of no significant main effect of treatment of gender on pupils' achievement in fraction was not rejected. However the slight difference achievement based on gender was presented in Table 3.

**Table 3.** Estimated Marginal Means of Post-Achievement Scores by Gender

| Gender | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| Boys | 5.90 | .26 | 5.39 | 6.41 |
| Girls | 6.49 | .33 | 5.83 | 7.14 |

Table 3 shows that the girls had a slightly higher adjusted post-achievement mean score (6.49) than the boys (5.90). The mean difference (.59) was in favour of the girl, although the difference is not statistically significant. This indicates that gender (whether pupils are boy or girl) does not have significant effect on pupils' achievement in fraction.

$Ho_3$: There is no significant interaction effect of treatment and gender on pupils' achievement in fraction. The results in Table 1 revealed that the interaction effect of treatment and gender is not significant ($F_{(1,83)}$= 1.42, p>.05). The null hypothesis which states that there is no significant interaction effect of treatment and gender on pupils' achievement in fraction is retained. Hence, treatment and gender has no interaction effect on pupils' achievement in fraction.

The discussions of the findings were thus stated; The treatment contributed a substantial change as observed in the achievement gain after the intervention. The experimental group exposed to inquiry-based instruction enriched with origami activities recorded higher marginal means scores compared to their counterpart in the control group. This may be due to the fact that inquiry-based instructional strategy is learner-centred full of activities which allows pupils to interact with the teaching materials through hands-on and minds-on activities during instruction process.

This finding agrees with Ferguson [37], who demonstrated that inquiry based mathematics instruction improves students' achievement in mathematics. Students exposed to inquiry-base instruction approach scored significantly higher in mathematics than their counterpart who were exposed to traditional method of instruction [35], [36], [59], and [60]. This result is in line with studies which have demonstrated that inquiry based learning has been found to support higher-level cognitive interaction [39], longer-term knowledge retention [41], [42], and more efficient collaboration [43].

The result revealed that there was no significant main effect of gender on pupils' achievement in fraction. The result of this study is in line with the findings of [61] who found that male and female did not significantly differ in achievement and retention in mathematics achievement. There was no significant difference in male and female achievement and retention when taught using origami [62]. Likewise, no significant difference in the mean achievement scores of male and female taught using origami [63]. There was no significant difference in the performance of male and female students in mathematics [64]. This is in contrast with the studies which reported gender difference in mathematics learning where males were said to be superior [53]-[55], [65], [66]. More so, the findings of this study revealed that girl child had a higher mean score than their boy counterparts in their achievement in fraction, although the difference was not significant. This implies that inquiry-based strategy as well as origami is gender friendly and effective in the teaching and learning of fractions.

The result of findings showed that there was no significant interaction effect of treatment and gender on pupils' achievement in fraction. That is, the treatment is not gender biased. It agrees with the finding of research who found that there was no significant interaction effect between group and gender in paper folding test and surface development test [46]. This finding contrast at the study of research which demonstrated that the moderating effect of gender among students was significant [37]. [46] also revealed significant interaction effect between group and gender in card rotation test.

## 4. CONCLUSION

Based on the findings of the study, it was established that the inquiry-based instruction enriched with origami activities produced pupils with significantly higher achievement in fraction than those pupils that were taught using conventional teaching method. The study has also shown that the influence of gender was not significant, although girl child demonstrated a slightly higher level of achievement in fraction. Lastly, gender had no moderating effect on achievement in fraction. The study has some educational implications for pupils, teachers and curriculum planners. Active participation of pupils in the class aids achievement and makes the lesson more meaningful. This study has implications on teachers who should adopt inquiry method of teaching, as well as origami activities which engages pupils in the learning process. It allows pupils to explore, discover, draw conclusions, reflect, evaluate and report their findings. Pupils learn better when they are involved in the learning activity. Inquiry-based instruction enriched with origami activities enhance pupils understanding of fraction and develop higher-order thinking skills. The findings of this study also have implication on the curriculum planners who are expected to plan for conceptual change over period of years.

Based on the findings of the study, it is recommended that mathematics teachers should adopt inquiry-based instructional strategy enriched with origami activities in the teaching of fractions to improve pupils' achievement in fraction. This study proved that inquiry-based instructional strategy enriched with origami activities would bridge the gender gap in pupils' achievement in fraction by providing equal opportunities for both boys and girls to interact with teachers, amongst themselves and the resources. Ministry of Education and professional organisations like Mathematics Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN), National Educational Research and Development Centre (NERDC), should organise in-service trainings like workshops, seminars and conferences for mathematics teachers to enhance and make them acquire better instructional strategies.

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