UNIVERSITY OF CAPE COAST

ADDING OR SUBTRACTING FRACTIONS: RELATIVE EFFECTIVENESS OF THE LCM AND THE EQUIVALENT FRACTIONS METHODS

BY

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DECLARATION

CANDIDATE'S DECLARATION

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Name: S. Z. NTRGH Signature: .... Date: 13-12-05

SUPERVISORS' DECLARATION

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

The purpose of the study was to compare the efficiency of the Equivalent Fractions (EF) method and the Least Common Multiple (LCM) method of doing the addition and subtracting of fractions on measures of accuracy and retention. All the 230 Form One students of Kaneshie '3' JSS and Kaneshie '1' JSS in the Okaikwei Sub - Metropolitan Area of the Greater Accra Region were involved in the study. Kaneshie '3' JSS had two streams with an enrolment of 110 students, whilst the Kaneshie '1' JSS with two streams had 120 students. The existing assembled classes of these Form One students were used in the study intact.

The pretest - posttest nonequivalent - groups design was used. The data-collecting instrument developed by the investigator comprised three achievement tests designated pretest, posttest and retention test with co-efficicients of reliability of 0.87, 0.79 and 0.86 (Cronbach Alpha Formula) respectively. A day after the administration of the pretest, the two sets of different groups was taught their respective treatment methods by their respective regular mathematics teachers. A day after the last day of teaching the posttest was administered. After a two - week period with no instructions in the two methods a retention test was administered.

The first six out of the ten hypotheses were analysized by the analysis of covariance, whilst the dependent t-test was used to test the remaining four. The major findings of this study were as follows:

1. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on tasks involving the addition and subtraction of fractions on the posttest.

2. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on the addition of fractions on the posttest.
3. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on subtraction of fraction tasks on the posttest.
4. There was significant difference between the mean scores of the pretest and the posttest for students who used the EF method on the addition and subtraction of fractions.
5. There was no significant difference between the mean scores of the pretest and the posttest for students who used the LCM method on the addition and subtraction of fractions.
6. There was no significant difference between the mean scores of the posttest and retention test for the EF Group.

Based on these findings it was recommended that curriculum developers improve upon the content of both EF and the LCM methods in the JSS and the primary school syllabuses, textbooks, teacher's handbooks and handouts. It was recommended that in-service training courses on the two methods be organised for classroom teachers; and teacher-training institutions include the exploration of theses methods in their programmes in order to expose student teachers to them.

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DEDICATION

This piece of work is dedicated first to my mother, Mariama, my wife and children and to my brothers and sisters.

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CHAPTER 1

INTRODUCTION

Background to the Study

Concerns for the difficulties pupils and students face in the study of fractions have been expressed by numerous researchers and mathematics educators in recent times. Some of these researchers and educators (Beardslee & Jerman, 1978; Bezuk, 1988; Cooney & Hirsh, 1990; Groff, 1994; Kinney, Marks & Purdy, 1965; Silvia, 1986) shared the view that fractions have traditionally been a source of difficulty for both children and adults, and gave various reasons for their claims. Kinney *et al*, (1965) contended that compared with the counting numbers, the historical development of a convenient notation for fractions was slow and algorithm for computing with fractions were unwieldy. They noted that the recording of fractional numbers by naming a pair of whole numbers and the expression of a fractional number in an infinite number of ways could be some of the several sources of difficulty.

Lay (cited in Cooney & Hirsh, 1990) shared similar views with other educators (Beardslee & Jerman, 1978; Silvia, 1986) that another source of the difficulty is that a fractional number is used to represent at least four distinct situations (namely: as a part of a whole, a quotient, a ratio and as a numeral). They observed that children must be familiar with each of the situations if they expect to be able to meaningfully use fractions. Schminke (cited by Groff, 1994) concluded that of all the mathematics taught in the elementary school, fractions are the most bothersome and least understood. Orton (1987) shared the views of Schminke. He noted that nearly all of what teachers teach as fractions in the primary school is re-taught to most pupils in the secondary school, because they have not achieved mastery. Skemp (cited in Orton, 1987) added that fractions provide the obvious example of a mathematical idea previously considered to be elementary which analysis of concept reveals as far from simple.

Some mathematics educators (Ball, 1988; Berman & Friederwitzer, 1983; Oslon, Sindt & Oslon, 1988) shared the view that student achievement tests in recent years show that schools have not yet been very successful in helping students become confident and competent in their use of fractions. They noted that fractions seem to be a problem area in many grade levels. Ball (1988) and Oslon *et al* (1988) concluded that there might be basic developmental pre-requisites that many students have not yet acquired before they are introduced to fractions. It is not surprising, therefore, to note that owing to the difficulties of fractions, Copeland (1967) suggested that informal approach to the concept of fractions should begin in the primary schools, and advised that a formal or organized treatment be deferred to the middle and upper grades of the elementary schools. Copeland's viewpoint was supported by Mandlate (1995) who had observed that until from the age of 12 to 15 years, pupils fail to recognize the infinite nature of equivalent fractions. He emphasized that the form $^a/_b$ for fraction seems to be abstract for most children, and that pupils can hardly visualize the various fractions through geometric models.

Brown, Carpenter, Lindquist, Kouba, Silver & Swarford (cited by Groff, 1994) observed that the 1990 National Assessment of Educational Progress (NAEP) results indicated that less than half of the 12th - grade students demonstrated a consistent grasp of fractions. They observed in this version of the NAEP that in any State in the United State of America (USA) no more than 24 percent of 8th - grade students at the most could solve problems involving fractions that they were taught in the 7th – grade. Lee. Stevenson & Stigler (cited by Groff, 1994) discovered that 5th - grade American children on the average could correctly compute only 15 percent of the fractions examples given them; and found that although Japanese and Chinese children compute twice as effectively as do American children their 5th-graders have relative difficulty of doing so. It was found that the Japanese and Chinese children computed fractions at only a 31 percent rate of success. The success rate of computing non - fraction mathematics items by these Japanese and Chinese were 74 percent and 77 percent respectively. It was noted that the American children in this study computed fractions at a 14 percent rate of success, and non- fraction mathematics items at a 50 percent rate. Keys (1999), commenting on the nine-year olds results for mathematics topic areas on the Third International Mathematics and Science Study (TIMSS), also noted various difficulties children encountered. Keys (1999) observed that the achievement rate of the English 9-year olds on fraction and proportionality exercises was the lowest as compared with the achievement on other mathematics topics. Their success rate of 45 percent and about 48 percent success rate by 9 – year olds from countries other than England were still lower than the rates of other mathematics topics tested.

Evidence of the students' poor achievement levels is also found in other research studies (Beardslee & Jerman, 1978; Ganoe, Grossnickle, Perry & Reckzeh, 1983; Saenz-Ludlow, 1994; Wearne-Hiebert & Hiebert, 1983). Commenting on the results of the National Assessment of Educational Progress (NAEP) in mathematics Saenz-Ludlow (1994) and Wearne-Hiebert & Hiebert (1983) noted that 9-year olds, 13-year olds and 17-year olds showed a low computational performance with fractions and little conceptual understanding. Ganoe, Grossnickle, Perry & Reckzeh (1983) found that the achievement of pupils on the Second National Assessment of Educational Progress (NAEP) was appallingly inadequate for addition and subtraction of fractions. It was noted that one –third of the 13 – year olds tested added numerators and denominators such that $^1/_2 + {^3/_4} = {^4/_6}$. Only one - third of the pupils were able to perform the computation correctly. It was observed that only 26 percent of the 13-year olds on the Second NAEP for selected topics on fractions could work $4^1/_4 + 3^2/_3$ correctly. The results of the National Assessment of Educational Progress (NAEP) Mathematics assessment administered to only 13- year olds and 17 – year olds (Beardslee & Jerman, 1978) showed students' poor performance levels on fractions too. Thirty percent of the 13- year olds added the numerators and denominators to obtain $^2/_5$ for $^1/_2 + {^1/_3}$. Only 42 percent obtained the correct answer. Sixteen percent of the 17-year olds also added the numerators and denominators. Summarising the difficulties of students from the results of the Fourth Mathematics Assessment of the NAEP, the National Council of Teachers of Mathematics (NCTM, 1989) observed that many students appeared to have learnt fraction computation as procedures without developing the underlying conceptual knowledge about fractions. The NCTM (1989) noted that a subtraction item, $7\,^1/_6 - 3\frac{1}{2}$, requiring regrouping was significantly more difficult than the other assessment items for the students. Only thirty two percent of 7th-grade and forty five percent of 11th-grade students assessed were able to compute the item correctly.

The statistics on fraction difficulties is wide spread. In Ghana too the low achievement rate of pupils and students on fractions is prevalent in the basic could not handle fractions and ratio properly; and suggested that the four rules on arithmetic be carefully and clearly taught. The 1993 and 1994 chief examiners' reports (WAEC. 1993,1994) noted poor manipulations of fractions as a significant weakness of candidates. The reports noted that candidates were confusing vectors with numerators and denominators of fractions. To address these difficulties, the reports suggested that candidates should be taken through various forms of fractions and their equivalents. They should also be helped to know the differences between the components of a vector and the numerator and denominator of fractions. The 1999 report (WAEC, 1999) contained yet some difficulties of fractions by students. It noted that multiplying a fraction by a whole number was a problem for students and adding two fractions together was a deeper crisis.

In November 2002, the investigator of this study surveyed the performances of Junior Secondary School Form One students from a few schools in the Okaikwei Sub- Metropolitan Area of the Greater Accra Region. The data collected also emphasized the difficulties of students in interpreting and computing tasks involving fractions. For instance, at Bubuashie ' 1' JSS, out of a number on roll of 43, only 16 percent were able to work $18^3/_4 + 7^1/_3$ correctly. Thirty percent of students who worked it wrongly exhibited some systematic error pattern. They first changed the mixed numerals into improper fractions, and added the numerators. At the Kaneshie Kingsway '2' JSS, out of a number of 49 students 57 percent were able to work $3^2/_3 - 1^1/_6$ correctly. Nineteen percent of the students who had difficulties with this item showed some common pattern of errors to obtain $2^1/_6$ as the answer. They had the least common multiple as 6, but failed to obtain the equivalent fraction for $^2/_3$. At the same school, seventy one percent of the students worked $^2/_3 + ^1/_5$ correctly. However, about 43 percent of the students who had difficulties with this item added the numerators and placed the result over the sum of the denominators to obtain $^3/_8$.

Statement of the Problem

The persistence of the low performance levels of students on fractions particularly on addition and subtraction at the basic schools in Ghana is overwhelming. These difficulties have been confirmed by the results of the CRT for 1992, 1993 and 1995 and the chief examiners' report on mathematics (Amissah, 2000; CRT UNIT, PREP, 1993, 1995; WAEC, 1991, 1993, 1994 & 1999). The survey on the work of the JSS Form One students in November 2002 by the investigator of this study also confirmed these difficulties. The survey showed a few difficulties that need highlighting. On addition task some students had the tendency to add the numerators and place the result over the sum of the denominators. On both addition and subtraction tasks some students had difficulties in computing the Least Common Multiple (LCM). On subtraction items where there was a need for borrowing, most students failed to effectively use the LCM concept for the purposes of regrouping. On occasions when students failed to find the LCM for given fractions, they resorted to the use of the common denominators. However, the use of the common denominators almost always resulted in huge numbers students find difficult to express in the lowest term.

Thus, the difficulties of the computation and application of the LCM concept hamper effective work on fractions. For this reason, the investigator is concerned about whether the continued use of the LCM concept for the teaching of addition and subtraction of fractions in the JSS can bring about the desired conceptual understanding and better achievement levels of work by the students. Systematic procedures for the use of the Equivalent Fractions (EF) method for adding and subtract fractions have been outlined in the primary and JSS teaching syllabuses for mathematics (CRDD, 2001). However, the reality on the ground is that teachers do not use these prescribed methods in the JSS. The survey made by the investigator on the work of the JSS Form One students on addition and subtraction of fractions has emphasized the abandonment of these Equivalent Fraction procedures by the JSS mathematics teachers for the LCM method. The investigator is of the view that, probably, the Equivalent Fractions procedures as presented by the curriculum developers in the syllabuses, if followed by teachers, may be effective in reducing the difficulties of learning fractions.

Therefore, the present study is designed to investigate whether the Equivalent Fractions method will be more effective than the LCM method in alleviating students' difficulties in the addition and subtraction of fractions in the JSS.

Purpose of the Study

The difficulties of the application of the Least Common Multiple (LCM) method in adding and subtracting fractions in the Junior Secondary School bring to the forefront the need to consider other procedures to remedy the situation. The purpose of this study, therefore, is to compare the effect of the use of the Equivalent Fractions (EF) and the LCM methods on the performance of students on tasks involving the addition and subtraction of fractions in Junior Secondary Form One in Accra. The study is to compare the mean scores of the EF Group and the LCM Group on a posttest and retention test to ascertain whether one of the two methods is significantly superior to the other.

Research Questions

The following questions have, thus, been raised to guide the research study.

1. Will students who are taught the use of the Equivalent Fractions (EF) method perform better than those who are taught the LCM method on tasks involving addition of fractions on the posttest?
2. Will students who are taught the use of the EF method perform better than those who are taught the LCM method on tasks involving the subtraction of fractions on the posttest?
3. Will students who are taught the use of the EF method perform better than those who are taught the LCM method on the retention test conducted two weeks after administering the posttest?

Hypotheses

From the fore going questions, the following null hypotheses have been formulated for testing, at the five percent level of significance.

1. There is no significant difference between the mean scores of the Equivalent Fractions (EF) Group and the LCM Group on addition and subtraction of fractions tasks on the posttest.
2. There is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the addition of fractions on the posttest.

3. There is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the subtraction of fractions on the posttest.
4. There is no significant difference between the mean scores of the EF Group and the LCM Group on addition and subtraction of fraction tasks two weeks after administering the posttest.
5. There is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the addition of fractions two weeks after administering the posttest.
6. There is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the subtraction of fractions two weeks after administering the posttest.
7. There is no significant difference between the mean scores of the pretest and the posttest for the EF Group.
8. There is no significant difference between the mean scores of the pretest and the posttest for the LCM Group.
9. There is no significant difference between the mean scores of the posttest and the retention test for the EF Group.
10. There is no significant difference between the mean scores of the posttest and the retention test for the LCM Group.

Assumptions

The following assumptions were made:

1. The students in the LCM and the EF groups are approximately equally motivated.
2. The students of the two separate JSS Form One classes have studied all aspects of fractions as contained in the JSS Teaching Syllabus for Mathematics (CRDD, 2001).
3. The teachers who taught the two methods were assumed to be about equally effective despite their differences in lengths of experiences.

Significance of Study

The value of information a research study gives to expose or solve a problem, its intrinsic ability to inspire and stimulate further research and the amount of light it sheds on specialised knowledge determine the depth of its importance. In this regard, therefore, the significance of this study is outlined as follows:

1. It is envisaged that the results of this study will bring about a better and deeper understanding for addition and subtraction of fraction concepts. A high level of understanding that may result can be applied in the learning of other mathematics topics such as ratios, proportions, simple and compound interests, statistics, probability and mensuration.
2. The results of this study will indicate to classroom teachers the use of either the LCM method or the EF method in teaching addition and subtraction of fractions. The results can be used to modify classroom

instructions, teaching materials on the topic and to remedy students' deficiencies in studying fractions.

3. The results may also be an indicator of one sort or the other to educational and curriculum planners to modify (if necessary) the present scope of topics on fractions in the JSS Mathematics syllabus.

4. Since not much probing has been done into methods of teaching fractions in Africa (Ocran, 2001), it is hoped that the results of this study will serve as reference materials to would-be researchers on the subject and related areas of study.

Delimitations

The study is restricted to the collection and analysis of data on addition and subtraction of fractions in public JSS Form One. Fraction tasks exclude word problems. Denominators of fractions include those that are alike, or have common factors, all being relatively prime or one being a factor of the other. The subtraction items include ones requiring the knowledge of regrouping concept.

Form One students have been chosen due to the fact that in the JSS it is only the Ghana Mathematics Series, Pupil's Book One (CRDD, 1987) that treats fractions.

Limitations

It would have been more ideal for the investigator to use a larger sample size and covered more schools in Accra. However, due to time, material and financial constraints, the study was limited to two schools in Circuit 27 of the Okaikwei Sub- Metropolitan Area. The investigator could not randomly select and assign subjects to the EF and LCM groups. The existing settings of the two schools (that is, the existing assembled classes) were used intact.

The investigator engaged two trained Certificate 'A' teachers for the study. The Form One mathematics teacher from the Kaneshie '3' JSS, with nine years teaching experience as JSS mathematics teacher, instructed the Equivalent Fractions (EF) Group; whilst the Form One mathematics teacher from the Kaneshie '1' JSS, with two years teaching experience as a JSS mathematics teacher, taught the LCM Group. Thus, the effects of differences in teacher effectiveness on the results of the study could not be ruled out. Researcher, in order to control teacher competence and favouritism toward or familiarity with one algorithm, could present instructions in future.

However, the performance pattern of the subjects (see Tables 2, 3 and 4) showed that the EF Group, with the lower mean scores than the LCM Group at pretest had increased more rapidly to higher mean scores at post-test. This picture depicts the presence of a crossover effect and the possible absence of selection-maturation and regression effects on the results of the study.

Definition of Terms

The following terms have been operationally defined to conform to how they have been used in this study.

Equivalent Fractions (EF) Group.

Subjects in this group were assigned the use of the Equivalent Fractions method. The group computed the addition and subtraction of fractions using the Equivalent Fractions procedures.

Least Common Multiple (LCM) Group.

Subjects in this group were assigned the use of the LCM method. Tasks involving the addition and subtraction of fractions were computed by the group using the LCM method.

Equivalent Fractions (EF)-1.

This refers to the first group of subjects in the Equivalent Fractions group. It was made up of 50 students.

Equivalent Fractions (EF)-2.

This constitutes the second group of subjects in the Equivalent Fractions group. It was made up of 51 students.

LCM-1.

This was a group of 52 students. It constitutes the first group of subjects in the LCM Group.

LCM-2.

This was a group of 54 students. It constitutes the second group of subjects in the LCM Group.

Groups-1.

This group refers to the pairing of EF-1 and LCM-1.

Groups-2.

This group refers to the pairing of EF-2 and LCM-2

Pretest-1.

This refers to the first group of subjects in the EF (or LCM) group who wrote the test.

Pretest-2.

This refers to the second group of subjects in the EF (LCM) group who wrote the test.

Posttest-1.

This refers to subjects who wrote the test and constitute the first group in the EF (or LCM) group.

Posttest-2.

This refers to subjects who wrote the test and constitute the second group in the EF (or LCM) group.

Retention Test-1.

This is the classification of subjects who wrote the test and form the first group in the EF (or LCM) group.

Retention Test-2.

This is the classification of subjects who wrote the test and form the second group in the EF (or LCM) group.

Summary of Chapter

The report of this investigation is organised in five chapters. Chapter 1 presents the problem of the study. The presentation includes the statement of the problem, purpose of the study, research questions, hypotheses, assumptions and the significance of the study. The chapter further highlights the delimitations and limitations of the study and concludes with the definition of terms.

Organisation of the Report

The rest of this study is made of four chapters. The literature review is in chapter 2. Chapter 3 presents the research design, population and sampling, instruments and data collection procedure. Chapter 4 reports the statistical results pertaining to the study, followed by the discussions of the results. Chapter 5, the final one, gives an overview of the research problem and methodology, draws conclusions, gives recommendations and suggestions for future research.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this study is to compare the effect of the use of the Equivalent Fractions (EF) and the Least Common Multiple (LCM) methods on the performance of students on tasks involving the addition and subtraction of fractions in the Junior Secondary Schools. The study is to compare the mean scores of the EF Group and the LCM Group on a post-test and retention test to ascertain whether one of the two methods is significantly superior to the other.

The chapter reviews the literature adjudged to be relevant to the study. It is presented in three sections. The theoretical framework is the first. It highlights the general and current consensus among writers on various aspects of fractions. These aspects include the meaning of fractions, equivalent fractions, addition of fractions involving like & unlike denominators, addition of fractions involving mixed numerals, subtraction of fractions involving like & unlike denominators and subtraction of fractions involving mixed numerals. The empirical framework follows second. It discusses studies on the LCM method, studies on EF method and studies on the LCM and EF methods. The summary section concludes the chapter with the summary of the literature review.

Theoretical Framework

Meaning of Fractions

Copeland (1967) defined fractions as symbols or numerals that represent a set called the fractional numbers; and that in the simplest sense a fraction may be thought of as a broken part of some whole. He interpreted fractions as (i) parts of a whole, (ii) parts of a set of objects as well as parts of a single unit, (iii) indicators of division, (iv) indicators of comparisons and (v) numerals. D' Augustine (1968) supported the views of Copeland (1967) and further expressed a fraction in the form $^a/_b$ where a and b name whole numbers; and where a is called the numerator and b the denominator. Other writers (Collier & Lerch, 1969; Fehr & Phillips, 1972; Gerber, 1982; Kinney, Marks & Purdy, 1965; May, 1970) supported the definitions and the attributes of fractions expressed by Copeland. However, Fehr & Phillips (1972) and Gerber (1982) thought it is difficult to maintain the distinction between the use of the words 'fraction' and 'fractional numbers'. D' Augustine (1968) argued that even though it is not appropriate to introduce the child to the definition of fractional numbers in his early intuitive explorations, the basic definition should always play a role in the teacher's presentation. May (1970) added that the fact that the real meaning of fractional numbers cannot be taught until a student's comprehension goes beyond halves and fourths.

Several writers, (Beavers, 1985; Hoelzle, Hutchison & Streeter, 1995; May, 1970; Williams & Shuard, 1988; Reisman, 1977) shared the views of D'Augustine (1968) about the definition of numerators and denominators. It was, however, explained further that the denominator tells us into how many parts a unit or a whole has been divided; and the numerator tells us how many parts of a unit are used. Diagrams in circular, rectangular and triangular forms were used by these writers to illustrate various numerators and denominators. Beardslee & Jerman (1978) and Paling (1982) argued that too often fraction terminology is stressed before children understand any of the basic concepts. They stated that in many instances, children become confused by the terminology. They thought that the introduction of the terms 'numerator' and 'denominator' could be learned easier through the teachers repeatedly using the terms than by forcing the young children to use them.

The mathematics textbooks for the basic schools, Ghana Mathematical Series, Primary Mathematics, Pupil's Book One to Three (CRDD 1991, 1987) introduced fractions as part of a whole and as part of a set. Extensive use is made of shaded congruent portions of geometrical shapes, pictures and the number line in illustrating the meaning of fractions. Significantly, however, is the absence of the use of 'numerator' and 'denominator' in these books. The Ghana Mathematic Series, Primary Mathematics, Pupil's Book Four to Six (CRDD, 1987), revise and emphasize the concept of fractions as a part of whole and part of a set. The Ghana Mathematics Series, Junior Secondary School, Pupil's Book One (CRDD, 1987) uses the number line extensively to consolidate the concept of fractions as part of a whole. This textbook and the Pupil's Book Four to Six (CRDD, 1987) used the terms 'numerator' and 'denominator' without defining them.

Equivalent Fractions

In the views of some writers (Byrne, 1966; Gerber, 1982; Hutchison & Streeter, 1995), two fractions that represent the same fractional number are said to be equivalent or equal. It was expressed that if $^{a}/_{b}$ is equivalent to $^{c}/_{d}$, then $^{a}/_{b} = {}^{c}/_{d}$ if and only if $a.d = b.c$. This was called the equivalence rule. However, other writers (Blevins, Hanson, Podraza & Prall, 1969; Brown & Webber, 1963; Kinney, Marks & Purdy, 1965) chose to call the concept 'the equality of fractions'. The equality principle or the equivalent rule was stated with illustrated examples. Ganoe, Grossnickle, Perry & Reckzeh (1983) stated that although they prefer the use of 'equal fraction' to indicate that two fractional numerals name the same number, both terms can be used to refer to the same idea. Fehr & Phillips (1972) supported the views of Ganoe *et al* (1983) and advised that when teaching the equivalence of fractions it is no real value to distinguish between the logical difference of equal and equivalent. The teacher may refer to $\frac{1}{2}$ and $^{2}/_{4}$ as equal in that they represent the same number. However, Beardslee & Jerman (1978) advised that when discussing equivalent fractions care should be taken to distinguish between the notions of equal and equivalence without confusing the children. The fear was expressed that when children see $^{a}/_{b} = {}^{c}/_{d}$ they might conclude that $a = c$ and $b = d$. It was observed that some textbooks used the symbol '$\approx$'to mean equivalence, but most textbooks use the '=' sign to minimise symbolism. It was noted that one of the reasons that the confusion between equal and equivalence arises is that the region model (the most frequently used model) illustrates equivalent fractions by comparing regions of equal area.

The concept of equivalent fraction was introduced to pupils in the Ghana Mathematics Series, Primary Mathematics, Pupil's Book Three to Six (CRDD, 1987) through the use of geometric shape. Pupil's Book Five and Six (CRDD, 1987) discussed the concept with few illustrated examples. The test of equality, namely, that $^{a}/_{b} = {}^{c}/_{d}$ is true only if $ad = bc$ was stated. The Ghana Mathematics Series, Junior Secondary School, Pupil's Book One (CRDD, 1987) consolidated the concept of equivalent fractions with shaded geometrical shapes and the number line. It concluded with the basic principle for fractions that if a is whole number and b and m are counting numbers, then $^{a}/_{b} = {}^{m\times a}/_{m\times b}$. Anticipating the difficulties teachers might face in the teaching of equivalent fractions some writers (Pothier & Sawada, 1990; Rowan, Payne & Towsley, 1990; Vance, 1992) cautioned that concept develops slowly over time. Teachers were advised to provide many opportunities for students to explore and make major adaptations to textbooks since no current textbook includes sufficient developmental work on concepts.

Addition of Fractions Involving Like and Unlike Denominators.

Several writers (Beavers, 1985; Booth, Dossey, Randull & Smith, 1992; Collier & Lerch, 1969; Demana & Leitzel, 1984; Hoelzle, Hutchison & Streeter, 1995; Shuard & Williams, 1988) outlined procedures for adding fractions with like and unlike denominators. To add two fractional numbers with the same denominators, the numerators should be added, and the sum placed over the common denominator. To add fractional numbers with different denominators; we should use the least common multiple concept to first express the fractions as equivalent fractions with common denominators. The numerators of the resulting fractions should be added and the sum placed over the common denominator. The learner is cautioned to simplify the resulting fraction when necessary. Worked examples were given in all cases to explain the application of the concepts. However, Beavers (1985) and Gerber (1982) offered more diagrammatic illustrations in introducing these concepts.

For the addition of fractions with same denominators, Gerber (1982) stated a principle that if $^a/_b$ and $^c/_b$ are two fractional numbers, then $a/b + c/b = (a+c)/b$ Similarly, for fractional numbers with different denominators, say, a/b *and* c/d, he stated that $a/b + c/d = ad/bd + bc/bd = (ad+bc)/bd$. Several other writers (Bennett & Nelson, 1998; Blevins, Hanson, Podraza & Prall, 1969;

Brown & Webber, 1963; Byrne, 1966; Demana & Leitzel. 1984; Dessart & Suydam. 1978; Dumas & Howard 1966: Lake & Newmark, 1977) shared the views of Gerber (1982). General principles with worked examples were stated. However, Dessart & Suydam (1978) questioned whether or not such a formal definition might serve as an adequate algorithm procedure for children when adding and subtracting fractions, particularly when the denominators are different. It was argued that even though the child may not need to determine a least common denominator, its obvious disadvantage is the increasing number of errors in expressing the final result to lowest term. Ganoe, Grossnickle & Reckzeh (1983) advised teachers to do early problem – solving work involving addition and subtraction of fractions with like denominators on exploratory level, using manipulative materials, drawings and visual models. D'Augustine (1968) shared the views expressed by Ganoe *et al* (1983). He stated that the utilization of a number line offers an advantage over most other models we might choose. He argued that the number line is readily adapted for sums of fractional numbers less than or equal to one, as well as for sums greater than one.

It is worthy to note that the number line and shaded geometric shapes were used to introduce the concept of addition of fractions involving like denominators to pupils in the Ghana Mathematics Series, Primary Mathematics, Pupil's Book Three (CRDD, 1987). Worked examples are illustrated with diagrams. The concept is not consolidated in the Pupil's Book Four (CRDD, 1987) by way of further discussions. Practice exercise on addition of fractions involving like and unlike denominators, nevertheless, have been given to pupils to do. Treatment is given to the addition of fractions involving like and unlike denominators in the Pupil's Book Five (CRDD, 1987). Worked examples have no diagrammatic illustrations. The concept of the least common multiple is used to rename given fractions into equivalent fractions with common denominators. The numerators of these equivalent fractions are added, and the sum placed over the common denominator. In the Ghana Mathematics Series, Primary Mathematics, Pupil's Book Six (CRDD, 1987), under the heading 'Addition and Subtraction of Rational Numbers', definition for the least common denominator and its application are discussed. This discussion was followed by practice exercises involving like and unlike denominators for pupils to do. Worked examples are not given for pupils to study. The Ghana Mathematics Series, Junior Secondary School, Pupil's Book One (CRDD, 1987) introduced only addition of fractions involving unlike denominators with a few worked examples. The concept of the least common multiples to rename the given fractions into equivalent fractions with common denominators was used. The numerators of the equivalent fractions were added and the sum was placed over the common denominator.

Kinney, Marks & Purdy (1965) stated that in the addition of fractions, careful teaching is required to avoid errors such has adding both numerators and denominators. They stated that such difficulties may be avoided by effective selection of experiences whereby pupils name sums by the use of materials and adding fractional numbers is related to adding whole numbers with pupils discovering the procedure. Some writers (Copeland, 1967; Fehr & Philips, 1972; Reisman, 1977) shared the views of Kinney *et al* (1965). A productive pedagogical device that may help to minimize the occurrence of mistakes, such as adding both numerators and denominators was highlighted. This was the use of the write –the- denominator – as – a – word notation, namely, (a) 2 fifths + 1 fifth and (b) 1 half + 1 third. It was commented that this device might be a constant reminder and a check to the learner to transform the fractions to be added so that they both have the same word before adding. Copeland (1967) explained further that a vertical presentation with the numerals as the numerators and the words as the denominators helps to establish the idea of adding the measures (numerators) and thinking of the denominators as the unit of measure.

It is appropriate to note also that Howard (1991) had observed that regardless of what teachers say about the way fractions should be added, students continue to believe that something is fundamentally, correct about the 'top + top' over 'bottom + bottom' method. He noted that students feel incapable of thinking through the meaning of adding fractions on their own and rely instead on habit or rote learning. He concluded that students have difficulty understanding the '+' algorithm for adding fractions because they are unable to fit it into their existing schemas for the numerical operations.

Addition of Fractions Involving Mixed Numbers.

A number of writers (Bennett & Nelson, 1981; Gerber, 1982; Hoelzle, Hutchison & Streeter, 1995; Reisman, 1977) shared similar views about the steps for adding mixed numbers. To add mixed numbers we need to (i) add the whole number parts, (ii) add the fractional parts and (iii) combine the results as mixed numbers. It was explained further that when the fractional portions of the mixed numbers have different denominators, we must rename these fractions as equivalent fractions using the least common denominator in order to perform the addition. Geier & Lamm (1978) and Beavers (1985) shared the views of these writers, but included diagrams to illustrate their worked examples. Even though Wilcox & Yarnelle (1967) and Brown & Webber (1963) shared the views of adding the whole numbers and fractions separately when finding the sum of two mixed numbers: they applied the associative and commutative properties for fractions. In addition to the use of the 'adding the whole numbers and fractions separately' process, other authors offered an alternative method. They (Andries & Touchett, 1999; Beardslee & Jerman, (1978); Collier & Lerch, 1969; Copeland, 1967; and D'Augustine, 1968) suggested re-naming the mixed numbers in improper fractions and then adding. The conversion of the given fractions to improper fractions should be such that they are equivalent with common denominators. The numerators could then be added and placed over the common denominators. However, the application of the improper fractions concept was introduced abstractly; no diagrams were used. But Dessart & Suydam (1978) cautioned that the use of the common denominators method has some disadvantages. The results obtained from this process leave the child with the tedious task of renaming. It is also worthy to note the advice of Hillerby (1967) to teachers. He stated that a careful choice by the teachers of the fractional parts to be added would avoid the calculations becoming too simple. He warned that in the initial stages, it is best to avoid fractions becoming too large and unwieldy. However, Fehr & Phillips (1972) argued that if children understand the principles involved, then they could carry out the operations on fractions with any denominator no matter how large. It was stated that to restrict denominators to those of one digit or two digits that are in common use is to use a mechanistic rote philosophy of learning arithmetic and not a philosophy that leads to learning the meaning and structure of the subject.

Even though the Ghana Mathematics Series, Primary Mathematics, Pupil's Book Five and Six (CRDD, 1987) and the Ghana Mathematics Series, Junior

Secondary School. Pupil's Book One (CRDD, 1987) treated addition of fractions involving like and unlike denominators, they failed to consolidate it with discussions on addition of fractions involving mixed numbers. However, practice exercises given to pupils include tasks involving mixed numbers.

Subtraction of Fractions: Involving Like and Unlike Denominators.

As in the case of the addition of fractions, several writers have outlined procedures for subtracting like and unlike denominators. These writers (Andries & Touchett, 1999; Beavers, 1985; Booth, Dossey, Randull & Smith, 1992; Fehr & Phillips, 1972; Geier & Lamm, 1978; Hoelzle, Hutchison & Streeter, 1995; Scott, 1991; Reisman, 1977) shared similar views that in dealing with like denominators the numerators should be subtracted first. The difference should be placed over the common denominator; and the resulting fraction should be simplified when necessary. With regard to subtraction with different denominators the given fractions should first be expressed as equivalent fractions with common denominators using the least common multiple concept. The numerators could be subtracted and the result placed over the common denominator. Some of the writers (Beavers, 1995; Geier & Lamm, 1978; Hoelzle *et al* 1995; Gerber, 1982) gave procedures with diagrams to illustrate these concepts to reduce the abstractness of the introductions. However, as in the addition of the like and unlike denominators, Fehr & Phillips (1972) and Copeland (1967) offered the use of the write – the – denominator – as – a – word notation for the subtraction concept. It was noted that the presentation in this form might be less abstract. In the expression, for instance, 3 fourths - 1 fourth, the denominator is seen more clearly as a unit of measure; and it is obvious to children that the answer is 2 fourths. It was, however, stated that in subtracting fractions with unlike denominators. the idea of renaming them as equivalent fractions with common denominators is necessary. As in the case of the addition concept, Gerber (1982) with several other authors (Bennett & Nelson, 1998; Blevins, Hanson, Podraza & Prall, 1969; Brown & Webber, 1963; Demana & Leitzel, 1984; Dumas & Howard, 1966; Lake & Newmark, 1977; Peters & Schaaf, 1968) outlined principles for the subtraction concept. For the subtraction of fractions with like denominators, it was stated that if $^{a}/_{b}$ and $^{c}/_{b}$ are two fractional numbers, then $^{a}/_{b} - ^{c}/_{b} = ^{a-c}/_{b}$. Similarly, for fractions with different denominators, $^{a}/_{b}$ and $^{c}/_{d}$ it was stated that $^{a}/_{b} - ^{c}/_{d} = ^{ad}/_{bd} - ^{bc}/_{bd} = ^{(ad-bc)}/_{bd}$ except for the presentation of Gerber (1982) who illustrated the concept and the worked examples with diagrams, most of the writers' introductions were abstractly done.

The Ghana Mathematics Series, Primary Mathematics, Pupil's Book Three and Four (CRDD, 1987) exposed pupils to practice exercises involving subtraction of like and unlike denominators without any worked examples. The Pupil's Book Five (CRDD, 1987) devoted itself to using examples involving only unlike denominators using the concept of the least common denominators. The concept of subtraction involving like denominators was not consolidated by way of examples. In the Pupil's Book Six (CRDD, 1987), definition for the least common multiple and its application were discussed as was done in the case of the addition of fractions. Practice exercises followed these explanations without any worked examples. The Ghana Mathematics Series, Junior Secondary School, Pupil's Book One (CRDD, 1987) introduced the concept of subtraction of fractions with a worked example involving unlike denominators. The concept of the least common multiple was used to re-name the given fractions into equivalent fractions with a common denominator. The numerators were subtracted and the result placed over the common denominator.

Subtraction of Fractions Involving Mixed Numbers.

A number of writers (Bennett & Nelson, 1998; Booth, Dossey Randull & Smith, 1992; Ganoe, Grossnickle, Perry & Reckzeh, 1983; Geier & Lamm, 1978; Gerber, 1982; Fehr & Phillips, 1972; May, 1970; Reisman, 1977) shared the opinion that the difference between two mixed numbers can be found by subtracting the whole numbers and the fractions separately. It was, however, stated that if the denominators of the fractions in the mixed numbers are unequal, the fractions must be replaced having a common denominator before the subtraction is carried out. It was highlighted that in subtracting mixed numbers, where the fraction in the minuend is less than the fraction in the subtrahend regrouping and replacing of fractions having a common denominator might be necessary. In illustrating the computational process, Ganoe *et al* (1983) used $5\ {}^{1}/_{3} - 2\ {}^{2}/_{3}$. The fraction $5\ {}^{1}/_{3}$ was re- named as $4\ {}^{4}/_{3}$. The work was then re-arranged as $4\ {}^{4}/_{3} - 2\ {}^{2}/_{3}$. The whole numbers and the fractions were subtracted separately to yield $2\ {}^{2}/_{3}$. In illustrating the concept, May (1970) stated that in, say, $8\ {}^{1}/_{3} - 5\ {}^{5}/_{8}$, there may be the need to re-name $8\ {}^{1}/_{3}$ as $7\ {}^{32}/_{24}$ and $5\ {}^{5}/_{8}$ as $5\ {}^{15}/_{24}$ to facilitate the subtraction.

Other writers (Andries & Touchett, 1999; Beavers, 1985; Collier & Lerch, 1969; Hoelzle, Hutchison & Streeter, 1995) shared the views of May (1970) and Ganoe *et al* (1983). It was noted that the procedure where the whole numbers and the fractions are subtracted separately is preferred because it relates closely to the method generally used for subtracting whole numbers. It was, however, stated that in subtracting two mixed numbers, re-naming the mixed numbers into improper fractions eliminates the need to regroup (or borrow). In illustrating this view point, Andries & Touchett (1999) stated that in say, $5\frac{1}{4} - 2\,{}^{4}/_{7}$, the fraction $5\frac{1}{4}$ could be re-named as ${}^{147}/_{28}$ and $24/_{7}$ as ${}^{72}/_{28}$ to facilitate the subtraction. May (1970) advised that in a case, say, $6 - 2\,{}^{3}/_{7}$, the 6 could be renamed as $5\,{}^{7}/_{7}$ to facilitate the subtraction. He cautioned that these regrouping procedures are difficult and advised that pupils should be given many practice problems until they understand each step. In treating a similar case, for instance, $6 - 2\frac{3}{4}$, Beavers (1985) and Hoelzle et al (1995) renamed the 6 as ${}^{24}/4$ and the $2\,{}^{3}/_{4}$ as ${}^{11}/_{4}$. The numerators were then subtracted and the result placed over the common denominator.

The Ghana Mathematics Series, Primary Mathematics, Pupil's Book Five and Six (CRDD, 1987) and the Ghana Mathematics Series, Junior Secondary School, Pupil's Book One (CRDD, 1987) failed to give treatment to fractions involving subtraction of mixed numerals. Despite the absence of the discussions on the concept, practice exercises have been given on it in these three textbooks.

Empirical Framework

Studies on the Least Common Multiple (LCM) Method

The difficulties of the applications of the LCM concept have been noted by some research findings (Dessart & Suydam, 1978; Howard, 1991). Howard had noted that anyone who teaches mathematics in grades four to ten is particularly aware of the difficulty students have with fractions in general and with addition of fraction in particular. Lankford (cited by Howard, 1991) supported this view in his studies. He found that students who had been taught basic fractional concept and operations through the use of concrete materials – and who seemed to have good grasp of the concept of fractions – still persisted in the use of a 'top + top' over 'bottom + bottom' algorithm when asked to solve addition problems symbolically. May (cited in Dessart & Suydam, 1978) acknowledging the difficulty of the use of LCM concept, recommended that the notion be introduced in the familiar setting of the multiplication of counting numbers rather than delaying its introduction until fractions are taught. Such an approach, the author noted, permits the LCM concept to serve as a starting point for teaching the addition and subtraction of fractions with unlike denominators.

Stenger (cited in Dessart & Suydam, 1978) explored the formal definition of the addition and subtraction of fractions by using (i) $a/b + c/d = (ad+bc)/bd$ (ii) $a/b - c/d = (ad-bc)/bd$ .He used such presentations with two 5th- grade classes. He found that it was particularly effective during the initial phase of instructions apparently because it removed the difficult step of having children determine the least common denominator. However, this advantage appeared to be traded for the disadvantage of increasing the number of errors in simplifying the final result to the lowest terms. However, Bat-haee (cited in Dessart & Suydam, 1978), in comparing the use of the factoring method (LCM method) and the inspection method for finding the least common denominators found the LCM method to be more effective. These two approaches were used with 112 5th-grade pupils. In the factoring method, denominators were expressed into prime factors in order to select the least common denominator, whilst students employing the inspection method used a less organised manner. Once the inspection method was done in a less organised manner, it might include lots of trials and errors and frustrated learners efforts, leaving the factoring method as the only alternative left for obtaining correct answers. Thus, the finding does not rule out the difficulty of the application of the LCM method.

Studies on Equivalent Fractions Method

Some studies using various types of materials to assess children's understanding of the concept of equivalent fractions have been conducted (Dessart & Suydam, 1978; Silvia, 1986; Vance, 1992).

Vance (1992) stated that the rules 'multiplying the numerator and denominator of a fraction by the same number' are relatively easy to learn, and children generally do well on routine tasks that require them to recognise or generate equivalent fractions. He noted in a study that success on these tasks, however, does not guarantee that the student attaches meaning to the procedures or appreciates the significance of the result. Mandlate (1995), supporting the views of Vance, noted in a study that until from the age of 12 to 15 years pupils fail to recognise the finite nature of equivalent fractions.

In the Boham research (cited in Dessart & Suydam, 1978), three techniques were employed. In one approach, diagrams and sets of objects were employed in which $^{a}/_{b}={}^{axn}/_{bxn}$ was used to generate sets of equivalent fractions. In a second approach, a method similar to the first was used, but paper folding was emphasized. In the third approach, an appeal was made to the 'property of one' to generate the equivalent fractions. Boham reported that the paper-folding technique produced superior results in achievement in a posttest and a retention test. Beardslee, Gau and Heimer (cited in Dessart & Suydam, 1978) used red and blue disks with 5th-and-6th-grade children to demonstrate the concept of equivalent fractions. In spite of the manipulative appeal of disks, the authors favoured the use of arrays of circles drawn on an activity sheet. Silvia (1986), using manipulative materials, led a group of nine-to-eleven-year old deaf children to successfully learn to generate sets of equivalent fractions. She taught the children addition of fractions with unlike denominators using the concept. She found from a post-test result that the children did all the tasks involving addition of fractions correctly. Thus, the findings of Boham, Beardslee, Gau and Heimer (cited in Dessart & Suydam, 1978) and Silvia (1986) support the views of Vance (1992) that the use of concrete and pictorial presentations gives opportunities to students to make meaningful connections among spoken, physical and symbolic representation of numbers.

Studies on the LCM and Equivalent Fractions Methods

Some studies have been conducted to compare the effects of the use of the Equivalent Fractions (EF) method and the LCM method on the performance of subjects on addition and subtraction of fractions (Dessart & Suydam, 1978; Ocran, 2001).

The findings of Duncan et al (cited in Ocran, 2001) showed that the LCM method was superior in measures of speed and accuracy. They noted that the method was less confusing as it does not involve the task of writing down the sets of fractions equivalent to the fractions under consideration. However, the findings of Ocran (2001), conducted at Akim-Oda Township in Ghana using 144 JSS students, contradicted the findings of Duncan et al (cited in Ocran, 2001). Ocran (2001) found the EF method superior, easier to learn and retain. Significantly, however, the findings of Anderson (cited in Dessart & Suydam,

1978) were not confirmed by the findings of Ocran or that of Duncan et al. Anderson's studies (cited in Dessart & Suydam, 1978), conducted in the United State of America (USA), compared the achievements of students who had been taught the use of equivalent fractions procedure and those taught to use the LCM procedure to determine the least common denominators for adding and subtracting fractions. She did not report any significant difference between the two groups. Her findings supported the theoretical assumptions or views of Post and Ott (cited in Ocran, 2001), who gave equal weights to the two procedures and felt that if both are taught properly, each will produce equally good results.

Summary

The following summarises the review of literature that is related to this study.

1. Many writers shared the view that a fraction is in the form $^a/_b$ where **a** and **b** name whole numbers. It was noted that a fraction could be interpreted as (i) part of a whole (ii) part of a set of objects (iii) indicator of a division (iv) indicator of comparison and (v) as a numeral.
2. Several writers agreed that in adding and subtracting fractions with like denominators, the numerators are added or subtracted and the result placed over the common denominator. In the case of fractions with unlike denominators, most writers agreed that the LCM of the denominators of given fractions should first be found. The LCM of these denominators should be used to re-name the given fractions into equivalent fractions. The numerators of the equivalent fractions could then be added or subtracted and the result placed over the common denominator.

3. Other groups of writers, however, used rows of equivalent fractions in the addition and subtraction of fractions. These writers generated equivalent fractions for fractions to be added or subtracted. Equivalent fractions for given fractions with same but least denominators are then selected. Their numerators are added or subtracted and the result placed over the common denominator.
4. In the addition and subtraction of mixed numbers, several writers shared the view that whole numbers and fractions should be added or subtracted separately, and then the result combined as a mixed number. Some writers were of the opinion that in order to avoid the problem of regrouping (or borrowing), mixed numbers may first be expressed as improper fractions before renaming them as equivalent fractions to aid adding or subtracting.
5. Mandlate (1995) noted that until from the age of 12 to 15 years pupils fail to recognise the infinite nature of equivalent fractions. However, Silvia (1986), through the use of manipulative materials, led nine-to-eleven-year-old deaf children to successfully generate sets of equivalent fractions. The concept was used adequately in adding fractions.
6. Anderson (cited in Dessart & Suydam, 1978) compared the achievements of students who had been taught the use of equivalent fractions and those who had been taught to factorise denominators of fractions in order to determine the common denominator. She did not report any significant difference between the two groups. However, the findings of a recent study conducted at Akim- Oda Township in the Eastern Region of Ghana contradict Anderson's results (Ocran, 2001).

Thus, there is evidence to show the efforts made by some researchers (Dessart & Suydam, 1978; Ocran, 2001) to establish the effectiveness of either the EF Method or LCM Method. However, some of their findings have yielded contradictory results (Ocran, 2001). Therefore, the present study is designed to investigate which method will be appropriate in alleviating students' difficulties in the addition and subtraction of fractions.

CHAPTER 3

METHODOLOGY

The methodology discusses the research design, population and sampling procedure for the study. It further discusses the research instrument used in collecting data, the data collection procedure and the method of data analysis.

Research Design

The pretest - posttest nonequivalent groups design was used for the study. It involved an Equivalent Fractions (EF) Group and a Least Common Multiple (LCM) Group. The EF Group was instructed using the EF method, whilst the LCM Group used the LCM method. Both groups were given a pretest before the instructional session. Immediately following two weeks of instructions in the EF and the LCM methods, a post-test was conducted. After a two-week period with no instructions in the two methods, a retention test was administered.

This design was chosen because the existing settings of the two schools (that is, the existing assembled classes) were used intact. This design is feasible for such naturally assembled groups (Best & Khann, 1993; Christensen, 1980).

Population and Sampling

The target population was all public Junior Secondary School Form One students in the Okaikwei Sub-Metropolitan Area of Accra in the Greater Accra Region. The accessible population was all public JSS Form One classes in Circuit 27 of the Sub-Metropolitan Area. The Circuit has nine Junior Secondary Schools. All these schools are mixed. All the Form One students of Kaneshie '3'

JSS and Kaneshie '1' JSS were involved in the study. These two schools were selected by random sampling.

The Form One mathematics teacher from the Kaneshie '3' JSS, a trained Certificate 'A' with nine years teaching experience as JSS mathematics teacher, instructed the EF Group. The Form One mathematics teacher from the Kaneshie '1' JSS, also a trained Certificate 'A' teacher with two years teaching experience as a JSS mathematics teacher, taught the LCM Group. The investigator engaged the two teachers to carry out the treatment session in order to control the effect of experimenter bias.

The samples consisted of students from a wide range of socio-economic background. Parents of subjects were predominantly businessmen, businesswomen or traders, artisans and public servants. The public servants included teachers, doctors, accountants and nurses. The artisans were mainly electricians, masons, tailors, drivers, seamstresses, hairdressers and carpenters (See Appendix A). It was envisaged that since the subjects came from such a heterogeneous parental background they were highly motivated, in respect of academic output, to participate in the study. Each of the sampled schools had two streams. The two streams Form One of Kaneshie '3' JSS had a total enrolment of 110 students, whilst the two streams Form One of Kaneshie '1' JSS had a total enrolment of 120 students. The sample size for the study, therefore, was 230. This number comprised 96 males and 134 females. To verify that subjects involved in the study had about the same level of chronological maturity, their ages were collected, computed and analysed (See Appendix B). The results showed an age range of 12 to 18 years for the Equivalent Fractions Group, with a mean age of 14 years and standard deviation of 1.34. The LCM Group had an age range of 12 to 20 years, with a mean age of 14 years and standard deviation of 1.29. The ages of students and their parents' occupations were collected using a questionnaire provided on the pretest, posttest and retention test (See Appendices C, D and E).

The students wrote a pretest. The duration of the test was 40 minutes. It was conducted in the students various classrooms on the same day and time, and invigilated by the mathematics teachers of the schools. Kaneshie '3' JSS was assigned to the Equivalent Fractions Group because it obtained the lower mean score in the pretest. Kaneshie '1' JSS with the higher mean score was assigned to the LCM Group. The Equivalent Fractions Group School's two streams Form One classes were designated EF-1 and EF-2. The EF-2 obtained the higher mean score in the pretest. Similarly, the LCM Group school's two streams Form One classes were designated LCM-1 and LCM-2. The LCM-2 had the higher mean score in the pretest. The EF-1 with mean score of 14.22 was paired with LCM-1 with mean score of 20.75. Similarly, the EF-2, with the mean score of 16.69, was paired with LCM-2 with mean score of 23.09. These groups were exposed to a two-week treatment session. The posttest means scores of the groups were compared. This was to find out whether the group with the lower mean at pretest might improve to exceed the group with the higher mean. Thus, the arrangement of the groups was put in place to find out whether treatment would yield a crossover effect (Christensen, 1980).

Instruments

One pretest, a post-test and a retention test all developed by the investigator were used for the study (see Appendices C, D and E). A ten-item test on addition and subtraction of fractions for the pretest was administered on the Equivalent Fractions Group and the LCM Group before treatment. Another set of a ten – item test equivalent to the pretest instrument was administered on the two groups for the posttest scores immediately following instructions. A test with equivalent set of items to the posttest was conducted two weeks after a period of no instructions for the retention test scores.

Validation of Test Instruments

The investigator developed the tests (pretest, posttest and the retention test) administered in the study with the assistance of two experienced JSS mathematics teachers. The assistance and contributions offered helped to focus the contents of these tests on addition and subtraction tasks Form One students were exposed to in their school work and as expressed in their textbook, the Ghana Mathematics Series, JSS, Pupil's Book One (CRDD, 1987).

The contents of the instrument had been read through and vetted by one of the investigator's supervisors, Mr. J. Gyening, of the Science Education Department of the University of Cape Coast. Comments made by the supervisor helped tremendously to improve the content and face validity of the instrument.

Reliability Co-efficient

The tests administered for the study were pilot-tested on three sets of 40 (a total of 120) Form One students of New Abossey Okai '1' & '3' Junior Secondary schools in the Ablekuma Sub-Metropolitan Area of the Greater Accra

Region on February 12th 2003. Each set of 40 students answered only one test. These schools had neither been considered for sampling nor covered by the investigator's visits of schools in the Okaikwei Sub-Metropolitan Area in November 2002. The sampled schools are separated from the Abossey Okai schools by a distance of about three kilometres and as such the effect of interaction was minimised.

Since the scoring of the entire test items were not on either correct or wrong basis, but on a partial credit-marking scheme, the Cronbach Alpha Formula was used to compute the co-efficient of reliability of the pretest, post-test and the retention test (McMillan, 1996). The co-efficient of reliability were found to be approximately 0.87, 0.79 and 0.86 respectively for the pretest, post-test and the retention test (See Appendix F).

Mode of Scoring

Marking schemes for the pretest, post-test and the retention test were read through and vetted by one the investigator's supervisors, Mr. J Gyening (See Appendix G). For the Section A of all the three tests, a total of five points could be scored on the first item, that is, Question 1. Five points could be scored on Question 2; four points on Question 3; six points on Question 4 and five points on Question 5. For Section A, therefore, a total score of zero to twenty five was possible. For Section B of all the three tests, a total of five points each could be scored on Questions 6 and 7. Four points could be scored on Question 8; five points on Question 9 and six points on Question 10. Thus, a total score of zero to twenty five was possible for Section B.

Data Collection Procedure

On Monday, April 28, 2003 the investigator contacted the heads of the two schools sampled with copies of a letter of introduction from the Head of the Science Education Department of the Faculty of Education, University of Cape Coast to ask for permission to conduct the study. At separate meetings the heads of the two schools agreed to release their students for the study. The mathematics teachers for the Form One classes of the two schools were informed and asked to give the investigator the necessary co-operations. It was agreed to use a four-day programme a week of 40 minutes per session for instructions. Mathematics periods as scheduled on the JSS Form One timetable were allocated for these lessons.

The procedure for data collection was in four phases. Phase one involved the pretest, phase two the treatment session, phase three the post-test and phase four the retention test.

Phase one dealt with the conduct of the pretest. It was administered on Friday, May 2nd, 2003, in the third term of the 2002/2003 academic years. The test was conducted in the students various classrooms on the same day and time under their normal terminal examination conditions. The investigator printed the test items on sheets of paper. The mathematics teachers of the various schools, who invigilated, distributed the test papers with answer sheets for working. The students sat one to a desk. They were allowed to carry only pens, pencils, rulers and erasers into the classrooms for the test. They were asked to write their index numbers, ages, sexes and the occupations of their parents at blank spaces provided on the test papers. Students were then asked to start work. The test lasted 40 minutes. The investigator collected all the scripts from the invigilators.

The marking of the test items was done solely by the investigator using a partial credit marking scheme (See Appendix G).

Phase two involved two weeks of instructional treatment. It started on Tuesday, 6th May 2003, and was completed on Thursday, May 15th, 2003. The investigator briefed the mathematics teacher of the EF Group on the use of the equivalent fractions concept for the addition and subtraction of fractions to enable her carry out the treatment session adequately. The teacher of the LCM Group, however, continued to use the traditional LCM concept for instructions during the session. The teachers of the LCM and the EF groups used a four-day programme a week of 40 minutes per session for instructions as agreed upon. Scripted daily lesson plans were made available to the teachers for use (see Appendices H and I). The two teachers were engaged to carry out the treatment session in order to control the effect of experimenter bias. However, the investigator was present at the schools so that after each daily lesson he would confer with the teachers and ensure appropriate preparations for subsequent lessons.

Owing to the excitements the teachers and the students showed at the presence of the investigator in the classrooms during the first lesson, such observations were discontinued. However, daily assignments the teachers gave to the students were received for marking. Items for these assignments were the same for both treatment groups. Errors and misconceptions found in the assignments were discussed with the teachers for corrections in the subsequent lessons.

At the first lesson of the treatment session, the LCM Group was taught addition and subtraction of two fractions, one whose denominator is a factor of the other. (See Table 1). This lesson was treated after a review of addition and subtraction of fractions with like denominators. The EF Group was taught how to generate and identify equivalent fractions at the first lesson and addition and subtraction of fractions, one whose denominator is a factor of the other at the second lesson. The LCM and EF Groups were taught addition and subtraction of fractions, with denominators that are relatively prime, at the second and the third lessons respectively. Addition and subtraction of fractions, with denominators that have common factors, were studied by the LCM Group at the third and fourth lessons respectively, whilst the EF Group learnt these topics at fourth and fifth lessons. Addition and subtraction of mixed numbers requiring no regrouping were treated at the fifth and sixth lessons respectively for the LCM Group. The EF Group learnt these topics at the sixth and seventh lessons. Subtraction of mixed numbers requiring regrouping was treated at the seventh and eighth lessons for the LCM Group, whilst the EF Group studied it at the eighth lesson.

Phase three dealt with the posttest. It was administered on Friday, May 16th, 2003. This test was designed to assess the effect of the treatment given to the two groups for the two weeks period. The LCM and the EF Groups were tested on posttest items (See Appendix D). The EF Group answered the test items using the Equivalent Fractions method, whilst the LCM Group used the LCM method. The test was conducted in the students various classrooms and was invigilated by the mathematics teachers of the schools. It was conducted in the same manner as was done for the pretest. Its duration was 40 minutes.

Phase four concluded the study with the administration of a retention test. It was conducted on Friday, May 30th, 2003 after the elapse of a two-week retention period during which no treatment was given. The steps for conducting the pretest were followed for administering the retention test too.

The data on nine students in the EF Group and fourteen in the LCM group were eliminated from the subsequent analyses. Owing to their numerous absences from school, these students could not write the pretest or posttest; and so none of them had data for all the three tests. Therefore, the investigator had adequate data covering only 101 students for the EF Group and 106 students for the LCM Group. The EF-1 had 50 students, comprising 19 males and 31 females. The EF-2 with 51 students had 21 males and 30 females. The LCM -1 had 52 students comprising 24 males and 28 females, whilst the LCM-2 with 54 students was made up of 22 males and 32 females. In all cases, the investigator was solely responsible for marking the tests.

Data Analysis

Data available in this study included: (i) the pretest scores, (ii) the posttest scores and (iii) the retention test scores.

These data were analysed to determine whether there was any significant difference in performance between the EF Group and the LCM Group on addition and subtraction of fractions.

Since the existing groups of the two schools were used intact and were assigned to the respective treatments on the basis of their pretest scores, the analysis of covariance was utilized to test hypotheses 1 to 6 (Christensen, 1980) (See Appendix K). The use of the analysis of covariance was intended to compensate for any variations that might have existed initially between the two

Table1

Design of the Study

Phase	Date	EF Group	LCM Group
1	2/5/03	Pretest	Pretest
2	6/5/03	Generating & Identifying EF	Adding & Subtracting Fractions. One denominator as a factor of the other
	7/5/03	Adding & Subtracting Fractions. One denominator as a factor of the other.	Adding & Subtracting Fractions. Denominators relatively prime.
	8/5/03	Adding & Subtracting Fractions. Denominators relatively prime	Adding Fractions. Denominators with common factors
	9/5/03	Adding Fractions. Denominators with common factors	Subtracting Fractions. Denominators with common factors
	12/5/03	Subtracting Fractions .Denominators with common factors	Adding Mixed Numbers (No regrouping)
	13/5/03	Adding Mixed Numbers (No regrouping)	Subtracting Mixed Numbers (No regrouping)
	14/5/03	Subtracting Mixed Numbers. (No regrouping)	Subtracting Mixed Numbers (Regrouping)
	15/5/03	Subtracting Mixed Numbers (Regrouping)	” ”
3	16/5/03	Post-test	Post-test
4	30/5/03	Retention Test	Retention Test

groups (Best & Khann, 1993). However, a dependent t-test was employed to test hypotheses 7 to 10 (See Appendix L). This test statistic is appropriate since the mean scores referred to in these hypotheses are for the same group of subjects who have not been randomly assigned (Best & Khann, 1993). In all cases, alpha 0.05 level of significance was used for the testing.

CHAPTER 4

RESULTS OF THE STUDY AND DISCUSSIONS

This chapter summarises the results of the statistical analyses of this study in relation to the formulated hypotheses. The results of the statistical tests, the decisions to retain or reject each hypothesis and the implications of the decision are highlighted. Discussions on the research findings are included. The chapter is divided into three parts: descriptive statistics, hypotheses related to the sampled groups and finally, discussions of the research findings.

Descriptive Statistics

In order to provide a better view of the population sampled, the means, standard deviations and adjusted means of the Equivalent Fractions (EF) and the LCM Groups have been reviewed. The means and standard deviations for both groups in all the three tests are summarised in Tables 2 – 4. The variables employed include N, the number of subjects; M, the mean score; SD, the standard deviation, LCM, LCM Group; EF, Equivalent Fractions Group; GM, the general means; T.1, the pretest; T.2, post- test and T.3, retention test. The number 1 after a variable in the Tables 2- 19 indicated the first group and 2 indicated the second group. The maximum total score for tasks involving addition and subtraction of fractions in each of the tests was 50; the maximum total score for addition of fractions (Section A) was 25; and subtraction of fractions (Section B) was 25. The inclusion of the Tables 5 – 20, and Appendix J, showing means, standard deviations and the adjusted means of the subjects give a clearer picture about their performance levels.

Table 2

Means and Standard Deviations for Designated Groups on Addition and Subtraction of Fractions

Test	EF. 1		LCM.1		EF. 2		LCM. 2	
	M	SD	M	SD	M	SD	M	SD
T.1	14.22	17.07	20.75	14.5	16.69	15.22	23.09	13.14
T.2	25.88	15.05	23.38	13.23	25.25	13.85	24.02	12.48
T.3	23.2	16.08	22.33	12.28	26.61	11.3	24.98	12.09

Table 3

Means and Standard Deviations for Designated groups on Addition of Fractions

Test	EF. 1		LCM.1		EF. 2		LCM. 2	
	M	SD	M	SD	M	SD	M	SD
T.1	7.54	8.91	11.29	7.77	8.57	8.0	11.61	7.08
T.2	13.6	7.81	11.94	7.23	13.27	7.5	11.48	7.4
T.3	12.14	8.88	10.6	5.35	14.16	7.82	12.76	6.11

Table 4

Means and Standard Deviations for Designated Groups on Subtraction of Fractions

Test	EF. 1		LCM.1		EF. 2		LCM. 2	
	M	SD	M	SD	M	SD	M	SD
T.1	6.68	8.85	9.46	7.53	8.12	8.22	11.46	6.81
T.2	12.28	8.88	11.44	7.78	11,98	8.30	12.54	6.95
T.3	11.06	8.83	11.73	7.62	12.45	6.32	12.22	6.99

Introduction to Hypotheses

The hypotheses 1 and 4 test for the significant difference between the mean scores of the EF Group and LCM Group on addition and subtraction of fraction tasks in the posttest and retention test respectively. Hypothesis 2 tests for the significant difference between the mean scores of the two groups on tasks involving the addition of fractions in the posttest, whilst hypothesis 5 tests for the difference in the retention test. Similarly, hypothesis 3 tests for the significant difference between the mean scores of the two groups on subtraction of fractions in the posttest, whilst hypothesis 6 tests for the same difference in the retention test. Hypothesis 7 tests for the significant difference between the mean score of the pretest and the posttest for the EF Group and the hypothesis 8 tests for the same difference in the LCM Group. Hypothesis 9 and 10 test for the significant difference between the mean scores of the posttest and the retention test for the EF Group and LCM Group respectively.

Hypothesis 1

It was hypothesized that there is no significant difference between the mean sores of the EF Group and the LCM Group on addition and subtraction of fraction tasks on the posttest.

The analysis of covariance of the post-test scores for the addition and subtraction of fractions comparing the two groups is shown in Table 5. As reflected in Table 5, the F_1 ratio was 1.57 at 0.05 significant level and degrees of freedom of 1 and 99. From tables, the critical value F_1 (1, 99) was 3.92. The F_1 ratio was less than the critical value. At 0.05 significant level and degrees of freedom of 1 and 102, the tabulated F_2 was read to be 3.92, and the computed F_2 value was found to be 0.194. The F_2 ratio value (0.194) was less than the critical value F_2 (3.92). Thus, there was no evidence to reject the null hypothesis. Therefore, the conclusion was that there was no significant difference between the mean scores of the EF and LCM Groups on addition and subtraction of fraction tasks in the posttest. Though the adjusted means showed that the EF Groups had higher mean scores on the posttest (See Table 6), the difference was not significant.

Table 5

Analysis of Covariance of Posttest Scores for Addition and Subtraction of Fractions, Using Pretest Scores as Covariate

Source of Variance	df	SS	MS	F_1
Between Groups –1	1	311.8	311.8	1.57
Within Group –1	99	19724.7	199.2	
Totals	100	20036.5		

Table 5 cont'd

Source of Variance	df	SS	MS	F_2
Between Groups-2	1	34.6	34.6	0.194
Within Groups-2	102	18192.4	178.4	
Totals	103	18227		

Table 6

Addition and Subtraction of Fractions: Pretest (x) – Posttest (y).

Adjusted Post-test Means

Groups	N	Mx	My	My.x (Adjusted)
LCM.1	52	20.75	23.38	22.87
EF.1	50	14.22	25.88	26.40
General means		17.55	24.63	

Groups	N	Mx	My	My.x (Adjusted)
LCM-2	54	23.09	24.02	23.99
EF-2	51	16.69	25.25	25.28
General means		19.98	24.64	

Hypothesis 2

It was hypothesized that there is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the addition of fractions on the posttest.

Table 7 shows the analysis of covariance of the post-test for addition of fractions for the two groups. At 0.05 significant level and degrees of freedom of 1 and 99, the tabulated F_1 was read to be 3.92 and the computed F_1 value was found to be 2.074. The F_1 ratio value (2.074) was less than the critical value F_1 (3.92). At 0.05 significant level and degrees of freedom of 1 and 102 the tabulated F2 was read to be 3.92 and the computed F_2 value was found to be 1.616. The F_2 ratio value (1.616) was less than the critical value F_2 (3.92). For these reasons, there was no evidence to reject the null hypothesis. The conclusion was that there was no significant difference between the mean scores of the EF and LCM Groups on tasks involving the addition of fractions on the posttest. Though the adjusted means showed that the EF Group had higher mean scores in the posttest (See Table 8), the difference was not significant.

Table 7

Analysis of Covariance of Posttest Scores for Addition of Fractions, Using Pretest Scores as Covariate.

Source of Variance	df	SS	MS	F_1
Between Group-1	1	117.6	117.6	2.074
Within Groups –1	99	5615.4	56.7	
Totals.	100	5733		

Table 7 cont'd

Source of Variance	df	SS	MS	F_2
Between Groups –2	1	92.3	92.3	1.616
Within Groups –2	102	5828.5	57.1	
Totals	103	5920.8		

Table 8

Addition of Fractions: Pretest (x) – Posttest (y), Adjusted Post-test Means.

Groups	N	Mx	My	My.x (Adjusted)
LCM –1	52	11.29	11.94	11.69
EF –1	50	7.54	13.6	13.87
General means		9.5	12.77	

Groups	N	Mx	My	My.x (Adjusted)
LCM –2	54	11.61	11.48	11.42
EF –2	51	8.57	13.27	13.33
General means		10.13	12.38	

Hypothesis 3

It was hypothesized that there is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the subtraction of fractions on the posttest.

Table 9 shows the analysis of the covariance comparing the two groups posttest scores for subtraction of fractions. With reference to this table, the F_1 ratio was 0.707 at 0.05 significant level and degrees of freedom of 1 and 99. From tables, the critical value, F_1 (1,99) was 3.92. The F_1 ratio was found to be less than the critical value F_1. Similarly, the F_2 ratio was 0.16 and the critical value F_2 was 3.92 at 0.05 significant level and degrees of freedom of 1 and 102. The F_2 ratio was less than the critical value F_2. Thus, there was no evidence to reject the null hypothesis. The conclusion, therefore, was that there was no significant difference between the mean scores of the EF and LCM Groups on tasks involving the subtraction of fractions in the posttest. However, the adjusted means indicated that the EF Group had slightly higher mean scores on the posttest (See Table 10); but the difference was not significant.

Table 9

Analysis of Covariance of Posttest Scores for Subtraction of Fractions, Using Pretest Scores as Covariate.

Source of Variance	df	SS	MS	F_1
Between Groups –1	1	48.6	48.6	0.707
Within Groups –1	99	6798.9	68.7	
Totals	100	6847.5		

Source of Variance	df	SS	MS	F_2
Between Groups –2	1	9.6	9.6	0.16
Within Groups –2	102	6126.1	60.1	
Totals .	103	6135.7		

Table 10

Subtraction of Fractions: Pretest (x) – Posttest (y). Adjusted Posttest Means.

Groups	N	Mx	My	My.x(Adjusted)
LCM–1	52	9.46	11.44	11.15
EF -1	50	6.68	12.28	12.58
General Means		8.10	11.86	

Groups	N	Mx	My	My.x (Adjusted)
LCM –2	54	11.46	11.54	11.57
EF –2	51	8.12	11.98	11.95
General means		9.84	11.76	

Hypothesis 4

It was hypothesized that there is no significant difference between the mean scores of the EF Group and the LCM Group on addition and subtraction of fraction tasks two weeks after administering the posttest.

The analysis of covariance comparing the groups is shown in Table 11. The critical value F_1 at 0.05 significant level and degrees of freedom of 1 and 99 was 3.92 as against the computed F_1 ratio of 0.045. Thus, the F_1 ratio value was less than the critical value F_1. At the same 0.05 significant level and degrees of freedom of 1 and 102, the F_2 ratio (0.404) was found to be less than the critical value F_2 (3.92). For these reasons, there was no evidence to reject the null hypothesis. The conclusion was that there was no significant difference between the means scores of the EF and LCM Groups on addition and subtraction of fraction tasks two weeks after administering the posttest. Though the adjusted means showed that the EF Group had higher mean scores on the retention test (See Table 12), the difference was not significant.

Table 11

Analysis of Covariance of Retention Test Scores for Addition and Subtraction of Fractions, Using Posttest Scores as Covariate.

Source of Variance	df	SS	MS	F_1
Between Groups –1	1	9.4	9.4	0.045
Within Groups –1	99	20525.6	207.3	
Total	100	20535		

Source of Variance	df	SS	MS	F_2
Between Groups –2	1	55.8	55.8	0.404
Within Groups –2	102	14086	135.1	
Total	103	14141.8		

Table12

Addition and Subtraction of Fractions: Posttest (x) - Retention Test (y), Adjusted Retention Test Means.

Groups	N	Mx	My	My.x (Adjusted)
LCM –I	52	23.38	22.33	22.47
FE -1	50	25.88	23.2	23.06
General means		24.61	22.77	

Groups	N	Mx	My	My.x (Adjusted)
L CM -2	54	24.02	24.98	25.06
EF -2	51	25.25	26.61	26.53
General means		24.62	25.8	

Hypothesis 5

It was hypothesized that there is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the addition of fractions two weeks after administering the posttest.

The result of the analysis of covariance comparing the two groups is shown in Table 13. At 0.05 significant level and degrees of freedom of 1 and 99, the critical value F_1 was read as 3.92. The F_1 ratio of 0.397 was found to be less than the critical value. Similarly, at 0.05 significant level, and degrees of freedom of 1 and 102, the critical value F_2 gave 3.92 as against the computed F_2

ratio value of 0.828. The F_2 ratio value was also less than the critical value F_2. Thus, there was no evidence to reject the null hypothesis. The conclusion was that there was no significant difference between the mean scores of the EF and LCM Groups on tasks involving the addition of fractions two weeks after administering the posttest. The adjusted means showed, however, that the EF Group had higher mean scores in the retention test (See Table 14); but the difference was not significant.

Table 13

Analysis of Covariance of Retention Test Scores for Addition of Fractions, Using Posttest Scores as Covariate.

Source of Variance	df	SS	MS	F_1
Between Groups –1	1	17.5	17.5	0.397
Within Groups -1	99	4363.1	44.1	
Totals	100	4380.6		

Source of Variance	df	SS	MS	F_2
Between Groups –2	1	41.5	41.5	0.828
Within Groups -2	102	5108.8	50.1	
Totals	103	5150.3		

Table 14

Addition of Fractions: Posttest (x) – Retention Test (y), Adjusted Retention Test Means.

Groups	N	Mx	My	My.x (Adjusted)
LCM -1	52	11.94	10.6	10.96
EF –1	50	13.6	12.14	11.79
General means		12.78	11.37	

Groups	N	Mx	My	My.x (Adjusted)
LCM –2	54	11.48	12.76	12.82
EF -2	51	13.27	14.16	14.10
General Means		12.35	13.46	

Hypothesis 6

It was hypothesized that there is no significant difference between the mean scores of the EF Group and the LCM Group on tasks involving the subtraction of fractions two weeks after administering the posttest.

The comparison of the two groups, using the analysis of covariance, is shown in Table 15. The critical value F_1 at 0.05 significant level and degrees of freedom of 1 and 99 was 3.92 as against the computed F_1 ratio value of 0.574. The F_1 ratio value was, therefore, less than the critical value F_1. At the same 0.05 significant level and degrees of freedom of 1 and 102, the F_2 ratio of 0.049 was again found to be less than the critical value F_2 of 3.92. For these reasons, there was no evidence to reject the null hypothesis. The conclusion, therefore, was that there was no significant difference between the mean scores of the EF and LCM Groups on tasks involving the subtraction of fractions two weeks after administering the posttest. The adjusted means (See Table 16) supported this conclusion.

Table 15

Analysis of Covariance of Retention Test Scores for Subtraction of Fractions, Using Post-test Scores as Covariate.

Source of Variance	df	SS	MS	F_1
Between Groups –1	1	30.1	30.1	0.574
Within Groups -1	99	5190.1	52.4	
Totals	100	5220.2		

Source of Variance	df	SS	MS	F_2
Between Groups –2	1	2.2	2.2	0.049
Within Groups –2	102	4624	45.3	
Totals	103	4626.2		

Table 16

Subtraction of Fractions: Posttest (x)-Retention Test (y). Adjusted Retention Test Means

Group	N	Mx	My	My.x (Adjusted)
LCM –1	52	11.44	11.73	11.93
EF–1	50	12.28	11.06	10.85
General means		11.85	11.40	

Group	N	Mx	My	My.x (Adjusted)
LCM -2	54	12.54	12.22	12.19
EF-2	51	11.98	12.45	12.48
General means		12.27	12.34	

Hypothesis 7

It was hypothesized that there is no significance difference between the mean scores of the pretest and the posttest for the EF Group.

The comparison of the pretest and the post-test for the EF Group was tested by a dependent t-test and is shown in Table 17. At 0.05 significance level, and degrees of freedom of 49, the critical t_1 value was 2.01. The computed t1 value was 3.95. Hence, the computed t_1 value was greater than the tabled t_1. Similarly, at 0.05 significant level and degrees of freedom of 51, the critical t_2 value was 2.01; and the computed t_2 value was 2.96. The computed t_2 was again greater than the tabled t_2 value. For these reasons, there was evidence to reject the null hypothesis. The conclusion was that there was significant difference between the mean scores of the pretest and the posttest for the EF Group.

Table 17

Analysis of the Difference Between the Mean Scores of the Pretest and Posttest of the Equivalent Fractions Group.

Group	N	Mean	SD	df	t_1
Pretest –1	50	14.22	17.07	49	3.95
Posttest –1	50	25.88	15.05		

Group	N	Mean	SD	df	t_2
Pretest –2	51	16.69	15.22	50	2.96
Posttest -2	51	25.25	13.85		

Hypothesis 8

It was hypothesized that there is no significant difference between the mean scores of the pretest and the posttest for the LCM Group.

The comparison of the pretest and the posttest for the group was tested by a dependent t-test and is shown in Table 18. At 0.05 significant level and degrees of freedom of 51, the critical t_1 value was 2.01. The computed t_1 value was 1.06, thus, the computed t_1 value was less than the critical t_1 value. Similarly, at 0.05 significant level, and degrees of freedom of 53, the critical t_2 value was 2.01. The computed t_2 value was 0.375. The computed t_2 (0.375) was, therefore, less than the critical t_2 value (2.01). Thus, for these reasons, there was no evidence to reject the null hypothesis. The conclusion was that there was no significant difference between the mean scores of the pretest and the posttest for the LCM Group.

Table 18

Analysis of the Difference Between the Mean Scores of the Pretest and the Posttest for the LCM Group.

Group	N	Mean	SD	df	t_1
Pretest –1	52	20.75	14.5	51	1.06
Posttest –1	52	23.38	23.23		

Group	N	Mean	SD	df	t_2
Pretest –2	54	23.09	13.14	53	0.375
Posttest –2	54	24.02	12.48		

Hypothesis 9

It was hypothesized that there is no significant difference between the mean scores of the posttest and the retention test for the EF Group.

The comparison of the posttest and the retention test for the group was tested by a dependent t-test and is shown in Table 19. At 0.05 significant level and degrees of freedom of 49, the critical t_1 value was 2.01. The computed t_1 value was 1.295. The computed t_1 value was thus, less than the critical t_1 value. Similarly, at 0.05 significant level, and degrees of freedom of 50, the critical t_2 value was 0.601. The computed t_2 (0.601) was thus, less than the critical t_2 value (2.01). For these reasons, there was no evidence to reject the null hypothesis. The conclusion was that there was no significant difference between the mean scores of the posttest and retention test for the EF Group.

Table 19

Analysis of the Difference Between the Mean Scores of the Post-test and the Retention Test for the Equivalent Fractions Group.

Group	N	Mean	SD	df	t_1
Posttest –1	50	25.88	15.05	49	1.295
Retention Test –1	50	23.2	16.08		

Group	N	Mean	SD	df	t_2
Posttest –2	51	25.25	13.85	50	0.601
Retention Test-2	51	26.61	11.3		

Hypothesis 10

It was hypothesized that there is no significant difference between the mean scores of the posttest and the retention test for the LCM Group.

The comparison of the post-test and the retention test for the group was tested by a dependent t-test and is shown in Table 20. At 0.05 significant level and degrees of freedom of 51, the critical value t_1 was 2.01. The computed t_1 value was 0.544. Thus, the computed t_1 value was less than the critical t_1 value. Again, at 0.05 significant level and degrees of freedom of 53, the critical t_2 value was 2.01, and the computed t_2 was 0.43. The computed t_2 (0.43) was, thus, less than the critical t_2 value (2.01). Hence, there was no evidence to reject the null hypothesis. The conclusion, therefore, was that there was no significant difference between the mean scores of the posttest and the retention test of the LCM Group.

Table 20

Analysis of the Difference Between the Mean Scores of the Posttest and the Retention Test for the LCM Group.

Group	N	Mean	SD	df	t_1
Posttest –1	52	23.38	13.23	51	0.544
Retention Test –1	52	22.33	12.28		

Group	N	Mean	SD	df	t_2
Posttest –2	54	24.02	12.48	53	0.43
Retention Test –2	54	24.98	12.09		

DISCUSSIONS

(i) Results of Tests on Addition and Subtraction of Fractions

Hypothesis 1 postulated that there is no significant difference between the mean scores of the EF and LCM Groups on addition and subtraction of fraction tasks on the posttest.

The analysis of covariance comparing the two groups revealed that there was no significant difference between the mean scores of the Equivalent Fractions and the LCM Groups (See Table 5). This means that there was no significant difference in performance between the JSS Form One students who used the Equivalent Fractions method and the LCM method on tasks involving the addition and subtraction of fractions on the posttest. This finding confirms the finding of Anderson (cited in Dessart & Suydam, 1978), in a study conducted in the USA. She reported no significant difference between the achievements of students who had been taught to use Equivalent Fractions method and those taught to use the LCM method to do addition and subtraction of fractions. The finding also confirms Anderson's report that the highest percentage of errors she registered was due to simplifying fractions. This finding also confirms the finding of Silvia (1986). She had to treat the simplification of fractions exclusively at a separate lesson in order to eliminate the difficulties or errors pupils had on addition of fractions.

The present study registered about 83.9 percent and 62.3 percent of the total EF and the LCM Groups respectively who wrongly simplified or failed to simplify fractional answers on the posttest. Similarly, about 90.4 percent and 87.3 percent of the total EF and the LCM Groups respectively wrongly simplified or failed to simplify fractional answers in the retention test. (See Appendix M).

The finding, however, contradicts the finding of Duncan *et al* (cited in Ocran, 2001). Duncan *et al* (cited in Ocran, 2001) reported that the LCM method was superior to the EF method on measures of speed and accuracy. They concluded that the LCM method is less confusing as it does not involve the task of writing down sets of fractions equivalent to the fractions under consideration. The finding of this study again contradicts that of Ocran (2001). His study, which involved 144 JSS students, was conducted at Akim Oda Township in the Eastern Region of Ghana. He compared the efficiency of the EF and the LCM methods. He found that the EF method was easier to learn and retain.

Hypothesis 4 postulated that there is no significant difference between the mean scores of the EF and LCM Groups on addition and subtraction of fraction tasks two weeks after administering the posttest. The analysis of covariance comparing the two groups showed that there was no significant difference between the mean scores of the EF and LCM groups on addition and subtraction of fraction tasks two weeks after administering the posttest (See Table 11). This finding implies that there was no significant difference between the achievements of the JSS Form One students who used the EF method and the LCM method on tasks involving the addition and subtraction of fractions on the retention test. Even though the summaries of the analyses of covariance for hypotheses 1 and 4 were not statistically significant, their respective EF Group mean scores were all higher than the LCM Group mean scores (See Tables 6 & 12).

Hypothesis 7 postulated that there is no significant difference between the mean scores of the pretest and the posttest for the EF Group. A comparison of the two results tested by a dependent t-test showed that there was significant difference between the mean scores of the pretest and the posttest for the EF

Group (See Table 17). This means that the achievement of the EF Group, using the EF method, on the addition and subtraction of fractions was higher on the posttest than on the pretest (See Tables 2 & 6). A comparison of similar results (See Table 18) tested by a dependent t-test, however, showed that there was no significant difference between the mean scores of the pretest and the posttest for the LCM Group who used the LCM method. This finding shows that the treatment on the EF Group yielded some dividends. Nevertheless, the EF Group could not sustain this gain. Two weeks after the posttest, there was no significant difference between the means of the posttest and the retention test (See Table 19). The comparison of the posttest and the retention test for the LCM Group, tested by a dependent t-test, also did not show any significant difference (See Table 20). Thus, the raw scores of the EF and the LCM Groups on the addition and subtraction of fractions (Appendices N & P) with their corresponding low means and standard deviations (See Table2) are indications that the students had some difficulties with the tests. This conclusion confirms the observations of mathematics educators (Groff, 1994; Orton, 1987) that students have difficulties with fractions in the elementary schools.

The contradictions of the finding of this current study with Duncan *et al* (cited in Ocran, 2001) and that of Ocran (2001); and its confirmation of the findings of Anderson (cited in Dessart & Suydam, 1978) may have some theoretical implications. The investigator is inclined to support the views of Post and Ott (cited in Ocran, 2001) that if both methods and procedures (the EF and the LCM methods) are taught properly, each will produce equally good results.

ii) Results of Tests on Addition of Fractions

Hypothesis 2 postulated that there is no significant difference between the mean scores of the EF and the LCM Groups on tasks involving the addition of fractions on the posttest.

The result of the analysis of covariance comparing the groups (See Table 7) showed that there was no significant difference in performance between the JSS Form One students using the EF method and the LCM method on the addition of fractions. Similarly, the result of the analysis of covariance (See Table 13) comparing the mean scores of the EF and the LCM Groups on the retention test administered two weeks after the post-test was not significant. Despite these results, the mean scores of the EF Group were higher than those of the LCM Group on the posttest and the retention test (See Tables 8 and 14). However, the raw scores of the EF and the LCM Groups on the addition of fractions (Appendices Q and R) with their respective mean scores (See Table 3) showed the relatively low achievement levels of the students. This observation is an indication that the students had difficulties with the concept. The difficulties of the concept confirms the conclusion of Howard (1991) who had noted in the USA that teachers in grades four to ten were aware of the difficulty students have with fractions in general and with addition of fractions in particular.

About 42 students out of the sample of 101 of the EF Group, constituting about 41.6 percent were able to compute Questions 1 and 5 correctly on the posttest (See Appendix D). Incidentally, this percentage is the highest for this test. For the LCM Group, 34.9 percent, the highest percentage of students, obtained full marks for Question 1. (See Appendices S and T). Appendix M showed the cases of students who computed the addition of fractions by placing the sum of the numerators over the sum of the denominators. These cases dropped from 32.5 percent of the total EF Group on the pretest to 8.6 percent on the posttest, and from 10.2 percent of the total LCM Group on the pretest to 10.1 percent on the posttest. The prevalence of these cases, even after the treatment session, confirms the finding of Lankford (as cited in Howard, 1991) that students who had been taught basic fractional concept and operations - and who seemed to have a good grasp of the concept of fractions - still persisted in the use of a 'top + top' over 'bottom + bottom' algorithm when asked to solve addition problems symbolically. The tendency of students to solve addition problems this way was also confirmed by Saenz-Ludlow (1994). From the results of the National Assessment of Educational Progress (NAEP) he found that 13-year olds and 17-year olds added numerators and placed the result over the sum of denominators for the solution of fractional addition problems.

(iii) Results of Tests on Subtraction of Fraction

Hypothesis 3 postulated that there is no significant difference between the mean scores of the EF and LCM Groups on tasks involving the subtraction of fractions on the posttest.

The result of the analysis of covariance comparing the two groups, as shown in Table 9, was not significant. This means that there was no significant difference in performance between the JSS Form One students who used the EF method and the LCM method on subtraction of fraction tasks. Similarly, the result of the analysis of covariance (See Table 15) comparing the mean scores of the EF and the LCM Groups on a retention test administered two weeks after the posttest was not significant. In spite of these results, the mean scores of the EF

Group were all higher than those of the LCM Group on the posttest. However, not all the mean scores of the Equivalent Fractions Group were higher than the mean scores of the LCM Group in the retention test. In addition to these observations, the raw scores of the EF and the LCM Groups on the subtraction of fractions and their mean scores (See Appendices U & V and Table 4) again showed the relatively low achievement levels of the students. This observation buttressed the fact that the students had difficulties with subtraction of fractions too. Appendix M also showed the cases of students who computed the subtraction of fractions by placing the differences of the numerators over the differences of the denominators. These cases dropped from 23.1percent of the total EF Group on the pretest to 4.5 percent on the posttest; and from 9.5 percent of the total LCM Group on the pretest to 7.6 percent on the posttest.

The frequency of marks obtained by students for each question is summarised in Appendices S and T. Questions 6 to 10 in each test constitute section B, all of which are subtraction items. These appendices showed that even half the numbers of students in each group answered no question correctly to merit the award of full marks. For instance, the Question 10, the item requiring regrouping, was one of the questions the students found difficult to compute. From the EF Group, for instance, twelve out of the 101 students, forming about 11.9 percent of the sample, computed the Question 10 correctly on the pretest, whilst about 69.3 percent scored zero. On the posttest about 26.7 percent were able to compute item ten correctly, whilst 47 percent scored zero. On the retention test the percentage of students computing the item ten correctly dropped to 12.9 percent, whilst 44.6 percent scored zero. May (1970) confirmed that these regrouping procedures are difficult and advised that students should be given many problems until they understand each step.

The difficulties showed by the students on the addition and subtraction of fractions in this study confirm the results of the Ghana Criterion-.Referenced Tests (CRT) for 1992, 1993 and 1995 (CRT UNIT, PREP, 1993, 1995). These poor CRT results are against the background that in the primary school mathematics syllabus (CRDD, 2001) procedures for adding and subtracting fractions are mainly in EF method. Therefore, the primary six pupils who wrote the CRT might have learnt and used the EF method for more than one academic year before writing them. The fact that students' difficulties surfaced again at the JSS Form One even when their teachers had abandoned the EF method for the LCM method strengthens the significance of the result of this study.

Thus, the finding of this study that there was no significant difference between the performance of the JSS Form One students who used the EF and the LCM methods on the addition and subtraction of fraction tasks may reflect the true picture of affairs on the ground. In the light of the difficulties students face in the learning of addition and subtraction of fractions, the investigator of this study tends to agree with the cautions and suggestions of Payne, Rowan and Towsley (1990) and Vance (1992). That is, concept develops slowly over time, and as such teachers need to make major adaptations to textbooks since no current textbook includes sufficient developmental work on concepts. Thus, a lot of teaching time may have to be given to the teaching of addition and subtraction of fractions. These concepts may have to be introduced only after the concepts of adding; subtracting, multiplying and dividing whole numbers are firmly established and rooted. In addition, as Vance (1992) suggested, students need to be provided with many opportunities to make connections among spoken, physical and symbolic representations of numbers to enhance the learning and teaching of addition and subtraction of fractions in the basic schools.

SUMMARY

The chapter was devoted to summarising the results of the statistical analyses of this study. The decisions as to whether to retain or reject each hypothesis and discussions on the research findings had been highlighted. The summary of decisions made, on the basis of the findings, regarding the retention or rejection of proposed null hypothesis, is as follows:

(i). Hypothesis 1: There was no significant difference between the mean scores of the EF and LCM Groups on addition and subtraction of fraction tasks on the posttest. This finding confirms the findings of Anderson (cited in Dessart & Suydam, 1978) but contradicts that of Ocran (2001)

(ii). Hypothesis 2: There was no significant difference between the mean scores of the EF and the LCM Groups on tasks involving the addition of fractions on the posttest. Though the adjusted mean scores of the EF Group were higher than those of the LCM Group the difference was not significant.

(iii). Hypothesis 3: There was no significant difference between the mean scores of the EF and LCM Groups on tasks involving the subtraction of fractions on the posttest. Even though the adjusted mean scores of the EF Group were higher than those of the LCM Group the difference was significant.

(iv). Hypothesis 4: There was no significant difference between the mean scores of the EF and the LCM Groups on addition and subtraction of fraction tasks two weeks after administering the posttest.

(v). Hypothesis 5: There was no significant difference between the mean scores of the EF and the LCM Groups on tasks involving the addition of fractions two weeks after administering the posttest. Despite this result, the adjusted mean scores of the EF Group were higher than those of the LCM Group but the difference was not significant.

(vi). Hypothesis 6: There was no significant difference between the mean scores of the EF and the LCM Groups on tasks involving the subtraction of fractions two weeks after administering the posttest.

(vii). Hypothesis 7: There was significant difference between the mean scores of the pretest and the posttest for the EF Group. This result showed that the treatment on the EF Group yielded some dividends.

(viii). Hypothesis 8: There was no significant difference between the mean scores of the pretest and the posttest for the LCM Group.

(ix). Hypothesis 9: There was no significant difference between the mean scores of the posttest and the retention test for the EF Group.

(x). Hypothesis 10: There was no significant difference between the mean scores of the posttest and the retention test for the LCM Group.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Overview

Students in the basic schools in Ghana experience lots of difficulties in computing tasks on the addition and subtraction of fractions. These difficulties have been confirmed by the Criterion-Referenced Tests (CRT) for 1992, 1993, 1995 and the chief examiners' report on mathematics (Amissah, 2000; CRT UNIT, PREP, 1993, 1995; WAEC, 1991, 1993, 1994 & 1999). The survey on the work of JSS Form One students on addition and subtraction of fractions in a few selected schools in Accra in November 2002, by the investigator of this study also confirmed these difficulties. The survey showed that the students computed these tasks using the LCM procedures.

However, systematic procedures for the use of the EF method for adding and subtracting fractions have been outlined in the primary and JSS mathematics syllabuses (CRDD, 2001). Therefore, the investigator was concerned about the continued use of the LCM method by the teachers at the JSS. The investigator was of the opinion that the Equivalent Fractions procedures as presented in the syllabuses, if followed by the teachers, might be effective in reducing the difficulties of learning fractions. The purpose of this study, therefore, was to compare the effect of the use of the EF and the LCM methods on the performance of students on tasks involving the addition and subtraction of fractions in Junior Secondary Form One in Accra. The comparison was to ascertain whether one of the methods was significantly superior to the other.

The existing assembled classes of Form One students of Kaneshie '3' JSS and Kaneshie '1' JSS were used intact in the study. Kaneshie '3' JSS, with a number on roll of 110, was assigned to the EF Group, whilst the Kaneshie '1' JSS, with an enrolment of 120, was assigned to the LCM Group. Kaneshie '3' JSS was assigned to the EF Group because it obtained the lower mean score in the pretest. The EF Group School's two streams Form One classes were designated EF -1 and EF - 2. The EF –2 obtained the higher mean score in the pretest. Similarly, the LCM Group School's two streams Form one classes were designated LCM –1 and LCM –2. The LCM –2 had the higher mean score in the pretest. The EF –1, with mean score of 14.22, was paired with the LCM –1, with a mean score of 20.75. The EF –2, with a mean score of 16.69, was paired with LCM –2, with a mean score of 23.09. These pairings were done for the purposes of the treatment session and comparisons in the study.

The EF Group received instructions on addition and subtraction of fractions using the EF method; and the LCM Group was taught using the LCM method. The investigator briefed the mathematics teacher of the EF Group on salient points of the EF method to enable her carry out the treatment session effectively. The EF Group teacher has got nine years teaching experience as a JSS mathematics teacher. The LCM Group teacher, with two years teaching experience as a JSS mathematics teacher, however, continued to use the traditional LCM method for instructions during the session. After two weeks of instructions a posttest was conducted. After a retention period of two weeks during which no instructions were given to the groups, the students wrote a retention test. The posttest and retention test scores were analysed to determine whether there was any significant difference in performance between the students who used the concept of EF and the LCM procedures. The analysis of covariance was used to test hypotheses 1 to 6; whilst a dependent t-test was employed to test hypotheses 7 to 10. Since the existing groups of the two schools were used intact and were assigned to the EF and LCM Groups on the basis of their pretest scores, the analysis of covariance was used in order to compensate for any variations that might have existed initially between the two groups. The mean scores referred to in hypotheses 7 to 10 were for the same group of subjects who were not randomly assigned; therefore, a dependent t-test was used to test them. The major findings in this study were as follows:

1. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on tasks involving the addition and subtraction of fractions in the post-test. This finding confirms the finding of Anderson (cited in Dessart & Suydam, 1978), but contradicts that of Ocran's (2001).

2. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on the addition of fractions on the posttest. Even though not significant, the adjusted mean scores of students who used the EF method were higher than the means of those who used the LCM method.

3. There was no significant difference between the mean scores of JSS Form One students who used the EF method and the LCM method on subtraction of fraction tasks. Though the adjusted mean scores of students who used the EF method were higher than the means of those who used the LCM method the difference was not significant.

4. There was significant difference between the mean scores of the pretest and the posttest for students who used the EF method on the addition and subtraction of fractions. The higher adjusted mean scores of the posttest scores support this finding.

5. There was no significant difference between the mean scores of the pretest and the posttest for students who used the LCM method on the addition and subtraction of fractions.

6. There was no significant difference between the mean scores of the posttest and the retention test for the EF Group.

Conclusions

From the results of this study, the following conclusions could be drawn.

1. There was no significant difference between the performances of the JSS Form One students who used the EF method and the LCM method on tasks involving the addition and subtraction of fractions. This finding confirms the findings of Anderson (cited in Dessart & Suydam, 1978). Thus, from the inconsistency of this current finding with the findings of Duncan *et al* (cited in Ocran, 2001) and that of Ocran (2001), it could be concluded that if both methods were taught effectively, each would produce equally good results. This conclusion confirms the theoretical assumptions of Post (cited in Ocran, 2001).

2. The performance of the JSS Form One students who used the EF method on tasks involving the addition and subtraction of fractions was higher in the posttest than in the pretest. But there was no significant difference

between the posttest and pretest mean scores of students who used the LCM method. These findings showed the presence of the cross-over effect (Christensen, 1980), and confirms the fact that the EF Group had some gains over the LCM Group even though not significant.

3. Considering the performance levels of the students on addition of fractions separately from the subtraction of fractions, there was no significant difference between the achievements of the students who used the LCM method and the EF method. This finding confirms the earlier conclusions - and buttresses the theoretical assumption of Post (cited in Ocran, 2001) - that, if taught properly, there would be no significant difference between the mean scores of the users of the EF method and the LCM method.

Recommendations

It is envisaged that the results of this study might impact positively on the Ghanaian basic mathematics curriculum and bring about better and deeper understanding for addition and subtraction of fractions. In the light of the findings in this study the investigator proposes the following recommendations.

1. Curriculum developers must improve upon both the EF and the LCM methods in the JSS and the primary school syllabuses and textbooks.
2. The two procedures (the LCM and the EF methods) need to be explained thoroughly in teacher's handbooks so that teachers who decide to opt for any one may use the steps effectively for the benefit of the students.

3. Lots of study materials such as handouts on the EF method and the LCM method are made available to all pupils and students who are studying the addition and subtraction of fractions.
4. The Mathematics Association of Ghana and heads of schools need to organise in-service training courses for mathematics teachers and acquaint them with the salient points and procedures of the two procedures adequately. This training may enable practising teachers to update their knowledge on the two methods and make meaningful choices for any one of them.
5. Teacher training institutions could include the exploration of both the EF and the LCM methods in their programmes; and require trainees to be well acquainted with the two methods for adding and subtracting fractions.

Suggestions for Future Research

In redesigning this study, the following recommendations should be considered.

1. The sample size should be improved and the number of teachers to be engaged be increased adequately. A much larger size would enhance the validity of the findings. Different environmental settings (namely, urban or rural) are suggested for a future study at the same time.
2. It is suggested that the selected group of subjects for a future study be stratified to include boys only, girls only, the gifted and the less gifted separately.

3. The two weeks of instructions of 40 minutes per day for this study might have been too brief. A future researcher may increase the instructional time and include the measurement of the speed of the subjects.

4. Daily scripted lesson notes and handouts should be given to teachers engaged in the study to practise for a longer period of time before the treatment session.

5. A close-circuit TV may be used to capture the treatment lessons for the necessary viewing by a future researcher in order to ensure the use of the lesson notes as planned. In order to control observer distraction, the investigator failed to observe the teachers directly.

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APPENDICES

APPENDIX – A

Distribution of Occupation of Parents of Subjects

(i) EF. Group (N = 101)

Occupation	Frequency Of Father	%	Frequency of Mother	%
Public Servant	27	26.74	7	6.93
Farming	5	4.95	1	0.99
Business/Trading	21	20.79	79	78.22
Artisan	42	41.58	12	11.88
Forces	5	4.95	-	-
Herbalist	-	-	-	-
Chief	-	-	-	-
Not Specified	1	0.99	2	1.98
Total	101	100%	101	100%

(ii) LCM. Group (N = 106)

Occupation	Frequency of Father	%	Frequency of Mother	%
Public Servant	24	22.65	10	9.44
Farming	10	9.44	1	0.94
Business/Trading	25	23.58	92	86.79
Artisan	41	38.68	3	2.83
Forces	3	2.83	-	-
Herbalist	1	0.94	-	-
Chief	1	0.94		
Not Specified	1	0.94	-	-
Total	106	100%	106	100%

APPENDIX – B

Sex/Age Distribution of Subjects (EF & LCM Groups)

(i) EF Group (N = 101)

Age	Male	%	Female	%
12	1	2.5	7	11.5
13	10	25	21	34.4
14	13	32.5	21	34.4
15	8	20	4	6.6
16	4	10	5	8.2
17	3	7.5	3	4.9
18	1	2.5	-	-
19	-	-	-	-
20	-	-	-	-
Total	40	100%	61	100%

(ii) LCM Group (N = 106)

Age	Male	%	Female	%
12	4	8.7	4	6.7
13	10	21.7	25	41.7
14	12	26.1	14	23.3
15	14	30.4	11	18.3
16	4	8.7	6	10.0
17	1	2.2	-	-
18	-	-	-	-
19	-	-	-	-
20	1	2.2	-	-
Total	46	100%	60	100%

a) Mean Age of EF Group $= \frac{\text{Total Age of Subjects}}{101}$

$= \frac{1419}{101}$

$= 14.049$

$= 14$yrs

Standard Deviations (SD) $= \sqrt{\frac{\sum X^2}{N} - \left(\frac{\sum X}{N}\right)^2}$

Where $\sum X^2 = 20117$; $\sum X = 1419$

$$SD = \sqrt{\frac{20117}{101} - \left(\frac{1419}{101}\right)^2}$$

$= 1.338 \quad = 1.34$

(b) Mean Age of LCM Group $= \frac{1487}{106}$

$= 14.028$

$= 14$ yrs.

$$SD = \sqrt{\frac{21037}{106} - \left(\frac{1487}{106}\right)^2}$$

$= 1.2923$

$= 1.29$

APPENDIX C

J.S.S. FORM ONE PRETEST TIME: 40MINS

The purpose of this test is purely an exercise to collect information for a research work. The result will not be used in any way to assess or grade you. Feel free to respond to all the items.

a. School

b. Index Number

c. Sex: Male ☐ Female ☐

d. Age:

e. What is the occupation of your parents?

(i) Father:

(ii) Mother:

ANSWER ALL THE QUESTIONS IN SECTIONS A & B ON YOUR ANSWER SHEET.

All working must be clearly shown. Give answers in their simplest form.

SECTION A

Find the following sums.

1. $\frac{3}{6} + \frac{1}{6}$

2. $\frac{2}{5} + \frac{14}{35}$

3. $\frac{2}{3} + \frac{1}{5}$

4. $\frac{2}{9} + \frac{5}{6}$

5. $2\frac{3}{8} + 1\frac{1}{12}$

SECTION B

Do the following subtractions.

6. $\frac{7}{10}-\frac{3}{10}$

7. $\frac{8}{12}-\frac{1}{3}$

8. $\frac{8}{7}-\frac{3}{4}$

9. $\frac{11}{15}-\frac{2}{6}$

10. $3\frac{3}{5}-1\frac{2}{3}$

APPENDIX D

J.S.S. FORM ONE POST-TEST TIME: 40MINS

The purpose of this test is purely an exercise to collect information for a research work. The result will not be used in any way to assess or grade you. Feel free to respond to all the items.

A School:

B Index Number

C Sex: Male ☐ Female ☐

D Age:

E What is the occupation of your parents?

(i) Father:

(ii) Mother:

ANSWER ALL THE QUESTIONS IN SECTIONS A AND B ON YOUR ANSWER SHEET.

All working must be clearly shown. Give your answers in their simplest form.

SECTION A

Find the following sums.

1. $\frac{5}{14}+\frac{7}{14}$

2. $\frac{15}{42}+\frac{3}{7}$

3. $\frac{5}{17}+\frac{2}{3}$

4. $\frac{7}{10}+\frac{5}{6}$

5. $3\frac{1}{8}+1\frac{3}{10}$

SECTION B

Do the following subtractions.

6. $\frac{13}{16}-\frac{11}{16}$

7. $\frac{7}{6}-\frac{2}{3}$

8. $\frac{8}{9}-\frac{4}{5}$

9. $\frac{9}{18}-\frac{1}{4}$

10. $5\frac{1}{8}-3\frac{1}{5}$

APPENDIX E

J.S.S. FORM ONE RETENTION TEST TIME: 40MINS

The purpose of this test is purely an exercise to collect information for a research work. The result will not be used in any way to assess or grade you. Feel free to respond to all the items.

A School

B Index Number

C Sex: Male ☐ Female ☐

D Age:

E What is the occupation of your parents?

(i) Father:

(ii) Mother:

ANSWER ALL THE QUESTIONS IN SECTIONS A AND B ON YOUR ANSWER SHEET.

All working must be clearly shown. Give your answers in the simplest form.

SECTION A

Find the following sums:

1. $\frac{9}{20}+\frac{7}{20}$

2. $\frac{7}{15}+\frac{6}{30}$

3. $\frac{4}{7}+\frac{2}{5}$

4. $\frac{11}{18}+\frac{2}{4}$

5. $3\frac{1}{4}+2\frac{1}{6}$

SECTION B

Do the following subtractions:

6. $\frac{11}{12}-\frac{5}{12}$

7. $\frac{7}{3}-\frac{4}{9}$

8. $\frac{5}{7}-\frac{3}{5}$

9. $\frac{5}{6}-\frac{7}{10}$

10. $3\frac{1}{3}-1\frac{3}{5}$

APPENDIX - F

Computation of the Co-efficient of Reliability

Formula Used: Cronbach Alpha Formula

$$r_{11} = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum (SD^2_i)}{SD^2_x}\right)$$

Where K = number of items

SD^2_x = Variance of items

$\sum (SD^2_i)$ = Total of variances of each item

i) Pretest

$K = 10$; $SD^2_x = 84.294$; $\sum (SD^2_i) = 18.325$

$$r_{11} = \frac{10}{9}\left(1 - \frac{18.325}{84.294}\right)$$

$= 0.87$

ii) Post-test

$K = 10$; $SD^2_x = 59.76$; $\sum (SD^2_i) = 17.2701$

$$r_{11} = \frac{10}{9}\left(1 - \frac{17.2701}{59.76}\right)$$

$= 0.79$

iii) Retention Test

$K = 10$; $SD^2_x = 69.347$; $\sum (SD^2_i) = 15.395$

$$r_{11} = \frac{10}{9}\left(1 - \frac{15.695}{69.347}\right)$$

$= 0.86$

APPENDIX G

MARKING SCHEME FOR TESTS

Pretest

(1) $\frac{3}{6}+\frac{1}{6}$

$=\frac{3+1}{6}$ 3

$=\frac{4}{6}$ 1

$=\frac{2}{3}$ 1

(2) $\frac{2}{5}+\frac{14}{35}$

$=\frac{14+14}{35}$ 3

$=\frac{28}{35}$ 1

$=\frac{4}{5}$ 1

(3) $\frac{2}{3}+\frac{1}{5}$

$=\frac{10+3}{15}$ 3

$=\frac{13}{15}$ 1

(4) $\frac{2}{9}+\frac{5}{6}$

$=\frac{4+15}{18}$ 3

$=\frac{19}{18}$ 1

$=1\frac{1}{18}$ 2

(5) $2\frac{2}{8}+1\frac{1}{12}$

$=3+\frac{9+2}{24}$ 4

$=3\frac{11}{24}$ 1

(Alternative Method)

(5) $2\frac{2}{8}+1\frac{1}{12}$

$=\frac{19}{8}+\frac{13}{12}$ 1

$=\frac{57+26}{24}$ 2

$=\frac{83}{24}$ 1

$=3\frac{11}{24}$ 1

(6) $\frac{7}{10} - \frac{3}{10}$

$= \frac{7-3}{10}$ 3

$= \frac{4}{10}$ 1

$= \frac{2}{5}$ 1

(7) $\frac{8}{12} - \frac{4}{3}$

$= \frac{8-4}{12}$ 3

$= \frac{4}{12}$ 1

$= \frac{1}{3}$ 1

(8) $\frac{8}{7} - \frac{4}{3}$

$= \frac{32-21}{28}$ 3

$= \frac{11}{28}$ 1

(9) $\frac{11}{15} - \frac{2}{6}$

$= \frac{22-10}{30}$ 3

$= \frac{12}{30}$ 1

$= \frac{2}{5}$ 1

(10) $3\frac{3}{5} - 1\frac{2}{3}$

$= 2 + \frac{9-10}{15}$ 4

$= 1 + \frac{24-10}{15}$ 1

$= 1\frac{14}{15}$ 1

(Alternative Method)

(10) $3\frac{3}{5} - 1\frac{2}{3}$

$= \frac{18}{5} - \frac{5}{3}$ 1

$= \frac{54-25}{15}$ 3

$= \frac{29}{15}$ 1

$= 1^{14}/_{15}$

Post-test (LCM Method)

(1) $\frac{5}{14} + \frac{7}{14}$

$= \frac{5+7}{14}$ ...3

$= \frac{12}{14}$ ...1

(2) $\frac{15}{42} + \frac{3}{7}$

$= \frac{15+18}{42}$ ...3

$= \frac{33}{42}$ ...1

$= \frac{6}{7}$ ...1

$= \frac{11}{14}$ ...1

(3) $\frac{5}{17} + \frac{2}{3}$

$= \frac{15 + 34}{51}$ ...3

$= \frac{49}{51}$ ...1

(4) $\frac{7}{10} + \frac{5}{6}$

$= \frac{21 + 25}{30}$ ...3

$= \frac{46}{30}$ ...1

$= \frac{23}{15}$ ...1

$= 1^8/_{15}$ ...1

(5) $3^1/_8 + 1^3/_{10}$

$= (3 + 1) + (^1/_8 + ^1/_{10})$

$= 4 + \frac{5 + 12}{40}$ ...4

$= 4^{17}/_{40}$ ...1

(5) (Alternative Method)

$3^1/_8 + 1^3/_{10}$

$= \frac{25}{8} + \frac{13}{10}$ ...1

$= \frac{125 + 52}{40}$ ...2

$= \frac{177}{40}$ ...1

$= 4^{17}/_{40}$ ...1

(6) $\frac{13}{16} - \frac{11}{16}$

$= \frac{13 - 11}{16}$ ...3

$= \frac{2}{16}$ ...1

$= \frac{1}{8}$ ...1

(7) $\frac{7}{6} - \frac{2}{3}$

$= \frac{7 - 4}{6}$ ...3

$= \frac{3}{6}$ ...1

$= \frac{1}{2}$ ...1

[illegible]

Alternative Method

[illegible]

Post-test: Equivalent Fractions Method

[illegible]

(3) $\frac{5}{17} + \frac{2}{3}$

$= \frac{15}{51} + \frac{34}{51}$ ...2

$= \frac{15 + 34}{51}$ ...1

$= \frac{49}{51}$ ...1

(4) $\frac{7}{10} + \frac{5}{6}$

$= \frac{21}{30} + \frac{25}{30}$ ...2

$= \frac{21 + 25}{30}$ ...1

$= \frac{46}{30}$ ...1

$= \frac{23}{15}$ ...1

$= 1^{8}/_{15}$ ...1

(5) $3^{1}/_{8} + 1^{3}/_{10}$
$= (3 + 1) + (^{1}/_{8} + {}^{1}/_{10})$

$= 4 + \frac{5}{40} + \frac{12}{40}$ ...3

$= 4 + \frac{5 + 12}{40}$ ...1

$= 4^{17}/_{40}$ ...1

(5) (Alternative Method)
$3^{1}/_{8} + 1^{3}/_{10}$

$= \frac{25}{8} + \frac{13}{10}$

$= \frac{125}{40} + \frac{52}{40}$ ...2

$= \frac{125 + 52}{40}$ ...1

$= \frac{177}{40}$ ...1

$= 4^{17}/_{40}$ ...1

(6) $\frac{13}{16} - \frac{11}{16}$

$= \frac{13 - 11}{16}$ ...3

$= \frac{2}{16}$ ...1

$= \frac{1}{8}$ ...1

(7) $\frac{7}{6} - \frac{2}{3}$

$= \frac{7}{6} - \frac{4}{6}$ ...2

$= \frac{7 - 4}{6}$ ...1

$= \frac{3}{6}$ ...1

$= \frac{1}{2}$ ...1

(8) $\frac{8}{9} - \frac{4}{5}$

$= \frac{40}{45} - \frac{36}{45}$ …2

$= \frac{40 - 36}{45}$ …1

$= \frac{4}{45}$ …1

(9) $\frac{9}{18} - \frac{1}{4}$

$= \frac{18}{36} - \frac{9}{36}$ …2

$= \frac{18 - 9}{36}$ …1

$= \frac{9}{36}$ …1

$= \frac{1}{4}$ …1

(10) $5^1/_8 - 3^1/_5$

$= \frac{41}{8} - \frac{16}{5}$ …1

$= \frac{205}{40} - \frac{128}{40}$ …2

$= \frac{205 - 128}{40}$ …1

$= \frac{77}{40}$ …1

$= 1^{37}/_{40}$ …1

(10) (Alternative Method)

$5^1/_8 - 3^1/_5$
$= 4^9/_8 - 3^1/_5$

$= (4 - 3) + (^9/_8 - {}^1/_5)$ …1

$= 1 + \frac{45}{40} - \frac{8}{40}$ …3

$= 1 + \frac{45 - 8}{40}$ …1

$= 1^{37}/_{40}$ …1

Retention Test (LCM Method)

(1) $\frac{9}{20} + \frac{7}{20}$

$= \frac{9 + 7}{20}$ …3

$= \frac{16}{20}$ …1

$= \frac{4}{5}$ …1

(2) $\frac{7}{15} + \frac{6}{30}$

$= \frac{14 + 6}{30}$ …3

$= \frac{20}{30}$ …1

$= \frac{2}{3}$ …1

(3) $\frac{4}{7} + \frac{2}{5}$

$= \frac{20 + 14}{35}$ ...3

$= \frac{34}{35}$ ...1

(4) $\frac{11}{18} + \frac{2}{4}$

$= \frac{22 + 18}{36}$ ...3

$= \frac{40}{36}$ ...1

$= \frac{10}{9}$ ...1

$= 1^1/_9$ ...1

(5) $3^1/_4 + 2^1/_6$

$= (3 + 2) + \frac{3 + 2}{12}$ ...3

$= 5 + \frac{5}{12}$ ...1

$= 5^5/_{12}$ ...1

(5) (Alternative Method)

$3^1/_4 + 2^1/_6$

$= \frac{13}{4} + \frac{13}{6}$ ...1

$= \frac{39 + 26}{12}$ ...2

$= \frac{65}{12}$ ...1

$= 5^5/_{12}$ ...1

(6) $\frac{11}{12} - \frac{5}{12}$

$= \frac{11 - 5}{12}$ ...3

$= \frac{6}{12}$ ...1

$= \frac{1}{2}$ ...1

(7) $\frac{7}{3} - \frac{4}{9}$

$= \frac{21 - 4}{9}$ ...3

$= \frac{17}{9}$ ...1

$= 1^8/_9$ ...1

(8) $\frac{5}{7} - \frac{3}{5}$

$= \frac{25 - 21}{35}$ ...3

$= \frac{4}{35}$ ...1

(9) $\frac{5}{6} - \frac{7}{10}$

$= \frac{25 - 21}{30}$ ...3

$= \frac{4}{30}$ ...1

$= \frac{2}{15}$ ...1

(10) $3^1/_3 - 1^3/_5$

$= (3 - 1) + \frac{5 - 9}{15}$ ...3

$= 2 + \frac{5 - 9}{15}$ ...1

$= 1 + \frac{20 - 9}{15}$ ...1

$= 1^{11}/_{15}$ ...1

(10) (Alternative Method)

$3^1/_3 - 1^3/_5$

$= \frac{10}{3} - \frac{8}{5}$ ...1

$= \frac{50 - 24}{15}$ ...3

$= \frac{26}{15}$ ...1

$= 1^{11}/_{15}$ ...1

Retention Test (Equivalent Fractions Method)

(1) $\frac{9}{20} + \frac{7}{20}$

$= \frac{9 + 7}{20}$ ...3

$= \frac{16}{20}$ 1

$= \frac{4}{5}$ ...1

(2) $\frac{7}{15} + \frac{6}{30}$

$= \frac{14}{30} + \frac{6}{30}$ ...2

$= \frac{14+6}{30}$ ...1

$= \frac{20}{30}$ ...1

$= \frac{2}{3}$ ...1

(3) $\frac{4}{7} + \frac{2}{5}$

$= \frac{20}{35} + \frac{14}{35}$ ...2

$= \frac{20 + 14}{35}$ ...1

$= \frac{34}{35}$ ...1

(4) $\frac{11}{18} + \frac{2}{4}$

$= \frac{22}{36} + \frac{18}{36}$ ...2

$= \frac{22 + 18}{36}$ ...1

$= \frac{40}{36}$ ...1

$= \frac{10}{9}$ ...1

$= 1^1/_9$ ...1

(5) $3^1/_4 + 2^1/_6$

$= (3 + 2) + (^1/_4 + ^1/_6)$

$= 5 + \frac{3}{12} + \frac{2}{12}$ ...3

$= 5 + \frac{3 + 2}{12}$ ...1

$= 5^5/_{12}$ ...1

(5) (Alternative Method)

$3^1/_4 + 2^1/_6$

$= \frac{13}{4} + \frac{13}{6}$

$= \frac{39}{12} + \frac{26}{12}$ ...2

$= \frac{39 + 26}{12}$ ...1

$= \frac{65}{12}$ ...1

$= 5^5/_{12}$ ...1

(6) $\frac{11}{12} - \frac{5}{12}$

$= \frac{11 - 5}{12}$ ...3

$= \frac{6}{12}$ ...1

$= \frac{1}{2}$ ...1

(7) $\frac{7}{3} - \frac{4}{9}$

$= \frac{21}{9} - \frac{4}{9}$ ...2

$= \frac{21 - 4}{9}$ ...1

$= \frac{17}{9}$ ...1

$= 1^8/_9$ ...1

(8) $\frac{5}{7} - \frac{3}{5}$

$= \frac{25}{35} - \frac{21}{35}$ ...2

$= \frac{25 - 21}{35}$ ...1

$= \frac{4}{35}$ ...1

(9) $\frac{5}{6} - \frac{7}{10}$

$= \frac{25}{30} - \frac{21}{30}$ ...2

$= \frac{25 - 21}{30}$ ...1

$= \frac{4}{30}$ ...1

$= \frac{2}{15}$ ...1

(10) $3^1/_3 - 1^3/_5$

$= \frac{10}{3} - \frac{8}{5}$ ...2

$= \frac{50}{15} - \frac{24}{15}$ ...1

$= \frac{50 - 24}{15}$ ...1

$= \frac{26}{15}$ ...1

$= 1^{11}/_{15}$ ...1

(10) (Alternative Method)

$3^1/_3 - 1^3/_5$

$= 2^4/_3 - 1^3/_5$ ...1

$= (2 - 1) + (^4/_3 - ^3/_5)$

$= 1 + \frac{20}{15} - \frac{9}{15}$ ...3

$= 1 + \frac{20 - 9}{15}$ ...1

$= 1^{11}/_{15}$ ...1

APPENDIX H

DAILY RECORD OF INSTRUCTIONAL ACTIVITIES FOR THE EQUIVALENT FRACTIONS METHOD.

FIRST SESSION

DURATION: 40 MINUTES

REFERENCE: Ghana Mathematics Series, JSS, Pupil's Book One, Pp. 71-84.

TOPIC. Equivalent Fractions

Objective: By the end of the lesson students should be able to generate equivalent fractions for any given fractions using the centimeter dot paper.

RPK: Students can locate and plot points on graphs.

Teaching/ Learning Materials: Centimetre Dot Paper

Teaching/ Learning Activities:

Step 1. Teacher locates sets of equivalent fractions, using letters, on the centimeter

dot paper. Teacher assists students to identify and write down a set or more of such equivalent fractions on the blackboard (bb). Teacher asks students to write the remaining sets shown on the centimetre dot paper into exercise books. Teacher goes round to help students in difficulties and discusses the answers on the bb.

Step 2. Teacher writes selected tractions on the bb., for example, $^1/_3{}^1/_5.\ ^1/_7$, $^1/_6$. Teacher asks students to locate and plot each of the given fractions; and two more equivalent fractions of each on the centimetre dot paper. Teacher goes round to help students in difficulties, and to discuss answers with them on the bb.

Step 3. Teacher writes selected fractions, with their numerators (or denominators) left blank, on the bb. Eg. a) $\frac{2}{3} = \frac{\square}{6}$ b) $\frac{1}{5} = \frac{3}{\square}$

Teacher asks students to fill in the blank spaces using the centimetre dot paper and discusses the answers.

Step 4. Evaluation. Teacher asks students to do the following exercises into exercise books for corrections.

1. Which of the fractions in the following set does not belong to it?

$\left\{ \frac{1}{2}, \frac{2}{4}, \frac{3}{5}, \frac{4}{8}, ---- \right\}$

2. Find the fraction for the blank space in the following set.

$\left\{ \frac{1}{8}, \frac{2}{16}, \_\_\_\_, \frac{4}{32}, ---- \right\}$

3. Write true or false against the following statement: $\frac{8}{12} = \frac{2}{3}$

SECOND SESSION

DURATION: 40 MINUTES

REFERENCE: Ghana Mathematics Series, JSS, Pupil's Book One, Pp. 71-84.

Topic Addition and Subtraction of Fractions.

Objective: By the end of the lesson, students should be able to compute the addition and subtraction of two fractions, one whose denominator is a factor of the other.

PK: (i) Students can compute the addition and subtraction of fractions with same denominators (ii) Students can locate and plot fractions and their equivalents on the centimeter dot paper.

Teaching /Learning materials: Centimetre dot paper

Teaching /learning Activities:

Step. 1 Teacher writes the following one after the other on the bb.

i) $\frac{1}{5}+\frac{3}{5}$ (ii) $\frac{3}{8}+\frac{2}{8}$ (iii) $\frac{7}{10}-\frac{4}{10}$

Teacher asks students to compute each example and mention the result. Teacher asks students to show working on the bb.

Step 2. Teacher writes $\frac{1}{3}+\frac{1}{6}$ on the bb and asks students whether the method used for example in Step 1 can be applied here and why? Teacher guides students, using the centimetre dot paper to rename $\frac{1}{3}$ *as* $\frac{2}{6}$ and asks students to compute $^2/_6 + ^1/_6$ for $^1/_3 + ^1/_6$

Teacher discusses the result with students.

Step.3. Teacher writes $\frac{2}{5}+\frac{3}{10}$ on the bb and asks students to use the centimetre dot paper to rename $\frac{2}{5}$ with the appropriate denominator. Teacher asks students to rewrite $\frac{2}{5}+\frac{3}{10}$ using the appropriate denominators and compute the sum. Teacher discusses the answer.

Step 4. Teacher writes $\frac{1}{7}+\frac{5}{14}$ on the bb and asks students to compute it into jotters,

using step 3 procedure. Teacher goes round to assist students in difficulties and to discuss solution on the bb.

Step 5. Teacher writes $\frac{2}{5}-\frac{3}{10}$ on the bb.
Teacher discusses question with students using step 3 results and writes

$\frac{2}{5}-\frac{3}{10}$ as $\frac{4}{10}-\frac{3}{10}$

Teacher helps students to compute work and discusses the result.

Step 6. Teacher writes $^1/_3 - ^3/_{12}$ on the bb and asks students to use step 4 procedure to compute it. Teacher goes through the solution with children to help them correct their errors.

Step 7. Evaluation. Teacher asks students to compute the following questions into exercise books for corrections.

1. $\frac{4}{10} \div \frac{1}{2}$ 2. $\frac{3}{2} \div \frac{1}{4}$ 3. $\frac{8}{9} - \frac{2}{3}$

THIRD SESSION

Duration: 40 minutes

Reference: Ghana Mathematic series. JSS. Pupil's Book One. Pp 71-84.

Topic. Addition and Subtraction of Fractions.

Objective: By the end of the lesson students should be able to compute the addition and subtraction of two tractions whose denominators and relatively prime.

RPK: (i) Students can generate equivalent fractions using the centimetre dot paper Teaching/Learning materials: Centimetre dot paper

Teacher/Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb.

(i) $\frac{4}{15} \div \frac{1}{3}$ (ii) $\frac{9}{16} - \frac{3}{8}$

Teacher asks students to compute the examples one after the other and discusses solutions on the bb.

Step 2. Teacher writes $\frac{1}{3} \div \frac{1}{2}$ on the bb and assists students using the centimetre dot paper to rename $^1/_3$ as $^2/_6$ and ½ as $^3/_6$

Teacher writes $\frac{1}{3} \div \frac{1}{2} = \frac{2}{6} \div \frac{3}{6}$ and discusses the solution with students on the bb.

Step 3. Teacher writes $\frac{2}{3} \div \frac{1}{5}$ on the bb and asks students to use the centimetre dot paper to rename given fractions. Teacher discusses students' results and ensures denominators are the least (lcd). Teacher asks students to compute the renamed fractions and discusses the result.

Step 4. Teacher writes $\frac{2}{3} - \frac{1}{5}$ on the bb and discusses it using the results of step 3.

Teacher rewrites $\frac{2}{3} - \frac{1}{5}$ as $\frac{10}{15} - \frac{3}{15}$ and guides students to compute it.

Step 5. Teacher writes $\frac{2}{3} - \frac{1}{3}$ on the bb and asks students to use step 4 procedure to compute it. Teacher goes through the solution with students on the bb.

Step 6. Evaluation: Teacher asks students to work the following questions into their exercise books for correction.

1) $\frac{1}{5} + \frac{1}{2}$ 2) $\frac{2}{5} + \frac{1}{3}$ 3) $\frac{2}{3} - \frac{1}{2}$

FOURTH SESSION

Duration: 40 minutes

Reference: Ghana Mathematics Series, JSS, Pupil's Book One.

Topic: Addition of Fractions.

Objectives: By the end of the lesson students should be able to compute the addition of two fractions whose denominators have common factors.

RPK: i) Students can generate equivalent fractions using the centimetre dot paper

(ii) Students can work the addition and subtraction of fractions whose denominators are relatively prime.

Teaching/ Learning material: Centimetre dot paper

Teaching/ Learning Activities:

Step 1 Teacher writes the following examples one after the other on the bb and asks students to compute them.

(i) $\frac{1}{4} + \frac{1}{3}$ (ii) $\frac{2}{5} - \frac{1}{3}$

Teacher discusses the solutions with the students on the bb.

Step 3. Teacher writes $\frac{1}{9} + \frac{1}{6}$ on the bb and asks students to use the centimetre dot paper to rename the given fraction. Teacher discusses students' results and ensures denominators are the least (lcd). Teacher asks students to compute the renamed fractions and discusses the solution on the bb.

Step 4. Teacher writes $\frac{3}{10} + \frac{1}{4}$ on the bb. and asks student to compute it using the centimetre dot paper. Teacher goes round to assist students in difficulties.

Step 5. Evaluation. Teacher asks students to work the following questions into exercises books for corrections

i) $\frac{1}{6} + \frac{3}{4}$ ii) $\frac{1}{9} + \frac{5}{6}$ 3) $\frac{7}{10} + \frac{3}{4}$

FIFTH SESSION

Duration: 40 minutes

Reference: Ghana Mathematic Series, JSS, Pupil's Book One. PP 71-84

Topic: Subtraction of Fractions

Objective: By the end of the lesson students should be able to compute the subtraction of two fractions whose denominators have common factors.

RPK: Students can add two fractions whose denominators have common factors

Teaching/ Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb.

i) $\frac{2}{6} + \frac{1}{4}$ ii) $\frac{3}{10} + \frac{1}{4}$. Teacher asks students to compute the examples and discusses the solution on the bb.

Step 2. Teacher writes $\frac{1}{4} - \frac{1}{6}$ on the bb. and guides students to rename $\frac{1}{4} - \frac{1}{6}$ as $\frac{3}{12} - \frac{2}{12}$

Teacher discusses the solution with the students noting the lcd concept.

Step 3. Teacher writes $\frac{2}{9}-\frac{1}{6}$ on the bb. and asks students to rename the given fractions using the appropriate least common denominator. Teacher discusses the results and asks students to compute the renamed fractions. Teacher discusses the answer.

Step 4. Teacher writes $\frac{4}{9}-\frac{1}{4}$ on the bb.

Teacher goes round to assist students with difficulties, and discusses the solution on the bb.

Step 5. Evaluate: Teacher asks students to work the following questions into their exercise books for corrections.

i) $\frac{5}{9} - \frac{2}{6}$ ii) $\frac{3}{4} - \frac{1}{6}$ iii) $\frac{7}{10} - \frac{1}{4}$

SIXTH SESSION

Duration: 40 minutes

Reference: Ghana Mathematics Series, JSS Pupil's Book One PP. 71-84

Topic: Addition of Fractions.

Objective: By the end of the lesson students should be able to compute the addition of two mixed numbers of various types.

RPK: Students can add two fractions whose denominators have common factors

Teaching/ Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb and asks students to compute them.

i) $\frac{1}{4} + \frac{1}{6}$ ii) $\frac{3}{10} + \frac{1}{6}$

Teacher discusses the solution with students on the bb.

Step 2. Teacher writes $1\,^1/_2 + 1\,^1/_4$ on the bb and guides students through discussions to rearrange. $1\frac{1}{2} + 1\frac{1}{4} = (1 + 1) + (\frac{1}{2} + \frac{1}{4})$

$= 2 + \frac{1}{2} + \frac{1}{4}$

Teacher guides students to rename $\frac{1}{2}$ as $^2/_4$ and rearrange $1\frac{1}{2} + 1\frac{1}{4}$

$= 2 + {^2/_4} + \frac{1}{4} = 2\frac{3}{4}$

Step 3. Teacher writes $2\frac{1}{2} + 1\,^1/_3$ on the bb and guides students to express it as in step 2. Teacher asks students to rename the fractional part $(^1/_2 + {^1/_3})$ and guides students to rearrange work as follows:

$2\frac{1}{2} + 1\,^1/_3 = (2+1) + (^3/_6 + {^2/_6}) = 3 + {^5/_6} = 3\,^5/_6$.

Step 4. Teacher writes $3\,^1/_6 + 2\frac{1}{4}$ on the bb and asks students to compute it using steps 2 and 3. Teacher goes round and assists students with difficulties and discusses the solution on the bb.

Step 5. Evaluation: Teacher asks students to work the following questions into their exercise books for corrections.

i) $1\,^2/_3 + 2\,^1/_5$ ii) $2\,^1/_3 + 3\,^1/_6$ iii) $2\,^1/_9 + 1\,^1/_6$

SEVENTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series. JSS Pupil's Book One Pp 71-84

Topic: Subtraction of Fractions

Objective: By the end of the lesson students should be able to compute the subtraction of two mixed numbers requiring no regrouping

RPK: Students can subtract two fractions

Teaching/ Learning Activities:

Step 1. Teacher writes the following example one after the other on the bb. and asks students to compute them

i) $\frac{3}{8} - \frac{1}{6}$ ii) $\frac{2}{5} - \frac{1}{3}$

Teacher discusses the solutions with the students on the bb.

Step 2. Teacher writes $3\frac{1}{2} - 1\frac{1}{4}$ on the bb, and through discussions guides students to rearrange $3\frac{1}{2} - 1\frac{1}{4} = (3-1) + (\frac{1}{2} - \frac{1}{4})$

$$= 2 + (\tfrac{1}{2} - \tfrac{1}{4})$$

Teacher guides students to rename ½ as $^2/_4$ and rearrange the work as $3\frac{1}{2} - 1\frac{1}{4}$

$$= 2 + (\tfrac{2}{4} - \tfrac{1}{4})$$

$$= 2 + \tfrac{1}{4} = 2\tfrac{1}{4}.$$

Step 3. Teacher writes $2\,^2/_3 - 1\frac{1}{2}$ on the bb and guides students to rearrange it as in step 2. Teacher asks students to rename the fractional portions. Teacher discusses the result and guides students to rearrange work as follows $2\,^2/_3 - 1\frac{1}{2} = (2-1) + (^4/_6 - ^3/_6) = 1 + (^1/_6 = 1\,^1/_6)$

Step 4. Teacher writes $3\frac{1}{4} - 2\,^1/_{10}$ on the bb and asks students to compute it using steps 2 and 3 procedures. Teacher goes round to assist students with some difficulties and to discuss the solution on the bb.

Step 5. Evaluation: Teacher asks students to work the following questions into their exercises books for corrections.

i) $2\,^2/_3 - 1\,^1/_5$ ii) $3\,^1/_3 - 1\,^1/_{12}$ iii) $5\,^2/_9 - 2\,^1/_6$

EIGHTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematic Series. JSS, Pupil's Book One Pp 71-84.

Topic: Subtraction of Fractions.

Objective: By the end of the lesson students should be able to compute the subtraction of two mixed numbers requiring regrouping.

RP: Students can compute the subtraction of two mixed numerals requiring no regrouping.

Teaching/Learning Activities:

Step 1. Teacher writes $3\frac{2}{9} - 1\frac{1}{6}$ on the bb and asks students to compute it Teacher discusses the solution with students on the bb.

Step 2. Teacher writes 3 ¼ - 2 ½ on the bb and guides students through questioning to arrange work as follows $3\frac{1}{4} - 2\frac{1}{2} = \frac{13}{4} - \frac{5}{2}$

teacher helps students through discussions to rename $\frac{5}{2}$ as $\frac{10}{4}$ and rearrange work as $3\frac{1}{4} - 2\frac{1}{2} = \frac{13}{4} - \frac{10}{4} = \frac{3}{4}$

Step 3. Teacher writes $2\,{}^{1}/_{3} - 1\,{}^{1}/_{2}$ on the bb and guides students to rearrange work as in step 2. Teacher discusses the results and guides students to arrange work as follows:

$$2\,{}^{1}/_{3} - 1\,{}^{1}/_{2} = {}^{7}/_{3} - {}^{3}/_{2}$$

$$= \frac{14}{6} - \frac{9}{6} = \frac{5}{6}$$

Step 4. Teacher writes $3\,{}^{1}/_{5} - 1\,{}^{1}/_{3}$ on the bb and asks students to compute it using steps 2 and 3 procedures. Teacher goes round and assists students with difficulties, and discusses the solution on the bb.

Step 5. Evaluation. Teacher asks students to work the following questions into exercise books for corrections. i) $3\,{}^{1}/_{2} - 1\,{}^{3}/_{5}$ ii) $2\,{}^{3}/_{10} - 1\,{}^{1}/_{2}$ iii) $2\,{}^{1}/_{6} - 1\,{}^{1}/_{4}$

APPENDIX I

DAILY RECORD OF INSTRUCTIONAL ACTIVITIES FOR THE LCM METHOD.

FIRST SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, Pupil's Book One, Pp. 71-84

Topic: Addition and Subtraction of Fractions.

Objective: By the end of the lesson students should be able to compute the addition and subtraction of two fractions, one whose denominator is a factor of the other

RPK: (i) Students can compute the LCM of whole numbers. (ii) Students can compute the addition and subtraction of fractions with same denominators.

Teaching /Learning Activities:

Step 1. Teacher writes the following questions one after the other on the blackboard (bb).

Teacher guides students to compute the LCM for each given pair on the bb.

1. Find the LCM of I). 6, 9 ii). 4, 10.

Step2. Teacher writes the following items one after the other on the bb.

(i) $\frac{1}{5} + \frac{3}{5}$ (ii) $\frac{3}{8} + \frac{2}{8}$ (iii) $\frac{7}{10} - \frac{4}{10}$

Teacher asks students to compute each example and discusses solutions on the bb.

Step 3. Teacher writes $^1/_3 + {}^1/_6$ on the bb; and guides students to find the LCM for 3 and 6 as follows: 3=3x1; 6=2x3; LCM = 2x3=6

Teacher discusses and guides students to arrange the work thus; $\frac{1}{3} + \frac{1}{6}$

$$\frac{2+1}{6} = \frac{3}{6} = ½$$

Step 4. Teacher writes $\frac{2}{5} + \frac{3}{10}$ on the bb.

Teacher guides students to find the LCM for 5 and 10 as follows: 5=5x1,

10 = 2x5; LCM = 2x 5 = 10.

Teacher discusses and guides students to arrange the work thus: $\frac{2}{5}+\frac{3}{10}$

$$\frac{4+3}{10} = \frac{7}{10}$$

Step 5. Teacher writes $\frac{1}{7}+\frac{5}{14}$ on the bb. and asks students to compute the sum using procedures in steps 2 and 3. Teacher goes round to help students in difficulties and discusses the solution on the bb.

Step 6. Teacher writes $\frac{2}{5}-\frac{3}{10}$ on the bb and discusses it with students using step 3 results.

Teacher arranges the work as follows on the bb.

$$\frac{2}{5}-\frac{3}{10}$$

$$\frac{4-3}{10} = \frac{1}{10}$$

Step 7. Teacher writes $\frac{1}{3}-\frac{3}{12}$ on the bb and asks students to use step 5 procedure to compute it. Teacher discusses the solution with students on the bb

Step 8. Evaluation. Teacher asks students to compute the following questions into exercise books for corrections.

i) $\frac{4}{10} + \frac{1}{2}$ ii) $\frac{3}{2} + \frac{1}{4}$ iii) $\frac{8}{9} - \frac{2}{3}$

SECOND SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS. Pupil's Book One pp. 71-84

Topic: Addition and Subtraction of Fractions.

Objective: By the end of the lesson students should be able to compute the addition and subtraction of two fractions whose denominators are relatively prime.

RPK: Students can compute the addition and subtraction of two fractions one whose denomination is a factor of the other.

Teaching/ Learning Activities:

Step 1. Teacher writes the following questions one after the other on the bb, and asks students to compute them. Teacher discusses the solutions with students on the bb.

Step 2. Teacher writes $\frac{1}{3}+\frac{1}{2}$ on the bb and helps students to compute the LCM of 2 and 3 as follows: 2= 2x1; 3= 3x 1; LCM = 2 X 3 = 6. Teacher discusses and arranges the, work as follows:

$$\frac{1}{3}+\frac{1}{2}$$
$$\frac{2+3}{6}=\frac{5}{6}$$

Step 3. Teacher writes $\frac{2}{3}+\frac{1}{5}$ on the bb and helps students to compute the LCM of 3 and 5 as follows: 3= 3 x 1; 5 = 5 x 1; LCM = 3 x 5 = 15 Teacher discusses and arranges the work as follows: $\frac{2}{3}+\frac{1}{5}=\frac{10+3}{15}=\frac{13}{15}$

Step 4. Teacher writes $\frac{2}{3}-\frac{1}{5}$ on the bb and discusses it with students using the results of step 3. Teacher guides student to arrange work as follows:

$$\frac{2}{3}-\frac{1}{5}$$
$$\frac{10-3}{15}=\frac{7}{15}$$

Step 5. Teacher writes $\frac{2}{5} - \frac{1}{3}$ on the bb, and asks students to use the step 4 procedure to compute it. Teacher discusses the solution on the bb with students.

Step 6. Evaluation: Teacher asks students to work the following questions into their exercises books for corrections.

i) $\frac{1}{5} + \frac{1}{2}$ ii) $\frac{2}{5} + \frac{1}{3}$ iii) $\frac{2}{3} - \frac{1}{2}$

THIRD SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, Pupil's Book One, Pp. 71- 84.

Topic: Addition of Fractions.

Objective: By the end of the lesson students should be able to compute the addition of two fractions whose denominators have common factors.

RPK: Students can work the addition and subtraction of fractions whose denominators are relatively prime.

Teaching/Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb; and asks students to compute them. Teacher discusses the solutions with students on the bb.

i) $\frac{1}{4} + \frac{1}{3}$ ii) $\frac{2}{5} - \frac{1}{3}$

Step 2. Teacher writes $\frac{1}{6} + \frac{1}{4}$ on the bb; and helps students to compute the LCM of 6 and 4 as follows: 6= 2x3, 4= 2x2, LCM = 2x2x3=12. Teacher discusses and guides students to arrange work as follows:

$$\frac{1}{6} + \frac{1}{4}$$

$$\frac{2+3}{12} = \frac{5}{12}$$

Step 3. Teacher writes $\frac{1}{9}+\frac{1}{6}$ on the bb, and guides students to compute the LCM of 9 and 6 as follows: 9 = 3x3; 6= 2x3, LCM = 2x3x3 = 18. Teacher discusses and guides students to arrange work as follows:

$$\frac{1}{9}+\frac{1}{6}$$
$$\frac{2+3}{18}=\frac{5}{18}$$

Step 4. Teacher writes $\frac{3}{10}+\frac{1}{4}$ on the bb and asks students to compute the sum using step 3 procedure. Teacher goes round to assist students in difficulties, and discuss the solution on the bb.

Step 5. Evaluation. Teacher asks students to work the following questions into exercise books for corrections.

1. $\frac{1}{6}+\frac{3}{4}$ 2. $\frac{1}{9}+\frac{5}{6}$ 3. $\frac{7}{10}+\frac{3}{4}$

FOURTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, Pupil's Books One, pp. 71-84

Topic. Subtraction of Fractions.

Objective: By the end of the lesson students should be able to compute the subtraction of two fractions whose denominators have common factors.

RPK: Student can add two fractions whose denominators have common factors

Teaching/Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb, and asks

students to compute. Teacher discusses the solution of each question with students on the bb.

(i) $\frac{2}{6}+\frac{1}{4}$ (ii) $\frac{3}{10}+\frac{1}{4}$

STEP 2. Teacher writes $\frac{1}{4} - \frac{1}{6}$ on the bb, and helps students to compute the LCM

of 6 and 4 as follows: 6 = 2x3; 4 = 2x2; LCM = 2x2x3 = 12. Teacher discusses

and guides students to arrange work as follows:

$$\frac{1}{4} - \frac{1}{6}$$
$$\frac{3 - 2}{12} = \frac{1}{12}$$

Step 3. Teacher writes $\frac{2}{9} - \frac{1}{6}$ on the bb, and guides students to compute the LCM

of 9 and 6 as follows: 9 = 3x3;, 6= 2x3, LCM = 2x3x3 = 18. Teacher guides

students through discussions to arrange work as follows:

$$\frac{2}{9} - \frac{1}{6}$$
$$\frac{4 - 3}{18} = \frac{1}{18}$$

Step 4. Teacher writes $\frac{4}{10} - \frac{1}{4}$ on the bb and asks students to compute it using the

procedure in step 3. Teacher goes round to assist students in difficulties and

discusses the solution on the bb.

Step 5. Evaluation: Teacher asks students to work the following questions into

exercise books for corrections.

i) $\frac{5}{9} - \frac{2}{6}$ ii) $\frac{3}{4} - \frac{1}{6}$ iii) $\frac{7}{10} - \frac{1}{4}$

FIFTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, and Pupil's Book One Pp 71-84

Topic: Addition of Fractions.

Objective: By the end of the lesson students should be able to compute the addition of two mixed numbers of various types.

RPK: Students can add two fractions whose denominators have common factors.

Teaching /Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb, and asks students to compute them. Teacher discusses the solutions with students on the bb.

i) $\frac{1}{4} + \frac{1}{6}$ ii) $\frac{3}{10} + \frac{1}{6}$

Step 2. Teacher writes $1\frac{1}{2} + 1\frac{1}{4}$ on the bb. for discussions. Teacher guides students through questioning to re-arrange $1\frac{1}{2} + 1\frac{1}{4} = (1+1) + (\frac{1}{2} + \frac{1}{4})$

$= 2 + \frac{1}{2} + \frac{1}{4}$

Teacher guides students to compute the LCM of 2 and 4 as follows

2=2x1, 4= 2x2; LCM = 2x2= 4.

Teacher guides students to arrange work as follows:

$$1\frac{1}{2} + 1\frac{1}{2} = 2 + \frac{1}{2} + \frac{1}{4} = 2 + \frac{2+1}{4} = 2 + \frac{3}{4} = 2\frac{3}{4}$$

Step 3. Teacher writes $2\frac{1}{2} + 1\frac{1}{3}$ on the bb. and guides students to rearrange $2\frac{1}{2} + 1\frac{1}{3}$ as expressed in step 2. Teacher guides students to compute the LCM of 2 and 3 as follows: 2 = 2 x 1; 3 = 3 x 1, LCM = 2x 3 = 6.

Teacher guides students to re- arrange work as follows:

$$2\frac{1}{2} + 1\frac{1}{3} = (2 + 1) + (\frac{1}{2} + \frac{1}{3}) = 3 + \frac{3+2}{6} = 3 + \frac{5}{6} = 3\frac{5}{6}$$

Step 4. Teacher writes $3\frac{1}{6} + 2\frac{3}{8}$ on the bb, and asks students to compute it using steps 2 and 3 procedures, Teacher goes round to assist students in difficulties and discuss solution on the bb.

Step 5. Evaluation. Teacher asks students to work the following questions into exercise books for correction. i) $1\frac{2}{3} + 2\frac{1}{5}$ ii) $2\frac{1}{2} + 3\frac{1}{6}$ iii) $2\frac{1}{9} + 1\frac{1}{6}$

SIXTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, and Pupil's Books One. Pp. 71-84.

Topic: Subtraction of Fractions.

Objectives: By the end of the lesson students should be able to compute the subtraction of two mixed numbers requiring no regrouping.

RPK: Students can subtract two fractions with various denominators.

Teaching/ Learning Activities:

Step 1. Teacher writes the following examples one after the other on the bb. Teacher asks

students to compute the examples and discusses the solutions on the bb.)

(i) $\frac{3}{3}-\frac{1}{6}$ (ii) $\frac{2}{5}-\frac{1}{3}$

Step 2. Teacher writes $3\frac{1}{2} - 1\frac{1}{4}$ on the bb. Teacher discusses and guides

students through questioning to re-arrange work as follows:

$3\,{}^{1}/_{3} - 1\frac{1}{4} = (3-1) + (\frac{1}{2} - \frac{1}{4}) = 2 + (\frac{1}{2} - \frac{1}{4})$

Teacher guides students to compute the LCM of 2 and 4 and re- arrange work as

follows:

$$3\frac{1}{2} - 1\frac{1}{4} = 2 + \frac{1}{2} - \frac{1}{4}$$
$$2 + \frac{2-1}{4} = 2 + \frac{1}{4} = 2\frac{1}{4}$$

Step 3. Teacher writes $3\,{}^{2}/_{3} - 1\frac{1}{2}$ on the bb and guides students to re-arrange the work as expressed in step 2. Teacher guides students to compute the LCM of 2 and 3; and to re- arrange work as follow:

$$2\frac{1}{2} - 1\,{}^{1}/_{3} = (2-1) + (\frac{1}{2} - {}^{1}/_{3})$$
$$= 1 + \frac{3-2}{6}$$
$$= 1 + {}^{1}/_{6} = 1\,{}^{1}/_{6}$$

Step4 Teacher writes $3\frac{1}{4} - 2\,{}^{1}/_{10}$ on the bb. and asks students to compute the question using the steps 2 and 3 procedures. Teacher goes round to assist students in difficulties and to discuss the solution on the bb.

Step 5. Evaluation: Teacher asks students to work the following questions into exercise books for corrections.

i) $2\,^{2}/_{3} - 1\,^{1}/_{5}$ ii) $3\,^{1}/_{3} - 1\,^{1}/_{12}$ iii) $5\,^{2}/_{9} - 2\,^{1}/_{6}$

SEVENTH SESSION

Duration: 40 Minutes

Reference: Ghana Mathematics Series, JSS, Pupil's Books One, Pp 71-84.

Topic: Subtraction of Fractions.

Objective: By the end of the lesson, students should be able to compute the subtraction of two mixed numbers requiring regrouping.

RPK: Students can compute the subtraction of mixed numerals requiring no requiring.

Teaching / Learning Activities:

Step 1. Teacher writes $3\,^{2}/_{9} - 1\,^{1}/_{6}$ on the bb and asks students to compute it. Teacher discusses the solution on the bb.

Step 2. Teacher writes $3\,¼ - 2\,½$ on the bb, and guides students through

questioning to arrange work as follows: $3\,¼ - 2\,½ = \frac{13}{4} - \frac{5}{2}$

$$\frac{13 - 10}{4} = \frac{3}{4}$$

Step 3. Teacher writes $2\,^{1}/_{3} - 1\,½$ on the bb and guides students to arrange work as in step 2. Teacher guides students to compute the LCM of 2 and 3, assist students to arrange work as follows: $2\,^{1}/_{3} - 1\,½ = \frac{7}{3} - \frac{3}{2}$

$$\frac{14 - 9}{6} = \frac{5}{6}$$

Step 4. Teacher writes $3\,{}^{1}/_{5} - 1\,{}^{1}/_{3}$ on the bb and asks students to compute it using steps 2 and 3 procedures. Teacher goes round to assist students in difficulties and discuss the solution on the bb.

Step 5. Evaluation: Teacher asks students to work the following questions into exercise books for corrections i) $3\,{}^{1}/_{2} - 1\,{}^{3}/_{5}$ ii) $2\,{}^{3}/_{10} - 1\,{}^{1}/_{2}$ iii) $2\,{}^{1}/_{6} - 1\,{}^{1}/_{4}$

APPENDIX J

COMPUTATION OF ADJUSTED MEANS

Statistical tool used for computations

$M_{y.x}$ = My - b (M_x - G M_x) where $b = \dfrac{\text{Within groups sum of products}}{\text{Within groups sum of squares on X}}$

$M_{y.x}$ = Adjusted mean: GM_x = General means; M_x=Means of X;

M_y=Means of Y.

i). Table 6.

i) LCM – 1; $b = \dfrac{4205.3}{25522.3} = 0.16$

$M_{y.x}$ = 23. 38 - 0. 16 (20. 75 – 17 . 55) = 22. 87

ii) EF – 1,
$M_{y.x}$ = 25- 88 – 0. 16 (14. 22- 17. 49) = 26.4

iii) LCM – 2 ; $b = \dfrac{221}{21141.5} = 0.01$
$M_{y.x}$ = 24. 02 – 0. 01 (23. 09- 19.98) = 23.99

iv) EF 2;
$M_{y.x}$ = 25. 25- 0.01 (16.69-19.98) = 25. 28

2) Table 8

i) LCM - 1; $b = \dfrac{1030.7}{7109.1} = 0.14$
$M_{y.x}$ = 11. 94 - 0. 14 (11. 29 – 9.5) = 11. 69

ii) EF - 1
$M_{y.x}$ = 13. 6- 0.14 - (7. 54-9.5) = 13. 87

iii) LCM – 2 $b = \dfrac{229.2}{5975.3} = 0.04$
$M_{y.x}$ = 11. 48 – 0. 04 (11. 61- 10 . 13) = 11. 42

iv) EF 2;
$M_{y.x}$ = 13. 27 – 0.04 (8. 57 – 10. 13) = 13. 33

3) Table 10

i) LCM - 1; $b = \dfrac{1415.9}{6865.8} = 0.21$
$M_{y.x}$ = 11.44 – 0. 21 (9. 46- 8.10) = 11. 15

iii) LCM -2; $b = \frac{585.1}{6128.4}$ 0.10

$M_{y,x}$ = 12.22 - 0.10 (12.54- 12.27) 12.19

iv) EF -2

$M_{y,x}$ = 12.45- 0.10 (11.98-12.27) 12.48

APPENDIX K

COMPUTATION OF ANALYSIS OF COVARANCE

Statistical tool used for computations.

1. T_{xx} – Total sum of squares on X
2. T_{yy} _Total sum of squares on Y
3. T_{xy} – Sum of products for total data
4. F_{xx} – Between groups sum of squares on X
5. F_{yy} – Between groups sum of squares on Y
6. F_{xy} – Between groups sum of products
7. $E_{xx} = T_{xx} - F_{xx}$: Within groups sum of squares on X
8. $E_{yy} = T_{yy} - F_{yy}$: Within groups sum of squares on y
9. $E_{xy} = T_{xy} - F_{xy}$: Within groups sum of products
10. $\Sigma Y^2 = T_{yy} - \frac{(T_{xy})^2}{T_{xx}}$: Adjusted total sum of Squares on y
11. $\Sigma Y^2 = E_{yy} - \frac{(E_{xy})^2}{E_{xx}}$: Adjusted within groups Sum of squares
12. Item 10-Item 11: Adjusted between groups sum of squares.
13. K-l: Degrees of freedom for adjusted between groups sum of squares (K= Number of groups)
14. N-K-l: Degrees of freedom for adjusted within groups sum of squares (N= Sample size).
15. $\frac{\text{Item 11}}{\text{N-K-l}}$: The within groups variance
16. $\frac{\text{Item 12}}{\text{K-l}}$: The between groups variance
17. $\frac{\text{Item 16}}{\text{Item 15}}$: The within groups variance estimate

Hypothesis One: Pretest (x) – Post-test (y)

EF Group (N = 50); $\sum x = 711$, $\sum y = 1294$

LCM Group (N = 52); $\sum x = 1079$ $\sum y = 1216$

Pretest totals = (711+1079) = 1790; Post-test totals = 2510

The sums of squares and cross product for the total data are as follows:

$$T_{xx} = 0^2+4^2 + \text{---} + 10^2 + 10^2 - \frac{(1790)^2}{102} = 26609.3$$

$$T_{yy} = 18^2+1^2+ \text{---}\ 19^2+18^2 - \frac{(2510)^2}{102} = 20576.3$$

$$T_{xy} = (0)(18) + (4)(1) + \cdots + (10)(19) + (10)(18) - \frac{(1790)(2510)^2}{102} = 3790$$

The between sums of squares and cross products are computed as follows:

$$F_{xx} = \frac{(711)^2}{50} + \frac{(1079)^2}{52} - \frac{(1790)^2}{102} = 1087$$

$$F_{yy} = \frac{(1294)^2}{50} \div \frac{(1216)^2}{52} - \frac{(2510)^2}{102} = 158.7$$

$$F_{xy} = \frac{(711)\ (1294)}{50} \div \frac{(1079)\ 1216)}{52} - \frac{(1790)\ (2510)}{102} = -415.3$$

By subtractions, the within groups (error) sum of squares are as follows;

$$E_{xx} = T_{xx} - F_{xx} = 25522.3$$

$$E_{yy} = T_{yy} - F_{yy} = 20417.6$$

$$E_{xy} = T_{xy} - F_{xy} = 4205.3$$

Sum of squares – 1		
	Pretest (x)	Posttest
Between	32499.7 –31412.7 = 1087	61924.4 – 61765.7=158.7
Within	26609.3 - 1087=25522.3	20576.3-158.7=20417.6
Total	58022-31412.7=26609.3	82342-61765.7=20576.3
Sum of products – 1		
Between	43632.7- 44048 = - 415.3	
Within	3790-(-415.3) = 4205.3	
Total	47838- 44048 = 3790	

The adjusted total sum of squares for $y = 20576.3 - \frac{(3790)^2}{26609.3} = 20036.5$

The adjusted within groups sum f squares $= 204176.3 - \frac{(4205.3)^2}{25522.3} = 19724.7$

The adjusted between groups sum of squares = 20036.5 – 19724.7 = 311.8

Sum of Squares –2		
	Pretest (x)	Posttest (y)
Between	42996.5-41920=1076-5	63680.3 – 63640.2 = 40.1
With in	22218 – 1076.5 = 21141.5	18234.8 – 40.1 = 18194.7
Total	64138 – 41920 = 22218	81875-63640.2 = 18234.8

Sum of Products - 2	
Between	51443-51650-8 = -207.8
Within	13.2 – (- 207.8) = 221
Total	51664 – 51650.8 = 13.2

The adjusted total sum of squares for y

$$= 18234.8 - \frac{(13.2)^2}{22218} = 18227$$

The adjusted within groups sum of square $= 18194.7 - \frac{(221)^2}{21141.5} = 18192.4$

The adjusted between groups sum of squares, = 18227 – 18192. 4 = 34.6

Hypothesis Two

Sum of squares – 1

	Pretest (x)	Posttest (y)
Between	9468.9 – 9110.7 = 358.2	16664.2 – 594.1=70.1
Within	7467.3 – 358.2 = 7109.1	5834.9 – 70.1 =5764.8
Total	16578- 9110.7= 7467.3	22429-16594.1 = 5834.9

	Sum of products – 1
Between	12137.3 - 12295.7 = -158.4
Within	872.3 – (-158.4) = 1030.7
Total	13168 – 12295.7 = 872.3

The adjusted total sum of squares for y,

$$= 5834.9 - \frac{(872.3)^2}{7467.3} = 5733$$

The adjusted within groups sum of squares

$$= 5764.8 - \frac{(1030.7)^2}{7109.1} = 5615.4$$

The adjusted between groups sum of squares,

$$= 5733 - 5615.5 = 117.6$$

Sum of Squares – 2

	Pretest (x)	Posttest (y)
Between	11024.7 – 10781.9=242.8	16105.3-16021=84.3
Within	6218.1 - 242.8 = 5975.3	5922-84.3 = 5837.3
Total	17000-10781.9 = 6218.1	21943-16021=5922

	Sum of products – 2
Between	12999.8-13142.9 = - 143.1
Within	86.1-(-143.1) = 229.2
Total	13229-13142.9 = 86.1

The adjusted total sum of squares for y.

$$= 5922 - \frac{(86.1)^2}{6218.1} = 5920.8$$

The adjusted within groups sum of squares,

$$= 5837.3 - \frac{(229.2)^2}{5975.3} = 5828.5$$

The adjusted between group sum of squares = 5920.8 – 5828.5 = 92.3

Hypothesis Three

Sum of squares – 1

	Pretest (x)	Posttest (y)
Between	6886.2-6689=197.2	14348.1-14330.2 = 17.9
Within	7063-197.2 = 6865.8	7108.8 – 17.9 = 7090.9
Total	13752 – 6689=7063	21439 – 14330,2 = 7108.8

Sum of products – 1

Between	9731.1- 9790.5 = -59.4
Within	1356.5 – (- 59.4) = 1415.9
Total	11147-9790.5 = 1356.5

The adjusted total sum of squares for y

$$= 7108 - \frac{(1356.5)^2}{7063} = 6847.5$$

The adjusted within groups sum of squares

$$= 7090.9 - \frac{(1415.9)^2}{6865.8} = 6798.9$$

The adjusted between groups sum of squares, = 6847.5-6798.9 = 48.6

Sum of squares – 2

	Pretest (x)	Post-test (y)
Between	10456.3 – 10162.8 = 293.5	15807.6 – 15799.5 = 8.1
Within	6250.2 – 293.5 = 5956.7	6136.5 – 8. 1 = 6128. 4
Total	16413-10162.8=6250.2	21936-15799.5=6136.5

Sum of products – 2

Between	12720.3-12671.5 = 48.8
Within	-68.5 – 48.8= - 117.3
Total	12603-12671.5=-68.5

The adjusted total sum of squares for y,

$$= 6136.5 - \frac{(-68.5)^2}{6250.2} = 6135.7$$

The adjusted within groups sum of squares

$$= 6128.4 - \frac{(-117.3)^2}{5956.7} = 6126.1$$

The adjusted between groups um of squares

$$= 6135.7 - 6126.1 = 9.6$$

Hypothesis Four

	Sum of squares – 1	
	Posttest (x)	Retention Test (y)
Between	61924.4 – 61765.7 = 158.7	52833.6-52814.1 = 19.5
Within	20576.3 – 158.7 = 20417.6	20776.9 – 19.5=20757.4
Total	82342-61765.7 = 20576.3	73591-52814.1 =20776.9

	Sum of Products –1
Between	57170.3- 57114.8 = 55.5
Within	2231.2 – 55.5 = 2157.7
Total	59346-57114.8 = 2231.2

The adjusted total sum of squares for y

$$= 20776.9 - \frac{(2231.2)^2}{20576.3} = 20535$$

The adjusted within groups sum of squares

$$= 20757.4 - \frac{(2175.7)^2}{20417.6} = 20525.6$$

The adjusted between groups um of squares =20535 – 20525.6 = 9.4

Sum of squares- 2

	Posttest (x)	Retention test (y)
Between	63680.3- 63640.2 = 40.1	69806.8 – 69737.5 = 69.3
Within	18234.8 –40.1 = 18194.7	14474.5-69.3= 14405.2
Total	81875-63640.2 = 18234.8	84212-69737.5 = 14474.5

Sum of products – 2

Between	66671.9 –66619.1 = 52.8
Within	2462.9 – 52.8 = 2410.1
Total	69082 - 66619.1 = 2462.9

The adjusted total sum of squares for y,

$$= 14474.5 - \frac{(2462.9)^2}{18234.8} = 14141.8$$

The adjusted within group sum of squares

$$= 14405.2 - \frac{(2410.1)^2}{18194.7} = 14086$$

The adjusted between groups um of squares,

$$= 14141.8 - 14086 = 55.8$$

Hypothesis Five

Sum of squares - 1

	Posttest (x)	Retention Test (y)
Between	16664.2 – 16594.1 = 70.1	13207.5 –13146.7 = 60.8
Within	5834.9 – 70.1 = 5764.8	5491.3 – 60.8 = 5430.5
Total	22429-16594.1 = 5834.9	18638-13146.7 = 5491.3

Sum of Products - 1

Between	14835.4-14770.2 = 65.2
Within	2545.8-65.2 = 2480.6
Total	17316-14770.2 =2545.8

The adjusted total sum of squares for y

$$5491.3 - \frac{(2545.81)^2}{5834.9} = 4380.6$$

The adjusted with groups sum of squares,

$$= 5430.5 - \frac{(2480.6)^2}{5764.8} = 4363.1$$

The adjusted between groups sum of squares,

$$4380.6 - 4363.1 = 17.5$$

Sum of square – 2

	Posttest (x)	Retention Test (y)
Between	16105.3 – 16021= 84.3	19012.4 18961.1 = 51.3
Within	5922-84.3 = 5837.7	5191.8 – 51.3 = 510.5
Total	21943-16021=5922	24153 – 18961.2 = 5191.8

Sum of Products – 2

Between	17494.9-17429.2 = 65.7
Within	495.8 – 65.7 = 430.1
Total	17925 – 17429.2 = 495.8

The adjusted total sum of squares for y

$$= 5191.8 - \frac{(495.8)^2}{5922} = 5150.3$$

The adjusted within groups sum of squares, $= 5140.5 - \frac{(430.1)^2}{5837.7} = 5108.8$

The adjusted between groups sum of squares,= 5150.3- 5108.8 = 41.5

Hypothesis six

Sum of square – 1

	Posttest (x)	Retention Test (y)
Between	14348.1 – 14330.2 = 17.9	13272 –13260.5 = 11.5
Within	7108.8 – 17.9 = 7090.9	6936.5-11.5 = 6925
Total	21439-14330.2 = 7108.8	20197-13260.5=6936.5

Sum of Products – 1

Between	13770.6 – 13785 = -14.4
Within	3493 – (- 14.4) = 3507.4
Total	17278 – 13785 = 3493

The adjusted total sum of square for y,

$$= 6936.5 \frac{(3493)^2}{7108.8} = 5220.2$$

The adjusted within groups sum of squares

$$= 6925 - \frac{(3507.4)^2}{7090} = 5190.1$$

The adjusted between groups sum of squares, = 5220.2 – 5190.1 = 30.1

Sum of square 2

	Posttest (x)	Retention Test (y)
Between	15807.6 – 15799.5 = 8.1	15973.1 15971.7 = 1.4
Within	6136.5 – 8.1 = 6128.4	4681.3-1.4 = 4679.9
Total	21936-15799.5 =6136.5	20653-15971.7 =4681.3

	Sum of products - 2
Between	15881.9 -15885.3=-3.4
Within	581.7 -(-3.4) = 585.1
Total	16467 – 15885.3 = 581.7

The adjusted total sum of squares for y.

$$= 4681.3 - \frac{(581.7)^2}{6136.5} = 4626.2$$

The adjusted within groups sum of squares

$$= 4679.9 - \frac{(585.1)^2}{6128.4} = 4624$$

The adjusted between groups um of squares

$$= 4626.2 - 4624 = 2.2$$

APPENDIX L

COMPUTATIONS OF DEPENDENT T- TEST

Statistical tools used for computations

1) Linear correlation coefficient

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2)][N\sum y^2 - (\sum Y)^2]}}$$

ii) Dependent t- test.

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N} + \frac{S_2^2}{N} - 2r\left(\frac{S_1}{\sqrt{N}}\right)\left(\frac{S_2}{\sqrt{N}}\right)}}$$

Hypothesis Seven

i) Linear correlation coefficient

Pretest (x) – Posttest (y)

$$r_1 = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][\sum y^2 - (\sum y)^2]}}$$

$$r_1 = \frac{(50)(20497) - (711)1294)}{\sqrt{[(50)(24679) - (711)^2][(50)(44808 - (1294)^2]}}$$

$r_1 =$ 0.1632

ii) Dependent t- test

$F = \frac{291.4}{258.6} = 1.13$ (Variance are homogeneous)

Pretest mean = x_2 ; Posttest mean = x_1

$$t_1 = \frac{X_1 - X_2}{\sqrt{\frac{S^2_1}{N} + \frac{S_2^2}{N} - 2r\left(\frac{S_1}{\sqrt{N}}\right)\left(\frac{S_2}{\sqrt{N}}\right)}}$$

$$t_1 = \frac{25.88-14.22}{\sqrt{\frac{226.5}{50} + \frac{291.4}{50} - 2\,(0.\ 1632)\left(\frac{15.05}{7.07}\right)\left(\frac{17.07}{7.07}\right)}}$$

$t_1 = 3.95$

i) Linear correlation coefficient

Pres test (x) - Post-test (y)

$$r_2 = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum X^2 - (2\,x)^2]\,[N\sum y^2 - (\sum y)^2]}}$$

$$r_2 = \frac{(51)(21408) - (1288)(851)}{\sqrt{[(51)(26015) - (851)^2]\,[(51)(42310) - (1288)^2]}}$$

$r_2 = -\ 0.\ 0078$

ii) Dependent t- test

$F = \frac{231.6}{191.8} = 1.21$ (variances are homogenous)

pretest mean = $\overline{X}_2$ Posttest mean = $\overline{X}_1$

$$t_2 = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S^2_1}{N} + \frac{S_2^2}{N} - 2r\left(\frac{S_1}{\sqrt{N}}\right)\left(\frac{S_2}{\sqrt{N}}\right)}}$$

$$t_2 = \frac{25.25-16.69}{\sqrt{\frac{191.8}{51} + \frac{231.6}{51} - 2(-0.0078)\left(\frac{15.22}{7.14}\right)\left(\frac{13.85}{7.14}\right)}}$$

$t_2 = 2.96$

Hypothesis Eight

i) Linear correlation coefficient

Pretest (x1 - Posttest (y)

$$r_1 = \frac{(52)(26933)-(1079)(1216)}{\sqrt{[(52)(33343)-(1079)^2][(52)(37534)-(1216)^2]}}$$

$r_1 = 0.1704$

ii) Dependent t- tested

$F = \frac{210.3}{175} = 1.2$ (variances are homogeneous)

Pretest mean = x_2 Posttest mean = $\bar{x}_1$

$$t_1 = \frac{23.38 - 20.75}{\sqrt{\frac{175}{52} + \frac{210.3}{52} - 2(0.1704)\left(\frac{13.23}{7.21}\right)\left(\frac{14.5}{7.21}\right)}}$$

$t_1 = 1.06$

$$r_2 = \frac{(54)(29856)-(1247)(1297)}{\sqrt{[(54)(38123)-(1247)^2][(54)(39565)-(1297)^2]}}$$

$r_2 = -0.0107$

ii) Dependent t- test

$$F = \frac{172.7}{155.8} = 1.11 \text{ (variances are homogeneous)}$$

Pretest mean $= \bar{X}_2$ Post-test mean $= \bar{X}_1$

$$t_2 = \frac{24.02 - 23.09}{\sqrt{\frac{155.8}{54} + \frac{172.7}{54} - 2(-0.0107)\left(\frac{12.48}{7.35}\right)\left(\frac{13.14}{7.35}\right)}}$$

$t_2 = 0.375$

Hypothesis Nine

i) Linear correlation coefficient

Posttest (x) - Retention (y)

$$r_1 = \frac{(50)(36794) - (1294)(1160)}{\sqrt{[(50)(44808) - (1294)^2][(50)(39834) - (1160)^2]}}$$

$r_1 = 0.56$

ii) Dependent t- test

$$F = \frac{258.6}{226.5} = 1.14 \text{ (variances are homogeneous)}$$

Posttest mean $= \bar{X}_1$ Retention Test means $= \bar{X}_2$

$$t_1 = \frac{25.88 - 23.2}{\sqrt{\frac{226.5}{50} + \frac{258.6}{50} - 2(0.56)\left(\frac{15.05}{7.07}\right)\left(\frac{16.08}{7.07}\right)}}$$

$t_1 = 1.295$

i) Linear correlation coefficient

Posttest (x) - Retention (y)

$$r_2 = \frac{(51)(35753) - (1288)(1357)}{\sqrt{[(51)(42310) - (1288)^2][(51)(42619) - (1357)^2]}}$$

$r_2 = 0.1857$

ii) Dependent t- test

$$F = \frac{191.8}{127.1} = 1.5 \text{ (variances are homogeneous)}$$

Posttest mean $= \bar{X}_2$ Retention Test means $= \bar{X}_1$

$$t_2 = \frac{26.61 - 25.25}{\sqrt{\frac{127.7}{51} + \frac{191.8}{51} - 2\,(0.1857)\left(\frac{11.3}{7.14}\right)\left(\frac{13.85}{7.14}\right)}}$$

$t_2 = 0.601$

Hypothesis Ten

i) Linear correlation coefficient

Posttest (x) - Retention (y)

$$r_1 = \frac{(52)(30568) - (1216)(1161)}{\sqrt{[(52)(37534) - (1216)^2]\,[(52)(33757) - (1161)^2]}}$$

$r_1 = 0.409$

ii) Dependent t- test

$$F = \frac{175.03}{150.8} = 1.16 \text{ (variances are homogeneous)}$$

Posttest mean $= \bar{X}_1$ Retention Test means $= \bar{X}_2$

$$t_1 = \frac{23.38 - 22.33}{\sqrt{\frac{175.03}{52} + \frac{150.8}{52} - 2\,(0.409)\left(\frac{13.23}{7.21}\right)\left(\frac{12.28}{7.21}\right)}}$$

$t_1 = 0.544$

i) Linear correlation coefficient

Posttest (x) - Retention (y)

$$r_2 = \frac{(54)(33329) - (1297)(1349)}{\sqrt{[(54)(39565) - (1297)^2][(54)(41593)-(1349)^2]}}$$

$r_2 = 0.1139$

ii) Dependent t- test

$F = \frac{155.75}{146.17} = 1.07$ (variances are homogeneous)

Posttest mean $= \bar{X}_2$ Retention Test means $= \bar{X}_1$

$$t_2 = \frac{24.98 - 24.02}{\sqrt{\frac{146.17}{54} + \frac{155.75}{54} - 2(0.1139)\left(\frac{12.09}{7.35}\right)\left(\frac{12.48}{7.35}\right)}}$$

$t_2 = 0.43$

APPENDIX M

CLASSIFICATION OF ERRORS

EF Group (N= 101)

(Addition & Subtraction of Fractions)

Error	Pretest		Posttest		Retention Test	
	No of Errors	% Total Errors	No of Errors	% Total Errors	No of Errors	% Total Errors
I	117	32.5	25	8.6	14	5.6
II	83	23.1	13	4.5	4	1.6
III	17	4.7	9	3.1	6	2.4
IV	115	31.9	230	78.8	205	82.7
V	28	7.8	15	5.1	19	7.7
TOTAL	360	100%	292	100%	248	100%

LCM Group (N= 106) Addition an Subtraction of Fractions

Error	Pretest		Posttest		Retention Test	
	No of Errors	% Total Errors	No of Errors	% Total Errors	No of Errors	%Total Errors
I	31	10.2	36	10.1	18	5.0
II	29	9.5	27	7.6	13	3.6
III	23	7.5	71	20.0	15	4.1
IV	218	71.5	213	60	299	82.1
V	4	1.3	8	2.3	19	5.2
Total	305	100%	355	100%	364	100%

Key:

i. Sum of Numerators over sum of Denominators
ii. Difference of numerators over Difference of Denominators.
iii. Use of Denominators other than the LCD
iv. Failure to simplify answers
v. Incorrect simplification of answers

APPENDIX N

TOTAL RAW SCORES OF THE EQUIVALENT FRACTIONS (EF) GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON ADDITION AND SUBTRACTION OF FRACTIONS SCORED OUT OF 50

First digit of Student's No	Second Digit of Student's Number									
	0	1	2	3	4	5	6	7	8	9
0		[0] (18) 11	[4] (1) 0	[33] (41) 38	[4] (28) 6	[4] (9) 23	[0] (14) 8	[0] (5) 17	[0] (9) 13	[0] (9) 17
1	[0] (22) 21	[0] (7) 19	[14] (31) 23	[0] (34) 2	[49] (37) 48	[26] (10) 25	[1] (50) 37	[0] (0) 12	[33] (10) 0	[0] (37) 34
2	[1] (39) 50	[36] (43) 42	[10] (41) 38	[20] (5) 42	[10] (9) 29	[0] (49) 12	[3] (10) 49	[46] (46) 44	[0] (40) 20	[39] (35) 45
3	[41] (10) 0	[6] (20) 20	[0] (34) 39	[0] (39) 19	[30] (34) 27	[9] (24) 41	[49] (41) 28	[42] (9) 0	[0] (40) 45	[0] (44) 46
4	[4] (38) 9	[23] (42) 38	[43] (50) 49	[15] (14) 0	[39] (29) 12	[48] (23) 19	[12] (29) 50	[0] (24) 21	[13] (13) 0	[0] (42) 8
5.	[4] (6) 5	[6] (34) 23	[21] (8) 27	[23] (9) 11	[33] (8) 29	[10] (44) 36	[8] (45) 31	[30] (8) 28	[16] (50) 24	[0] (47) 8
6.	[4] (24) 8	[5] (45) 41	[39] (32) 39	[42] (11) 5	[5] (33) 40	[49] (39) 23	[39] (48) 24	[40] (23) 31	[39] (25) 18	[0] (20) 36
7.	[0] (19) 45	[0] (25) 34	[44] (49) 11	[9] (31) 27	[0] (35) 9	[0] (27) 45	[0] (17) 43	[22] (27) 36	[43] (27) 40	[21] (38) 16
8.	[46] (31) 35	[10] (9) 16	[5] (12) 21	[4] (4) 25	[4] (31) 44	[8] (28) 22	[8] (44) 41	[8] (10) 25	[23] (40) 28	[5] (31) 39
9.	[0] (22) 42	[17] (19) 23	[22] (6) 35	[34] (2) 8	[8] (2) 27	[25] (29) 20	[36] (6) 10	[6] (9) 12	[0] (33) 22	[14] (38) 35
10.	[5] (16) 20	[15] (18) 19								

Key: [ ] Pretest ( ) Posttest

Non-bracket : Retention test

EF Group –1: 1-50

EF Group -2: 51-101

APPENDIX P

TOTAL RAW SCORES OF THE LEAST COMMON MULTIPLE (LCM) GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON ADDITION AND SUBTRACTION OF FRACTIONS SCORED OUT OF 50

First Digit of Student's No	Second Digit of Student's Number 0	1	2	3	4	5	6	7	8	9
0		[17] (29) 28	[1] (16) 33	[0] (0) 8	[0] (4) 12	[0] (8) 13	[0] (4) 8	[34] (39) 34	[25] (21) 4	38] (39) 37
1.	[32] (39) 38	[4] (31) 29	[26] (7) 13	[28] (23) 30	[0] (33) 15	[14] (43) 31	[14] (19) 23	[7] (33) 14	[11] (12) 33	[10] (40) 39
2.	[12] (34) 19	[34] (12) 12	[34] (9) 4	[16] (7) 8	[15] (8) 0	[37] (10) 33	[46] (20) 21	[20] (18) 8	[18] (37) 38	[19] (36) 12
3.	[16] (42) 42	[17] (29) 15	[8] (47) 15	[4] (15) 0	[5] (11) 36	[48] (9) 40	[34] (10) 39	[42] (44) 38	[27] (34) 33	[31] (41) 25
4.	[0] (22) 31	[0] (7) 8	[23] (21) 14	[43] (30) 10	[35] (14) 15	[35] (5) 32	[37] (29) 38	[32] (41) 32	[41] (41) 26	[42] (31) 18
5.	[27] (25) 9	[10] (19) 34	[10] (18) 14	[40] (33) 37	[30] (30) 21	[33] (26) 15	[40] (12) 37	[27] (24) 27	[34] (24) 21	[2] (18) 39
6.	[20] (31) 40	[30] (28) 4	[16] (20) 7	[21] (39) 7	[14] (6) 12	[8] (11) 13	[42] (17) 15	[36] (10) 42	[14] (23) 35	[32] (42) 19
7.	[27] (32) 36	[20] (30) 10	[14] (37) 13	[10] (41) 27	[0] (13) 43	[10] (13) 40	[6] (44) 41	[6] (43) 37	[42] (37) 45	[25] (29) 40
8.	[29] (1) 41	[27] (45) 31	[35] (9) 10	[19] (34) 38	[13] (14) 27	[9] (23) 37	[9] (34) 36	[5] (44) 34	[45] (43) 23	[35] (42) 5
9.	[40] (18) 25	[41] (35) 10	[42] (20) 20	[38] (9) 6	[4] (5) 17	[8] (27) 12	[0] (8) 4	[21] (25) 17	[18] (0) 20	[27] (20) 23
10.	[30] (6) 16	[33] (9) 32	[0] (21) 33	[39] (20) 25	[27] (18) 27	[27] (36) 31	[27] (18) 26			

Key: [ ] Pretest ( ) Posttest

Non- brackets: Retention test

LCM Group – 1-52; LCM Group - 2: 53- 106

APPENDIX Q

RAW SCORES OF THE EQUIVALENT FRACTIONS (EF) GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON ADDITION OF FRACTIONS SCORED OUT OF 25

First Digit of Student's No	Second Digit of Student's Number. 0	1	2	3	4	5	6	7	8	9
0		[0] (4) 7	[0] (1) 0	[16] (19) 18	[4] (19) 1	[4] (5) 12	[5] (9) 4	[0] (5) 13	[0] (9) 8	[0] (5) 10
1.	[0] (10) 4	[0] (1) 10	[8] (25) 14	[0] (20) 1	[24] (12) 25	[14] (10) 18	[0] (25) 14	[0] (0) 0	[20] (1) 0	[0] (21) 13
2.	[0] (18) 25	[18] (22) 17	[6] (19) 20	[14] (5) 24	[5] (5) 15	[0] (24) 8	[0] (5) 4	[21] (23) 24	[0] [(19) 20	[17] (15) 23
3.	[22] (10) 0	[5] (20) 20	[0] (17) 22	[0] (19) 14	[9] (19) 17	[4] (15) 23	[24] (19) 14	[24] (5) 0	[0] (20) 22	[0] (23) 21
4.	[0] (16) 5	[23] (23) 19	[20] (25) 25	[11] (9) 0	[19] (6) 0	[24] (5) 0	[8] (19) 25	[0] (20) 20	[13] (12) 0	[0] (21) 8
5.	[0] (1) 0	[6] (20) 13	[5] (4) 18	[5] (4) 0	[16] (4) 9	[4] (22) 16	[4] (23) 11	[25] (4) 4	[10] (25) 20	[0] (24) 4
6.	[4] (14) 4	[0] (22) 25	[22] (14) 25	[21] (7) 5	[5] (21) 23	[24] (14) 18	[17] (23) 5	[18] (10) 14	[17] (0) 13	[0] (19) 21
7.	[0] (19) 25	[0] (21) 17	[24] (25) 7	[4] (18) 23	[0] (18) 5	[0] (17) 25	[0] (12) 23	[5] (14) 19	[19] (14) 20	[16] (21) 11
8.	[23] (18) 21	[6] (5) 4	[0] (8) 17	[4] (0) 8	[0] (18) 25	[4] (10) 11	[4] (19) 20	[4] (10) 13	19 (19) 11	5 (13) 22
9.	[0] (0) 24	[8] (15) 14	[9] (2) 21	[19] (2) 4	[4] (2) 22	[13] (15) 11	[19] (5) 4	[5] (5) 4	[0] (17) 14	[9] (21) 25
10.	[5] (8) 0	[6] (11) 4								

Key: [ ] Pretest ( ) Posttest

Non- bracket: Retention test

EF – 1: 1-50

EF –2: 51-101

APPENDIX R

RAW SCORES OF THE LCM GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON ADDITION OF FRACTIONS SCORED OUT OF 25.

First Digit of Student's No	Second Digit of Student's Number. 0	1	2	3	4	5	6	7	8	9
0		[9] (21) 16	[1] (12) 18	[0] (0) 4	[0] (0) 6	[0] (4) 9	[0] (0) 4	[22] (21) 16	[21] (21) 4	[20] (19) 17
1.	[18] (19) 17	[4] (12) 10	[13] (12) 7	[14] (10) 16	[0] (14) 9	[6] (19) 9	[6] (13) 10	[7] (14) 8	[6] (3) 13	[5] (20) 16
2.	[6] (14) 12	[18] (6) 8	[18] (9) 0	[9] (7) 3	[9] (8) 0	[17] (3) 12	[23] (20) 12	[17] (5) 5	[10] (19) 17	[15] (21) 7
3.	[10] (21) 19	[9] (20) 3	[4] (23) 10	[0] (6) 0	[1] (9) 16	[24] (3) 18	[21] (7) 16	[21] (21) 17	[19] (13) 16	[12] (21) 9
4.	[0] (0) 10	[0] (7) 8	[9] (13) 7	[19] (16) 6	[17] (3) 8	[17] (3) 18	[20] (15) 17	[23] (21) 16	[19] (21) 10	[21] (16) 4
5.	[14] (11) 8	[7] (7) 18	[6] (8) 8	[23] (13) 16	[13] (18) 8	[19] (11) 11	[23] (6) 17	[14] (12) 8	[15] (12) 16	[2] (0) 18
6.	[8] (10) 19	[17] (14) 3	[9] (18) 7	[13] (18) 3	[8] (4) 6	[4] (0) 5	[23] (17) 7	[19] (3) 20	[14 (9) 15	[15] (22) 11
7.	[15] (17) 20	[8] (13) 5	[10] (17) 8	[4] (21) 8	[0] (5) 21	[2] (5) 20	[2] (24) 20	[2] (22) 17	[23] (17) 20	[12] (17) 18
8.	[18] (0) 20	[14] (20) 15	[15] (0) 6	[10] (19) 19	[4] (4) 18	[4] (0) 20	[1] (16) 19	[1] (22) 13	[25] (21) 15	[19] (22) 4
9.	[21] (10) 4	[22] (19) 6	[17] (16) 11	[13] (9) 1	[4] (3) 6	[4] (9) 6	[0] (0) 4	[12] (12) 4	[7] (0) 10	[13] (4) 13
10.		[13] (0) 8	[13] (3) 18	[0] (11) 22	[18] (16) 16	[14] (8) 18	[14] (8) 18	[14] (20) 18		

Key: [ ] Pretest ( ) Posttest

Non- bracket: Retention Test

LCM Group - 1: 1- 52; LCM Group – 2: 53- 106

APPENDIX S

FREQUENCY DISTRIBUTION OF MARKS EF GROUP (N= 101)

(Addition and Subtraction of Fractions)

Question/Test		MARKS 6	5	4	3	2	1	0
	T1	-	23	39	1	-	2	36
1	T2	-	42	45	-	-	3	11
	T3	-	27	54	1	-	-	19
	T1	-	5	26	-	6	5	59
2	T2	-	12	50	2	3	4	30
	T3	-	34	26	2	4	6	29
	T1	-	-	26	2	4	6	63
3	T2	-	-	27	-	1	8	65
	T3	-	-	51	1	1	6	42
	T1	18	3	8	2	-	4	66
4	T2	25	11	16	-	4	8	37
	T3	13	12	12	-	3	10	51
	T1	-	11	6	1	5	10	68
5	T2	-	42	4	4	6	21	24
	T3	-	49	2	11	2	5	32
	T1	-	17	39	2	-	-	43
6	T2	-	23	55	-	-	-	23
	T3	-	23	58	-	-	-	20
	T1	-	20	11	1	3	5	61
7	T2	-	28	27	-	3	4	39
	T3							
	T1	-	-	23	4	2	3	69
8	T2	-	-	40	1	2	5	53
	T3	-	-	48	1	1	6	45
	T1	-	8	15	1	3	3	71
9	T2	-	25	20	-	2	4	50
	T3	-	16	30	1	1	7	46
	T1	12	6	-	-	2	11	70
10	T2	27	9	4	3	4	6	48
	T3	13	2	-	-	1	40	45

KEY:

T1- Pretest

T2- Posttest

T3 – Retention Test.

APPENDIX T

FREQUENCY DISTRIBUTION OF MARKS LCM GROUP (N= 106)

Addition and Subtraction of Fractions

Questions/Test		MARKS 6	5	4	3	2	1	0
	T1	-	25	48	2	1	9	21
1	T2	-	37	34	2	1	18	14
	T3	-	23	58	2	-	6	17
	T1	-	7	42	1	21	8	27
2	T2	-	9	42	7	12	17	19
	T3	-	19	32	2	9	19	25
	T1	-	2	54	3	2	10	30
3	T2	-	-	24	3	5	5	69
	T3	-	-	52	2	6	9	37
	T1	13	4	29	-	3	10	47
4	T2	2	14	33	3	3	11	40
	T3	5	15	24	6	4	3	49
	T1	-	23	8	2	4	11	58
5	T2	-	23	17	2	9	27	28
	T3	-	36	16	4	4	12	34
	T1	-	15	63	3	-	1	24
6	T2	-	38	44	2	-	3	19
	T3	-	17	57	1	-	5	26
	T1	-	21	39	1	4	5	36
7	T2	-	22	35	5	12	8	24
	T3	-	11	29	6	9	13	38
	T1	-	-	43	9	3	6	45
8	T2	-	-	46	3	7	13	37
	T3	-	-	42	4	3	9	48
	T1	-	3	33	2	4	5	59
9	T2	-	8	28	-	6	8	56
	T3	-	4	35	9	1	5	52
	T1	5	-	13	11	2	19	56
10	T2	7	4	23	4	7	27	34
	T3	8	14	12	4	10	16	42

Key:

T1- Pretest

T2- Posttest

T3- Retention Test.

APPENDIX U

RAW SCORES OF THE EF GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON SUBTRACTION OF FRACTIONS SCORED OUT OF 25

First digit of Student's No	Second Digit of Student's Number. 0	1	2	3	4	5	6	7	8	9
0		[0] (14) 4	[4] (0) 0	[17] (22) 20	[0] (9) 5	[0] (4) 11	[0] (5) 4	[0] (0) 4	[0] (0) 5	[0] (4) 7
1.	[0] (12) 17	[0] (6) 9	[6] (6) 9	[0] (14) 1	[25] (25) 23	[12] (0) 7	[1] (25) 23	[0] (0) 12	[13] (9) 0	[0] (16) 21
2.	[1] (21) 25	18] (21) 25	[4] (22) 18	[6] (0) 18	[5] (4) 14	[0] (25) 4	[3] (5) 4	[25] (23) 20	[0] (21) 0	[22] (20) 22
3.	[19] (0) 0	[1] (0) 0	[0] (17) 17	[0] (20) 5	[21] (15) 10	[5] (9) 18	[25] (22) 14	[18] (4) 0	[0] (20) 23	[0] (21) 25
4.	[4] (22) 4	[0] (19) 19	[23] (25) 24	[4] (5) 0	[20] (23) 12	[24] (18) 19	[4] (10) 25	[0] (4) 1	[0] (1) 0	[0] (21) 0
5.	[4] (5) 5	[0] (14) 0	[16] (4) 0	[18] (5) 0	[17] (4) 20	[6] (22) 20	[4] (22) 20	[5] (4) 24	[6] (25) 4	[0] (23) 4
6.	[0] (10) 4	[5] (23) 16	[17] (18) 14	[21] (4) 0	[0] (12) 17	[25] (25) 5	[22] (25) 19	[22] (13) 17	[22] (25) 5	[0] (0) 15
7.	[0] (0) 20	[0] (4) 17	[20] (24) 4	[5] (13) 4	[0] (17) 4	[0] (10) 20	[0] (5) 20	[17] (13) 17	[24] (25) 20	[5] (23) 5
8.	[23] (13) 14	[4] (4) 12	[5] (4) 4	[0] (4) 17	[4] (13) 19	[4] (18) 11	[4] (25) 21	[4] (0) 12	[4] (21) 17	[0] (18) 17
9.	[0] (22) 18	[9] (4) 9	[13] (4) 14	[15] (0) 4	[4] (0) 5	[12] (14) 9	[17] (1) 0	[1] (4) 0	[0] (16) 8	[5] (17) 10
10.	[0] (8) 20	[9] (7) 15								

Key: [ ] Pretest ( ) Posttest

Non- bracket: Retention Test

EF- 1: 1- 50; EF – 2 : 51-101

APPENDIX V

RAW SCORES OF THE LCM GROUP ON THE PRETEST, POSTTEST AND RETENTION TEST ON SUBTRACTION OF FRACTIONS SCORED OUT OF 25

First digit of Student's No	Second Digit of Student's Number									
	0	1	2	3	4	5	6	7	8	9
0.		[8] (8) 12	[0] (4) 15	[0] (0) 4	[0] (4) 6	[0] (4) 4	[0] (4) 4	[12] (18) 18	[4] (0) 0	[18] (20) 20
1.	[14] (20) 21	[0] (19) 19	[13] (5) 6	[14] (13) 14	[0] (19) 6	[8] (24) 22	[8] (6) 13	[0] (19) 6	[5] (9) 20	[5] (20) 23
2.	[6] (20) 7	[16] (6) 4	[16] (0) 4	[7] (0) 5	[6] (0) 0	[20] (7) 21	[26] (0) 9	[3] (13) 3	[8] (18) 21	[4] (15) 5
3.	[6] (21) 23	[8] (9) 8	[4] (24) 5	[4] (9) 0	[4] (2) 20	[24] (6) 22	[13] (3) 23	[21] (23) 21	[8] (21) 17	[19] (20) 16
4.	[0] (22) 2	[0] (0) 0	[14] (8) 7	[24] (14) 4	[18] (11) 7	[18] (2) 14	[17] (14) 21	[9] (20) 16	[22] (20) 16	[21] (15) 14
5.	[13] (14) 1	[3] (12) 16	[4] (10) 6	[17] (20) 21	[17] (12) 13	[14] (15) 4	[17] (6) 20	[13] (12) 19	[19] (12) 5	[0] (18) 21
6.	[7] (21) 21	[13] (14) 1	[7] (2) 0	[8] (21) 4	[6] (2) 6	[4] (11) 8	[19] (0) 8	[17] (7) 22	[0] (14) 20	[17] (20) 6
7.	[12] (15) 16	[12] (17) 5	[4] (20) 5	[6] (20) 19	[0] (8) 22	[8] (8) 20	[4] (20) 21	[4] (21) 20	[19] (20) 25	[13] (12) 22
8.	[11] (1) 21	[13] (25) 16	[20] (9) 4	[9] (15) 19	[9] (10) 9	[4] (23) 17	[8] (18) 17	[4] (22) 21	20] (22) 8	[16] (20) 1
9.	[19] (8) 11	[19] (16) 4	[25] (4) 9	[25] (0) 5	[0] (2) 11	[4] (18) 6	[0] (8) 0	[9] (13) 13	[11] (0) 10	[14] (16) 10
10.	[17] (5) 8	[20] (6) 14	[0] (10) 11	[21] (4) 9	[13] (10) 9	13] (16) 13	[13] (8) 8			

Key: [ ] Pretest ( ) Posttest

Non- bracket: Retention test

LCM -1: 1-52; LCM - 2: 53-106