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Perception of Teacher Trainees on the use of Cuisenaire Rod in Learning Fractions

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Abstract: Ghana as a nation cannot develop rapidly if sustainable strategies are not put in place to improve upon the teaching and learning of mathematics in our schools. This is because these students are the future leaders of the nation and if the educational structure cannot give them a good foundation in mathematics then they cannot have the requisite material and the technical know-how needed to contribute their quota towards the development of the nation. The study therefore sought to investigate the perception of teacher trainees on the use of Cuisenaire Rods in teaching and learning fractions at the Enchi College of Education. The study sought to find out the perception of teacher trainees on the differences of using Cuisenaire Rods for teaching the concept of fractions in mathematics and how confident are teacher trainees about their ability to use Cuisenaire Rods in solving problems involving fractions. The descriptive design was adopted for the study. The sample size of the study comprised one hundred sixty teacher trainees and four tutors in Enchi College of Education. Questionnaire and structured interviewed were employed in the data collection. The quantitative data and analysis were done by using the SPSS (16) software package. The study revealed that the use of Cuisenaire Rods greatly improves the teaching of fractions in mathematics. It was also realized that the teacher trainees grasp a concept when they are taken through the procedure from concrete through semi-concrete and finally to abstract. The implications of the findings are that teacher trainees should be encouraged to use Cuisenaire Rods to teach fractions.

Keywords: Teacher Trainees, Perception, Fractions, Cuisenaire Rod, Teaching and Learning

1. Introduction

Mathematics is one of the important foundational subjects that constitute the core curriculum for basic education in most countries throughout the world. In Ghana it is a compulsory subject in the primary and secondary schools. The subject occupies a privileged position in the school curriculum because the ability to cope with more of its operations improves one's chances of social improvement. It obtained this position when it was made to replace classical language like Latin or Greek which prior to the early half of the twentieth century were used as screening devices for entry to higher education and certain professions (Mereku, 2004).

"Mathematics is a difficult subject, it is the preserve for students with a higher intellectual ability, females cannot study mathematics" (Nabie, 2002, p. 87) are but a few of the popular comments or utterances among majority of students in our educational institutions. This mental barriers or mind sets by students about mathematics accounts for the massive drift towards the study of social sciences such as the General Arts by many good Science and Mathematics students (Nabie, 2002). The importance of mathematics can be seen from

its application in our daily lives and its role in technology and other subjects forms a strong binding force among various branches of science and without it, knowledge of science often remains superficial (Singletary, 1997). This indicates that without proper grasp of the underlying principles in mathematics, the necessary skills and concepts in science and technology cannot be acquired and applied by students.

Ghana as a nation cannot develop rapidly if sustainable strategies are not put in place to improve upon the teaching and learning of mathematics in our schools. This is because these pupils or students are the future leaders of the nation. If the educational structure cannot give them a good foundation in mathematics then they cannot have the requisite material and the technical know–how needed to contribute their quota towards the development of Ghana. Mathematics can enable students to achieve deeper understanding of science concepts by providing ways to quantify and explain science relationship (McBride & Silverman, 1997, p. 102). For several decades we have seen increasing failure in mathematics in spite of intensive effort in many directions to improve matters. It would be reasonable also to suspect that the causes are fundamental in the ways in which they are taught, how children learn and the teaching situations (Skemp, 1991, p. 72). Every child who enters the educational system had to study mathematics till the matriculations level (Evans, 2002). It is for this reason that effective methods coupled with good pedagogical skills interplayed with versatile teaching and learning material such as Cuisenaire Rods are necessary to help teacher trainees to teach mathematics in general and fractions in particular. [1] stated that: “We need to make students see the relevance of the mathematics they study. We need to occupy the mind of our students with useful activities that impact on them positively. There is the need to organize workshops for mathematics teachers nationwide to help them become part of the solution to the mathematics phobia that students experience in the country” (p. 27). According to the IOE, Chief Examiner’s Report (2006), although students’ performance in Algebra (FDC 112) saw slight improvement over that of the previous years, some candidates had problems in answering questions on the teaching of fraction in the basic school using Cuisenaire Rods. The report mentioned students misunderstanding of the concept of fractions as well as lack of requisite skills to apply in solving questions as some students’ weakness in the mathematics methodology paper. Also, Chief Examiner’s Report (2007) on UTDBE (Untrained Teachers’ Diploma in Basic Education) indicates that many students do not do well in questions that involve fractions. UTDBE students had difficulties with addition of fractions with different denominators. They could not make use of equivalent fractions. Besides, questions that involve division and multiplication of fractions were not properly answered, students could not state vital steps needed before writing the final answer. Working with fractions poses serious problem to most candidates, even, regular trainees had difficulties in solving questions involving fractions.

Fractions seem to be a problem in many levels of education. There are many pre-requisites that many students of Enchi College of Education had not yet acquired before they were introduced to fractions. It is therefore not surprising that owing to the difficulty in mathematics, students perform poorly in answering questions on fractions and more so they are unable to teach fractions as expected during teaching practice. Many students appear to have learnt fractional computations as procedures without developing the underlying conceptual knowledge about fractions.

To help these students to overcome the above difficulties, Cuisenaire Rods have been identified by the researcher as one of the effective teaching and learning materials that can be used. Cuisenaire Rods, sometimes called number Rods or factor Rods are one of the simplest and most versatile mathematical teaching materials. Cuisenaire Rods have hundreds of many activities for which they can be used for developing many mathematical concepts but it is important to remember that when developing new concepts, students should be given many different situations as possible. Activities using Cuisenaire Rods give a good introduction to the concept of fractions, equivalence of fractions and addition and subtraction of fractions. The use of Cuisenaire Rods has been emphasized in the basic school syllabus hence the choice of it among the numerous teaching and learning materials available to remedy this situation.

2. Cuisenaire Rods and Mathematics Teaching and Learning

Cuisenaire Rods were invented over 75 years ago by George Cuisenaire a Belgian mathematics teacher. He invented this unique system to help students grasp abstract concepts in mathematics using coloured cardboard strips of varying lengths called Cuisenaire Rods (Thompson, 1994). A pack of Cuisenaire Rods consist of 74 rectangular Rods in 10 cm different lengths and 10 different colours. Each color corresponds to a different length. The content of the pack is thus: 22 white Rods of 1 cm each, 12 red Rods of 2 cm each, 10 light green Rods of 3 cm each, 6 purple Rods of 4 cm each, 4 yellow Rods of 5 cm each, 4 dark red Rods of 6cm each, 4 black Rods of 7cm each, 4 brown Rods of 8cm each, 4 blue Rods of 9 cm each and 4 orange Rods of 10 cm each (Thompson, 1994).

Dollan (2000) noted that Cuisenaire Rods are a versatile mathematical manipulative used for elementary school mathematics training as well as at other levels of learning and even with adults. Dollan held the view that

Cuisenaire are used to teach a wide variety of mathematical topics such as the four basic arithmetic operations, working with fractions, areas and volumes of figures, square roots, solving simple linear and quadratic equations and systems of equations.

The Cuisenaire Rods (reglettes in the original French) are named after their inventor George Cuisenaire (1891-1976), a Belgian primary school teacher, who published a book on their use in 1952 called 'les nombres en couleurs' (Costelpe & Hemstock, 1957). According to Costelpe & Hemstock (1957) the use of Cuisenaire Rods for both mathematics and language teachers was developed and popularized by Caleb Gattegno in many countries around the world. In her first school and in school since then, Maria Montessori used Cuisenaire Rods in the classroom to teach concepts of length in mathematics.

These Rods could be used as manipulative and symbolic concrete representations in teaching concepts in mathematics. Learners explore whole numbers, fractions, measurements, ratio, area, perimeter, symmetry, congruency, 3-dimensional geometry and functions, etc using Cuisenaire Rods (Thompson, 1994). Cuisenaire Rods' approach is a hands-on and minds on manipulative activities filed approach for teaching abstract concepts in mathematics and sciences. It is a valuable educational tool for modelling relationships between what is taught in school and what exists at home, making connection between what is taught in school and their everyday life activities (Elia, Gagatsis &Demetrio, 2007).

It enables every student to work independently and in a group on meaningful mathematics contents while the teacher provides individual attention to other students (Elia, Gagatis & Demetrico, 2007). Because Cuisenaire Rods are ready-made tools, its approach minimizes preparation and set up time both for the teacher and the students. This approach helps to develop key skills such as classification, critical thinking, problem solving, and logical, mathematical and spatial reasoning (Rule & Hllagan, 2006).

It involves a lot of cooperatively and collaboratively working group (Butler, et al, 2003). In a Cuisenaire Rods' approach classroom, the lesson begins with students shared into groups of threes or fours and a park of Cuisenaire Rods given to each group. They are acquainted with the content of the park and what each colour stands for. The teacher explains to the students what is expected from them, the objectives of the lesson and the type of cooperation needed. Here the teacher is only a resource person, an instructor and a guide to the experiment. It begins with the exploration of the learner's immediate environment and ends with the application of the lesson learnt to his immediate environment (Butler, et al, 2003).

Learner's past experience forms the basis of the teaching and learning. This means relating classroom activities to learner's life experience which enables him to see the relationship between what is taught in school and what is done at home thereby facilitating transfer of learning (Case, Cates, Smith, & Jackson, 2003). There are group discussions among members of the groups, inter group discussion, teacher student discussion which leads to effective interaction and daily assignments. This discussion forum warms up and sparks off students' interest from the beginning to the end of each lesson. As the learner progress from one manipulative representation to the other, they learn and understand important mathematics concepts and develop abstract logical thinking (Case, et al, 2003).

Endless opportunities are presented to investigate and reinforce key mathematics topics and ask questions freely without fear. This lesson involves cooperation, collaboration and individual works (Moyer, 2001). This approach helps the learner to learn from others and be able to ask questions when he does not understand or when in a fix as opposed in today's mathematics classroom. It requires minimal preparation by the teacher. The fun involved in this approach makes students absorbed in the varieties of the activities (Butler, et al, 2003). Studies carried out on this approach revealed that students taught using this approach rapidly acquired problem solving skills, maintained these skills over a two-month period and transferred these skills to a paper and pencil problem solving format (Case, et al, 2003).

It as well sustains the interest of learners for a longer period because it is learning by doing which is at the heart of mathematics knowledge (Weissglass, 1977). The newness, practical, result-oriented and explorative nature excites the learners so much that they begin to emulate the work of their teachers resulting in frequent practice at home even without being given home exercise in and outside the classroom. Those who learnt, begin to teach the younger ones. The use of concrete material for practical takes away the abstractness seen in mathematics concepts (NCTM, 1989). Its problem-solving ability leads to discovery which is aesthetic. This method favours both sexes thereby encouraging male and female students (Weissglass, 1977). Lake & Newmark (1977) stressed that this is possibly the first instance of Cuisenaire Rods being used in the classroom for this purpose. Doctor Catherine Stern also advised a set of Cuisenaire Rods produced by staining with aesthetically pleasing Cuisenaire colours. In 1961 Sector Pollock produced the colour factor system, consisting of Cuisenaire Rods from length one centimeter to ten centimeters. The odd numbered lengths have cold colours, and the even numbered lengths have warm colours (Durnas &Howard, 1966). Figure 1 shows the colours of Cuisenaire Rods

with interpretation.

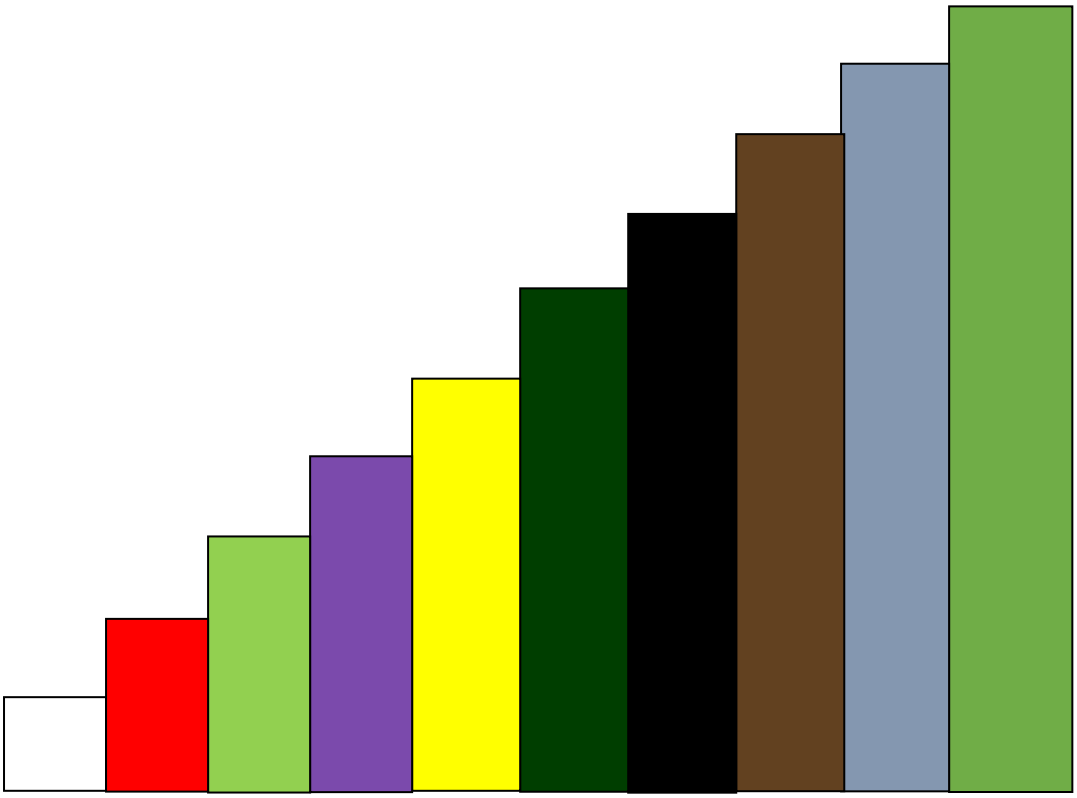

Figure 1: Cuisenaire Rods

2.1. Fractions

Costelpe & Hemstock (1957) explain vulgar fractions as the same as simple fraction. They explained that if you have $\frac{1}{4}$, the lower number that is 4 is the denominator and 1 is the numerator. The golden rule says that before fractions could be added or subtracted, they must have the same denominators that is $\frac{1}{5}$ and $\frac{2}{5}$ could be added to get $\frac{3}{5}$, however $\frac{1}{2}$ and $\frac{1}{3}$ cannot be added until they are changed into fractions of the same denominators. They also explained that if a fraction is multiplied by a whole number, the denominator remains the same. For instance, $3 \times \frac{4}{12} = \frac{12}{12} = 1$. Moreover, when a fraction is multiplied by a fraction, multiply the numerators together and the denominators also together, for example, $\frac{3}{4} \times \frac{3}{5} = \frac{3\times3}{4\times5} = \frac{9}{20}$. The rule also says that division of fractional numbers changes the divisor and the numerator becomes the denominator whiles the denominator becomes numerator, for instance $\frac{8}{15} \div \frac{2}{5} = \frac{8}{15} \times \frac{5}{2} = \frac{10}{20} = \frac{4}{3}$

Obeng (2005) stated that addition or subtraction of fractions with different denominators can be solved by using the following steps. Express each fraction as an equivalent fraction with the same denominators of the fractions as illustrated in the examples: $\frac{4}{7} + \frac{3}{5}$

Equivalent fractions of $\frac{4}{7}$ are $\frac{8}{14} = \frac{12}{21} = \frac{16}{28} = \frac{20}{35} = \frac{24}{42}$.

Those of $\frac{3}{4}$ are $\frac{6}{10} = \frac{9}{15} = \frac{12}{20} = \frac{15}{25} = \frac{18}{30} = \frac{21}{35}$. Then, $\frac{4}{7} + \frac{3}{5} = \frac{20}{35} = \frac{21}{35} = \frac{41}{35}$.

In the same way; $\frac{2}{3} - \frac{1}{4}$.

Equivalent fractions of $\frac{2}{3}$ are $\frac{4}{6} \equiv \frac{6}{9} \equiv \frac{8}{12} \equiv \frac{10}{15}$. That of $\frac{1}{4}$ are $\frac{2}{8} \equiv \frac{3}{12} \equiv \frac{4}{16}$.

Therefore, $\frac{2}{3} - \frac{1}{4} = \frac{8}{12} - \frac{3}{12} = \frac{5}{12}$.

The equivalent fraction is obtained by finding common multiples of the denominator of the two fractions given.

2.2. Theoretical Framework

Framework development is useful to think about some perspectives on teaching. Education thinkers and writers have variously emphasized different aspects of the teaching role. Cramer, Behr, Post & Lesh (1997) summarize these as:

1. The teacher as an expert in the subject
2. The teacher as a facilitator of learning
3. The teacher as a motivator and source of inspiration
4. The teacher as upholder of moral standards
5. The teacher as deliverer of a prescribed curriculum
6. The teacher as researcher

Zeichner (1991) and CRDD (2001) provided five categories of ideologies or conceptual orientations in teacher education which they suggest have characterized reform movement within the United States. The orientations refer to a body of values and beliefs about teaching and teacher education that at different points in history have been particularly influential in shaping the nature of initial teacher education courses. The orientations are:

1. The academic orientation
2. The practical orientation
3. The technical orientation
4. The personal orientation
5. The critical-inquiry orientation

2.3. Statement of the Problem

One of the weaknesses listed in the mathematics Chief Examiner's Report for the 2002, 2004 and 2008 Basic Education Certificate Examinations was candidates' inability to answer questions that involve fractions. According to the 2007 Chief Examiner's Report for UTDBE conducted by the Institute of Education, UCC most of the UTDBE students were not able to answer questions that involve addition, subtraction, multiplication and division of fractions. The researcher is not surprised that some candidates at BECE could not effectively answer a question that involves fractions because even some of the teacher trainees do not understand the concept of fractions well and therefore are unable to effectively teach the concept of fractions.

2.4. Research Questions and Research Design

The following questions were formulated to guide the research study:

1. What is the perception of Teacher Trainees on the differences of using Cuisenaire Rods for teaching and learning the concept of fractions in Mathematics?
2. How confident are Teacher Trainees about their ability to use Cuisenaire Rods in solving problems involving fractions?

2.5. Research Design

This study adopted the descriptive survey. The researcher finds descriptive survey design appropriate since it involves collecting data to answer questions concerning the current status of the subject. Both qualitative and quantitative.

2.6. Participants

The total sample size for the study was therefore 164 as summarized in Table 1.

Table 1. *Number of Respondents or participants*

Class	Number
DBE 2A	32
DBE 2B	32
DBE 2C	32
DBE 2D	32
DBE 2E	32
Mathematics Tutors	4
Total	164

Source: Field Work, 2011

3. Instruments

A questionnaire made up of fourteen (14) close-ended five-point Likert scale structured items were administered to one hundred and sixty (160) teacher-trainees at Enchi College of Education. Fifteen (15) likert

scale questions were also administered to four mathematics tutors at Enchi College of Education in the Western Region. Questions made consisted of three sections. The instrument dwelt on effects of using Cuisenaire Rods in teaching fractions. The questionnaire was used to determine the extent of agreement or disagreement on some issues about the problem. The three-point Likert scale with numerical rating includes: Agree (A)→3; Uncertain (U)→2 and Disagree (D) → 1.

Interview guide made up of ten (10) semi-structured items were also administered to four mathematics tutors of Enchi College of Education. Content validity was carried out. Some items were scrapped off and reframed before I handed them over to my supervisor for scrutiny. Internal consistency on the questionnaire, the Cronbach's Alpha = .84, very good (DeVellis, 1991, p. 85). This exercise reduced the questionnaire for college mathematics tutors and teacher-trainees from 60 to 14 and 32 to 15 respectively. The interview guide was also reduced from 17 to 10.

Four tutors were interviewed. The interviews were semi-structured. Reliability of data from the semi-structured interview of this research was ensured by playing back recorded interview to each interviewee that there has been true recording of proceedings. The transcript was read out in the presence of each interviewee to be sure of its transcription.

4. Results

4.1. What is the perception of Teacher Trainees on the Effectiveness of using Cuisenaire Rods for teaching and learning the concept of fractions?

In order to answer this question, the responses of six items from the questionnaire were used. The details are displayed in Table 2. Responses to item 4 which "is the use of Cuisenaire Rods as teaching material would greatly improve the teaching of fractions in mathematics" shows that out of the four respondents for the study, 3 (75%) agreed, whilst one remained uncertain. This shows that most of the respondents agreed that Cuisenaire Rods as teaching material would greatly improve the teaching of fractions in mathematics.

Table 2: *How Cuisenaire Rods can improve teaching of the concept "Fractions".*

Statements	D	U	A	Total
	(%)	(%)	(%)	(%)
The use of Cuisenaire Rods as teaching material would greatly improve the teaching of fractions in mathematics	0 (0)	1 (25)	3 (75)	4 (100)
Teachers use Cuisenaire Rods in teaching fractions in mathematics	2 (50)	0 (0)	20 (50)	4 (100)
Cuisenaire Rods can be used to teach addition of fractions	0 (0)	0 (0)	4 (100)	4 (100)
Cuisenaire Rods can be used to teach subtraction of fractions	0 (0)	0 (0)	4 (100)	4 (100)
Cuisenaire Rods can be used to teach division of a whole number by fraction	1 (25)	1 (25)	2 (50)	4 (100)
Cuisenaire Rods are one of the effective teaching materials teacher trainees can use to teach fractions	1 (25)	0 (0)	3 (75)	4 (100)

Source: Field Survey, Erzuah (2015)
NOTE: Figure in brackets are percentages.

4.2. How Confident are Teacher Trainees about their Ability to use Cuisenaire Rods in Solving Problems involving fractions?

In order to answer this question, the responses of two items from the questionnaire were used. The details are displayed in Table 3. As to whether teacher-trainees can add unlike fractions without difficulties using Cuisenaire Rods, out of the 160 respondents, 96 representing 60% agreed to the statement. Thirty-nine representing 24.4% disagreed to the statement and 25 (15.6%) were uncertain. The results show that most of the respondents can add unlike fractions without difficulties using Cuisenaire Rods.

Table 3: Difficulties Teacher Trainees encounter in Teaching Addition and Subtraction of Fractions.

Statements	D (%)	U (%)	A (%)	Total (%)
Teacher-trainees can add unlike fractions without difficulties using Cuisenaire Rods	39 (24.4)	25 (15.6)	96 (60)	160 (100)
Teacher-trainees find questions on subtraction of unlike fractions difficult to solve using Cuisenaire Rods	38 (24)	32 (20)	90 (56)	160 (100)

Field Survey, Erzuah (2015) N.B. Figures in bracket are percentages

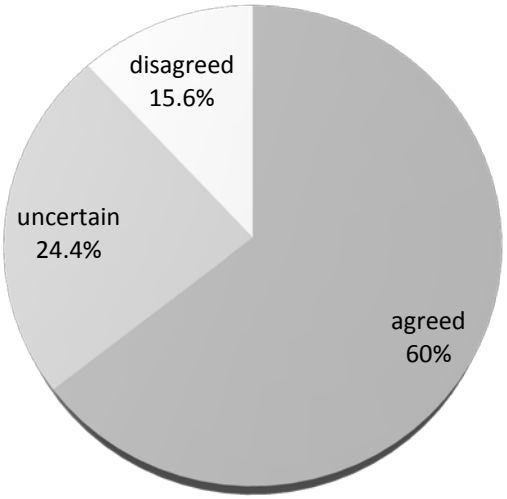

Figure 2: Teacher-trainees' ability to unlike fractions using Cuisenaire Rods

4.3. Summary

The analysis of the data gathered in the study reveals the following results:

1. Cuisenaire Rods as a teaching material would greatly improve the teaching of fractions in mathematics.
2. Tutors were divided as to whether Cuisenaire Rods can be used in teaching fractions in mathematics.
3. Cuisenaire Rods can be used to teach addition of fractions.
4. Cuisenaire Rods can be used to teach division of a whole number by fraction.
5. Cuisenaire rod is one of the effective teaching materials teacher trainees can use to teach fraction.
6. Trainees can add unlike fractions without much difficulty using Cuisenaire Rods.
7. Teacher-Trainees find questions on subtraction of unlike fractions difficult to solve using Cuisenaire Rods
8. Teacher-trainees find it difficult to divide whole numbers by fraction.
9. Teacher-trainees do not understand the concept of dividing fractions by another fraction using Cuisenaire Rods.
10. Teacher-trainees can easily multiply two unlike fractions with the use of Cuisenaire Rods.

The demographic data findings show that there were four teachers selected for the study, three were males whilst one was a female. All of them had been teaching for more than three years. Also, there were one hundred and sixty students made up of 102 (63.8%) males and 58 (36.2%) females.

The results in relation to the three research questions reveal the following are findings:

1. Most of the respondents agreed that Cuisenaire Rods as teaching and learning material would greatly improve the teaching of fractions in mathematics.
2. Teacher-trainees were divided whether Cuisenaire Rods can be used in teaching fractions in mathematics.
3. Teacher-trainees had difficulty in using Cuisenaire Rods to teach division of a whole number by fraction.
4. Most of teacher-trainees do not understand the concept of dividing whole numbers by fractions using Cuisenaire Rods.
5. Most of the tutors agreed that Cuisenaire Rods are one of the effective teaching materials teacher trainees can use to teach fraction.

4.4. Implication for Teaching

Implication drawn from the findings is teachers who are not fond of using Cuisenaire Rods in teaching fractions in mathematics may tend to influence students on materials which they only use in teaching fractions and might not see the need to use Cuisenaire Rods in teaching fractions. With this, much is needed to assist mathematics teachers to be abreast with the importance of using Cuisenaire Rods in teaching mathematics. When done in a harmonized manner will improve the quality of teaching and learning of fractions.

5. Conclusions

The background knowledge of some respondents was weak, especially, most of the teacher-trainees do not understand the concept of dividing by fractions using Cuisenaire Rods. These results are a clear indication that the essence of using Cuisenaire Rods in teaching fractions in mathematics is not adequately achieving the desired goals in Ghanaian schools.

5.1. Recommendations

On the basis of the findings and its implication for effective teaching of fraction in mathematics, some recommendations are made: Fraction in mathematics as a topic can be taught better using Cuisenaire Rods. Apart from the above, the recommendations made based on the findings derived from the analysis of the questionnaire and interviews are:

1. The Colleges of Education should work out a common in-service programme in collaboration with the Ghana Education Service (GES) for serving teachers already in the field on regular basis. This will guide them to re-evaluate and upgrade their knowledge base and conceptions about the topic and prepare them to face the challenges engulfing the teaching of the topic. It will also help teachers to be abreast with the new and innovative techniques for the effective teaching of fraction in mathematics.
2. Colleges of Education should evaluate the courses on methodology and content for mathematics for student-teachers to reflect not only the teaching of the cognitive but must also be skill-oriented in the use of manipulatives like Cuisenaire Rods.

6. Acknowledgment

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7. Reference

[1] Anku, S. E. (2006, October 19). Revamping mathematics education in Ghana: A private sector initiative. *Daily Graphic* (No. 149874), p. 27.

[2] Anku, S. E. (2008, February 18). National mathematics day. *Daily Graphic* (No.150284), p. 27.

[3] Butler, F. M., Miller, S. P., Crelan, K., Babbitt, B., & Pierce, T. (2003). Learn. *Disability Research Practice, 18*(2), 99 -111.

[4] Case, M., Cates, D., Smith, M., & Jackson, C. (2003). Effect of manipulative instruction on solving area and perimeter problems on students with learning disabilities. *Learn Disability Research. Practice, 18*(2), 112-120.

[6] Chief Examiner's Report (2007). *Methods of teaching primary mathematics.* Cape Coast: UCC.

[7] Cobbold, C. (2010). Induction for teacher retention: The missing link in teacher education policy in Ghana. *Postscript, 8*(1), 7-8.

[8] Copeland, R. W. (1967). *Mathematics and the elementary teacher*. Philadelphia: W.B. Saunders Company.

[9] Costelpe P. J., & Hemstock, H. F. (1957). *Modern arithmetic*. Toronto: Thomas Nelson and Sons Ltd.

[10] Cramer, K., Behr, M., Post, T., & Lesh, R. (1997). *Rational number project: Fraction lessons for the middle grades level 2*. Dubuque: Kendall/Hunt Publishing.

[11] Curriculum Research Development Division (CRDD) (1987). *Ghana mathematics series for primary schools, pupils' book three.* Accra: Ministry of Education.

[12] Curriculum Research Development Division (CRDD) (1991). *Ghana mathematics series for primary schools, pupils' book two.* Accra: Ministry of Education.

[13] Curriculum Research Development Division (CRDD) (2001). *Ghana mathematics series teaching syllabus for mathematics for JHS.* Accra: Ministry of Education.

[14] Curriculum Research Development Division (CRDD) (2002). *Ghana mathematics series for primary schools, pupils' book one.* Accra: Ministry of Education.

[15] Dirkes, M. A. (1980). *Mathematics pursuits one.* Toronto: MacMillan Company Limited.

[16] Dollan, D. (2000). *Activities for elementary mathematics teachers* (4th ed.). London: Sage Publishers.

[17] Dotse, D. (2000). Mathematics and the threshold of the new millennium. *Journal Mathematics Connection, 1*(1), 78-82.

[18] Dumas, E., & Howard, C. F. (1966). *Teaching contemporary mathematics*. New York: Haper and Row publishers.

[19] Elia, L., Gagatsis, A., & Demetrico, A. (2007). The effects of different modes of representation on the solution of one-step additive problems. *Educational Research and Review, 3*(11), 339-343

[20] Evans, K. (2002). *Teaching of mathematics in senior secondary school in Ghana.* Unpublished Monograph.

[21] Feiman-Nemser, S., (1990). Describing teacher education: A framework and illustrative findings from a longitudinal study of six students. *Elementary School Journal, 89*, 365-377.

[22] Hantrais, L. (2005). Combining methods: A key to understanding complexity in European societies? *European Societies, 7*(3), 399-402.

[23] Hasemann, K. (1981). Difficulties with fraction. *Educational Studies in Mathematics, 12,* 71-87.

[24] Hawson, G., & Wilson, B. (1986). *Mathematics in the 1990s.* Cambridge: Cambridge University Press.

[25] Institute of Education Chief Examiners Report (2006). *Chief examiner report for untrained teachers Diploma in basic education.* Cape Coast: UCC Press.

[26] Jencks, S. M. (1981). *Experiencing fractions*. Monterey: Curriculum Development Associates.

[27] Lake, F., & Newmark, J. (1977). *Mathematics as a second language* (2nd ed.). Massachusetts: Addison-Wesley Publishing Company.

[28] Mack, N. (1990). Learning fractions with understanding: Building on informal knowledge. *Journal for Research in Mathematics Education, 21*, 16-32.

[29] McBride, P., & Silverman, F. (1997). *Integration elementary school science and mathematics.* Cambridge: Cambridge University Press.

[30] Mereku, K. (2004). *Mathematics curriculum: Implementation in Ghana.* Accra: Danjoe Production Ltd.

[31] Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulative to teach mathematics. *Edward Studies in Mathematics, 87*(2), 175-197.

[32] Nabie, J. M. (2002). *Fundamentals of the psychology of learning mathematics.* Accra: Akonta Publishers.

[33] National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston: NCTM.

[40] NCTM. (1989). *Curriculum and evaluation standards for school mathematics*. Reston: National Council Teachers of Mathematics (NCTM).

[41] Obeng, A. K. B. (2005). *Core Maths for West African secondary schools and colleges.* Kumasi: Approaches Publication Ltd.

[42] Rule, A. C., & Hllagan, J. E. (2006). Pre-service elementary teachers' use: Drawing and make-sets of materials to explain multiplication and division of fractions. *Educational Research and Review, 3*(11), 339-343.

[44] Singletary, L. M. (1997). *Teachers' conceptions of integration: Uncovering the process standards.* San Diego: National Council of Teachers of Mathematics.

[45] Skemp, R. (1991). *Mathematics in the primary schools.* Worcester: Bulling Sons Ltd.

[46] The West Africa Examinations Council (W.A.E.C) (1991). *Chief examiner's report for Basic Education Certificate Examination (BECE).* Accra: W.A.E.C.

[47] Thompson, P. W. (1994). Concrete materials and teaching for mathematical understanding. *Arithmetic Teacher, 41*(9), 556-558.

[48] Weissglass, J. (1977). Mathematics for elementary teaching: A small group laboratory approach. *Am. Math. Mon., 84*(5), 377- 362.

[49] Zeichner, K. (1983). Alternative paradigms of teacher education. *Journal of Teacher Education, 34*(3), 3-9.

[50] Zeichner, K. (1991). Preparing reflective teachers: An overview of instructional strategies which have been employed in preservice teacher education. *International Journal of Educational Research, 11*, 565-575.