UNIVERSITY OF EDUCATION, WINNEBA

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USING BEAM BALANCE TO ASSIST DBE STUDENTS TO IMPROVE ON THEIR CONCEPTUAL KNOWLEDGE OF LINEAR INEQUALITIES IN ONE VARIABLE

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BY

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DECLARATION

CANDIDATE'S DECLARATION

I, WILSON KOFI FIAKUMAH**,** hereby declare that this thesis, with the exception of quotations and references contained in published works which I have been identified and acknowledged, is entirely the result of my own original research and that no part of it has been presented, either in part or whole, for another degree in this University or elsewhere.

Candidate‟s Signature: ....

Date: ....

SUPERVISOR'S DECLARATION

I, DR. ASIEDU ADDO, hereby declare that the preparation and presentation of this thesis was supervised by me in accordance with the guidelines on supervision of thesis, as laid down by the University of Education, Winneba.

Supervisor‟s Signature: ....

Date: ....

DEDICATION

To my lovely wife, Esenam Rita Ahatsi, and to my beautiful daughters Adwoa Selorm Rosemary Fiakumah and Gertrude Selikem Fiakumah for all their love, prayers, support and encouragement.

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Last but not the least, I also express my profound gratitude to the Principal, Staff and Students of St. Francis College of Education, Hohoe for their tremendous support and the needed information and the opportunity offered me to undertake the research in the school successfully.

ABSTRACT

This study was undertaken to assist DBE ONE „A‟ students of St. Francis College of Education, Hohoe to improve on their conceptual knowledge of linear inequalities in one variable using the beam balance model. The entire DBE ONE „A‟ students represented the population of the study. Data was gathered through instruments such as test in the form of pre-test and post-test. Due to the large size of the population a total of 40 students which represented 20% of the 200 DBE ONE „A‟ students comprising of 15 women and 25 men were selected to represent the sample size of the study. The purposive sampling technique was used to select DBE ONE „A‟ students of St. Francis College of Education, Hohoe, since this was the school where I encountered the problem with the students. This procedure was also used because the students can be easily accessible for the data to be collected for the study. I also considered this class because the students had attained some level of maturity required for self and cooperative use of the seesaw or the balance model with minimal tutor intervention and supervision, hence ensuring their full participation in the study. The findings of the study revealed that there has been a drastic improvement in the students‟ ability level as far as the study of linear inequalities is concerned, which is the result of the intervention put in place using the Beam Balance Model. It was also observed that the students have developed more positive attitude towards the use of the Beam Balance to explore other mathematics concepts without any instructions from any tutor. Analysis and discussions were made to ascertain the effectiveness of the research intervention. A recommendation was then made to further researchers, teachers and curriculum developers. The researcher therefore recommended that Beam Balance must be used as a teaching learning material for mathematics especially in the teaching of linear inequalities in one variable.

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CHAPTER 1

INTRODUCTION

1.0 Overview

During the last twenty-five years there has been a worldwide movement towards making the content of mathematical courses in schools (preschools, primary and presently junior high schools), colleges and universities more appropriate to present needs, (Paling , 1986). In today‟s modern world, mathematics is being increasingly used in science, technology, industry, government, education and economics. Taking note of the importance mathematics plays in national development, the government of Ghana has attached great importance to the teaching and learning of mathematics in schools throughout the country.

1.1 Background to the Study

Nearly every part of our lives involves mathematics. It has played an essential role in the development of modern technology- the tools, materials, techniques and sources of power that make our lives and work easier. A nation that wants to keep in touch with development and inventions need a wider knowledge of scientific advancement, (Benneth, 1985). High technology has influenced the mathematics demands for better scientists and technicians in man‟s life and many fields of study in the educational settings, and therefore we cannot do away with the ideas in mathematics.

In view of the new educational reforms, the Free Compulsory, Universal Basic Education programme (FCUBE) which took off in 2007, reviewed by Anamuah- Mensah, Educational Review Committee, the mathematics teaching syllabi of the Colleges of

Education, Senior High Schools, Junior High Schools, Basic Schools and the Pre-Schools have also been revised to meet the needs of the efficiency in engineering, science and technological advancements we see around us. Thus, the teaching syllabuses for mathematics of teacher training colleges now Colleges of Education have been revised to meet the following aims and objectives:

(a) To extend the students" own mathematical ability to a level significant beyond that which he or she is likely to teach mathematics in schools;

(b) To give students knowledge of the mathematical content and processes contained in the teaching of basic school Mathematics (Kindergarten, Primary and Junior High School) and Colleges of Education Mathematics syllabuses;

(c) To provide professional skills and knowledge relating to the methods of teaching (i.e. teaching how to teach) which is appropriate for basic education.

The Colleges of Education mathematics teaching syllabuses clearly among other things stated the importance of inequalities such as students at the end of the course should be able to:

- differentiate between an inequality and equations;
- distinguish between a linear and rational inequalities and
- solve simple problems involving inequalities correctly.

Considering the objectives of studying mathematics at the Colleges of Education and the basic schools discussed earlier on in this section, it has prompted me to research into the topic and find ways to minimise and reduced the poor performance in inequalities of DBE ONE „A" students of at St. Francis Colleges of Education, Hohoe. According to Appau (2007), "an inequality is a mathematical relation or statements involving the use of any of the symbols $<, >, \leq$ and $\geq$" (p.120). For example, $5x - 4 > 16$, $2x + 1 \leq 10$ and so forth are inequalities. Inequalities can be solved in a similar way as solving equations. Most operations give an equivalent inequality.

Hesse (2005), also says that, "when symbols such as $<$, $>$, $\leq$, $\geq$ and $\neq$ are used in an expression, we refer to such statements as "inequalities". For example,$a \geq b$, a is greater than or equal to b, $a \neq b$, a is not equal to b. He also pointed out that, the following are guidelines in dealing with inequality problems in mathematics:

a. When both sides of an inequality are multiplied or divided by a negative number, the sign of the inequality is reversed. For example, if $-x \leq 7$, i.e. $x \geq -7$.
b. When both sides of the inequality are multiplied or divided by a positive number, the inequality sign remains unchanged. For example, if $x \geq 2$, i.e. $3x \geq 6$.
c. The same number may be added or subtracted from both sides of an inequality without changing the inequality sign. For example, $x + 1 \leq 4$, ie $x \leq 3$.

In the case St. Francis College of Education, Hohoe a detailed analysis of the examination results for the past three years from the Chief Examiners" report (2009;2010), as discussed earlier revealed that only 15% of the students obtained a pass mark, that is 50% and above. This clearly showed that the problem existed among the students. It is in line with this that, I have decided to undertake the study in order to help solve the problem on "The Use of a Beam balance model by DBE ONE students of St. Francis College of Education, Hohoe in solving simple problems involving inequalities.

1.2 Diagnosis and Evidence of the Problem

(a) Evidence: An assessment and detailed analysis was carried out on the mathematics past results for the end of each semester examinations for the past three years and it was realized that only about 10% of the DBE ONE students of St. Francis College of Education, Hohoe had grade „A‟ at the final examination. The outcome of the students‟ responses revealed that, the problem involving simple questions on the topic existed among the pupils. The Pre-test items enabled me to determine the extent of the students‟ strengths and weaknesses on the concept.

Based on this, I gave series of questions based on inequalities of different types, thus $n - \frac{2}{3} > \frac{1}{3} - n$; $5x - 8 \geq 2x + 4$; $5(x - 1) \geq 39$ and $2x - 1 \leq 1$, to solve. These set of test items have been selected from students Mathematics Course Book for Diploma One. After I gave them enough time to work, I collected the scripts for marking. After I have finished marking I realized that, most of the pupils did not do well at all.

Most of the pupils did not know how to group like terms, if for example, terms of the same variable are on both sides of the inequality sign, they did not know how to expand brackets first before proceeding, if the questions involved brackets and also did not know how to deal with fractions if the questions entail that.

After the Pre-test was conducted, it was found out that even though the students were taught linear inequalities in one variable, the results clearly indicated that the students did not understand the topic very well, hence the poor performance. It was also realized that students did not understand the topic because the lesson was delivered without the use of manipulative teaching learning materials. Therefore, the researcher has designed a balance model to be administered as an intervention strategy to address the problem identified. The results from the Pre-test indicated that, the problem identified earlier on existed among the DBE ONE „A" students of St. Francis College of Education, Hohoe.

When I conducted a class test for the students on the topic, majority of them solved some of the expressions wrongly. Some of the errors identified are:

a. The inequality signs are left unchanged if even if the variables are multiplied or divided by negatives to make them positive;

b. The inequality signs are changed to equality signs forgetting that the problem deals with inequality but not equations.

Few examples are presented below:

i. $2x + 4 \geq 3x - 1$

$\Rightarrow 2x - 3x \geq -1 - 4$

$\Rightarrow -x \geq -5$

$\therefore \; x \geq 5$

ii. $3x + 3 < 6$

$\Rightarrow 3x = 6 - 3$

$\Rightarrow 3x = 3$

$\therefore \; x = 1$

iii. $\frac{1}{2}x + 1 < \frac{1}{3}(2x + 3)$

$\Rightarrow \; x + 2 < 6x + 9$

$\Rightarrow x - 6x < 9 - 2$

$\Rightarrow -5x < 7$

$\therefore x < -\frac{7}{5}$

Also in the mid-semester quiz, students were asked to simplify the expression: $3x + 3 \geq 6$. About 10% of the students mistook the expression for an equation and therefore equated it to zero and solve for x for no apparent reasons.

1.3 Statement of the Problem

The introduction of the new educational reform (FCUBE) introduced in September 2007 considered Mathematics as one of the subject for the award of Basic Education Certification Examination (B.E.C.E). Detailed analysis of the past examination results of the B.E.C.E results revealed that many Teacher Trainees at the Colleges of Education lack the requisite knowledge as to how to answer questions in the Mathematics subjects involving Methodologies. Hence, teachers have been using lecture methods in teaching the subject at the basic level. Also, the Mathematics teachers do not use teaching learning materials and thus made the subject more abstract for students. A few students interviewed said that, they write a lot of notes during Mathematics lessons.

Awanta (2005) by a critical analysis of the 1992 and 1999 BECE past papers reveals that there has not been any significant increase in encouragement of the use of practical activities, development of problem-solving skills, the facilitation of discussion of Mathematical ideas and the development of logical reasoning and the making of meaningful Mathematical connections. The teacher should no longer be a depository of knowledge to the students. To him, the teacher is now a facilitator of learning and therefore interacts with the students and knowledge comes directly from the students. Therefore the use of beam balance model in solving linear inequalities as means of encouraging students through the use of practical activities to develop their problem-solving skills in Mathematics.

Again, many of the students do not perform well in studying Mathematics even though it is one of the subjects which had to be passed before moving to the next step in the educational ladder. It was found out that the students do not do well in Mathematics class test conducted. Based on the above problem identified the researcher was touched to research into the problem using an intervention involving the use of a Beam Balance model to minimize and reduced the problem.

1.4 Purpose of the Study

The purpose of the study is to:

- assist students to improve on their conceptual knowledge of the principle of solving linear inequalities.
- assist students to use the concepts and the principles acquired in solving linear inequalities.

1.5 Research Questions

The following research questions were formulated to guide the study:

- To what extent will the use of the Beam Balance model assist DBE ONE „A" students of St. Francis College of Education, Hohoe to use the correct inequality sign when solving problems on linear inequalities in one variable?
- To what extent will the use of the Beam Balance model help minimise DBE ONE „A" students" errors of changing inequality signs to equality signs in Mathematics at St. Francis College of Education?

1.6 Significance of the Study

After a successful completion of the intervention, students will appreciate and understand how to apply some basic laws in solving simple problems on inequalities correctly and also help me to vary my teaching methods to enable the students understand the concept of inequalities effectively.

Finally, the findings of this study will provide teachers and educational authorities the insight of teaching skills and policies upon recommendations. The policies and recommendations from the research will be reformed to suit the students of today‟s fast changing world. It will also enlighten teachers and other scholars to know the problems students encounter when learning inequalities and guide them to vary their teaching methods in the classroom whilst teaching linear inequalities.

1.7 Limitations of the Study

During the process of the study, I encountered a lot of setbacks. In the first place, due to truancy and absenteeism, some students were not present in class throughout the period of the intervention and this has affected the data collected from some of the students because it has delayed the processing of the results of the data collected. When this happened, it has caused me not to gather my data on time for critical analysis and inferences to be drawn from the information on the topic. Another setback was that, during the period of the intervention, the week was over loaded with a lot of curricular activities on the schools academic calendar such as inter-halls and inter-collegiate sports activities which makes it difficult for me getting the sample class during the intervention activities. Results from the research has shown that the unconcerned behaviour of the major stakeholders (students, tutors, etc) of education as the paramount source of hindrances encountered during the research process, thus it became very difficult rounding up results from the findings due to their insufficient and uncooperative attitude.

1.8 Delimitation of the Study

The research work was confined to only DBE ONE „A" students of St. Francis College of Education, Hohoe. This was mainly because the problem was identified by the researcher with the students in a DBE ONE „A" class. However, due to the inadequate time and lack of funds on the part of the researcher, the study was only limited to DBE ONE „A" students where the students have the difficulties on inequalities, although there were other students in the same school who are facing similar problem.

1.9 Organization of the Study

The project comprises five chapters. Chapter one deals with the background of the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitation of the study, limitation of the study and the organization of the study.

Chapter two talks about the review of related literature, thus the empirical and theoretical studies relevant to the topic under the study.

Chapter three is the research methodology which talks about research design, procedures employed in obtaining data, population and sampling techniques, pre-intervention, intervention and its implementation, post-intervention and data analysis plan.

Chapter four focuses on the presentation and analysis of data such as the use of figures, charts, tables, graphs and diagrams.

Chapter five focuses on the summary, conclusions and recommendation and suggestions offered for further research.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter presents the review of relevant literature of other researchers on the topic "The use of Beam Balance to assist DBE ONE „A‟ students to improve on their conceptual knowledge of Linear Inequalities in one variable". The review will be based on the following headings:

- The Concept of Inequalities
- Methods (strategies) and Principles of Solving Inequalities
- The Use of the Beam Balance
- Discussions on the Intervention Strategies of Solving Inequalities

2.1 The Concept of Inequalities

The concept of inequalities has been looked at from different perspectives by different scholars; such as Hardy et al (1999) and Beckenbach and Bellman (1975) etc. Teaching and learning of linear inequalities in one variable has been described in other research work as very important concepts children need to understand to enable them study algebra (MOE, 2007). Hence, it is important to link this study to some of the findings, theories and recommendations from other researchers‟ works.

According to Otchere (2010), the concept of linear inequalities in one variable has been defined as an inequality that can be written in the form "$ax + b \geq, \leq, >, < c$, where, „$a$‟, „$b$‟ and „$c$‟ are all constants and „a‟$\neq 0$.

Auvil (1996) defines inequalities as "a statement with two algebraic expressions that are not equal". Here are some examples, $x < 10$, $3y - 12 \geq 0$ and $1 \leq 2$.

2.2 Strategies and Principles of Solving Inequalities

In this section, some notable models for solving linear inequalities in one variable at the Colleges of Education would be treated and discussed thoroughly. They include the following:

i. The Algebraic or Formal Model
ii. The Beam Balance Model

2.2.1 Solving Inequalities through- Algebraic or Formal Model

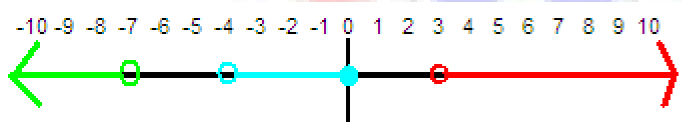
The teaching of linear inequalities is a pre-requisite for the learning and graphing of solution sets of inequalities on the number line, and linear programming for the maximization of profits, therefore becomes very important. Dugopolski (2002), came to a similar conclusion when he confirmed that linear inequalities and equations for that matter are one of the most important topics in Mathematics and one of the first concepts a younger encounters in pre- algebra course.

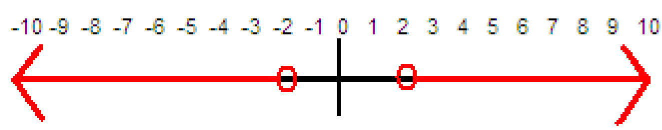
The process of solving linear inequalities, according to Backhouse and Houldsworth (2001) is almost the same as solving linear equations. Considering an example :$(\boldsymbol{\alpha})$: $\boldsymbol{x} + \boldsymbol{4} < 13$, all we have to do is to subtract 4 from both sides. We will then get $x < 9$, and that is the answer! They explained however, that the answer is not a single number, but a set of solutions. Any number that satisfies the condition $x < 9$ (any number that is less than 9) is a solution to the inequality. It is very convenient to represent the solution using the number line:

```
<------------------o
<-+-----+-----+-----+-----+-----+-->
  6     7     8     9     10    11
```

Backhouse and Houldsworth (2001) said that the circle (o) is used to show that 9 is not included, that is for the strict inequalities but when the inequality contains ($\leq$ and $\geq$) signs, we use "$*$" or ● to show that the value is included in the solution set. Considering another complicated example involving brackets: **(β): 3x-2**>2 (x – 3) **.** First we expand the right hand side to obtain **3x - 2 > 2x-6**. Then we simply rearrange it so that all the unknowns are on one side (usually the left), **3x – 2x > - 6 + 2**. Here finally we can easily get the answer as**:** $\boldsymbol{x} > -4$**.**

Graphs of Inequalities in one variable: Information read on graphs of inequalities in one variable from http://www.math.kth.se/math/TOPS/index.html is clearly illustrated below:





The first number line above shows the inequalities $x > 3$, $\boldsymbol{x} < -7$, and $-4 < x \leq \mathbf{0}$**.** The second line shows the disjunction of the inequality: $\boldsymbol{x} < -2$ **or** $\boldsymbol{x} > 2$.

Godman, Talbert and Ogum (2000) outlined an example of an inequality where the direction changes when finding the solution**: *(γ): 4 – 6x > 22.***

- First we subtract 4 from both sides leaving: $-6x > 18$.
- Now we divide through by -6, thus changing the direction of the inequality: $\frac{-6x}{-6} < \frac{18}{-6}$.
- The solution to the inequality is: $x < -3$.

Stroud (2007) agrees with Godman et al (2000) that inequalities, unlike equations have an infinite number of solutions. For example:

- For $x > A$ means that x is **greater than** A, where A is not a solution.
- For $x < A$ means that x **less than** A, where A is not a solution.
- For $x \geq A$ means that x is greater than or equal to, where A is a solution.
- For $x \leq A$ means that x is less than or equal to A, where A is a solution.

2.2.2 Special cases- Inequalities with a Variable in the Denominator

Godman et al (2000) further submitted that finding solutions to an inequality with variable in the denominator, for example, $\frac{2}{x-1} < 2$, one cannot multiply the right hand side by $(x-1)$ because the value of x is unknown. According to them since x may be either positive or negative, you can"t know whether to leave the inequality sign as $<$, or reverse it to $>$.

The method for solving this kind of inequality according to Barnett and Ziegler (1997), Godman et al (2000) and Backhouse and Houldsworth (2001) suggested the following four steps:

1. Find out when the denominator is equal to 0. In this case it"s when $x = 1$.
2. Pretend the inequality sign is an = sign and solve it as such: , $\frac{2}{x-1} = 2$, so $x = 2$.

3. Plot the points $x = 1$ and $x = 2$ on a number line with unfilled circle because the original equation included a $<$ sign (note that it would have been a filled circle if the original equation included $\leq$ and $\geq$). They explained that there are three regions which are separated by unfilled circles. These regions are: $x < 1, 1 < x < 2$, and $x > 2$.
4. Test each region independently. In this case test if the inequality is true for $1 < x < 2$ by picking a point in the given region (e.g. $x = 1.5$) and trying it in the original inequation. For $x = 1.5$, the original inequality doesn‟t hold. Now, attempt $x > 2$ (e.g. $x = 3$). In this case the original inequation holds, and so the solution for the original inequation is $x > 2$.

Hessse (2005) also propounds some steps to be followed when solving problems involving inequalities. Some of these are:

1. Change every mixed fraction to an improper fraction if there is any. Example: $\frac{21}{9} + \frac{5x}{6} < 4$ becomes $\frac{7}{3} + \frac{5x}{6} < 4$
2. If there are fractions multiply through the inequality by the least common multiple (L.C.M) of the denominators. Example: $\frac{7}{3} + \frac{5x}{6} < 4$

   $6 \times \frac{7}{3} + 6 \times \frac{5x}{6} < 6 \times 4$ (Multiply by L.C.M i.e. 6)

   $\Rightarrow \quad 14 + 5x < 24$
3. If there are brackets, expand to remove them. Example, $2(x + 3) \geq -3 + 6x$
4. Group all terms containing the unknown on the left hand side (LHS) of the inequality and the constant terms on the right hand side (RHS).
5. Example, $2x + 6 \geq 6x - 3 \Rightarrow 2x - 6x \geq -3 - 6$

6. Simplify both sides of the equation: $-4x \geq -9$ or $4x \leq 9$
7. Divide through by the coefficient of x to obtain solution of the inequality.

   Example: $\frac{4x}{4} \leq \frac{9}{4}$.

2.2.3 Rules and Principles for Solving an Inequality

Another prominent author, Asiedu (2005) and Asiedu-Addo & Yidana (2000) as cited in Otchere (2010) argued that in dealing with the concept of inequalities, there are certain rules, principles and steps to be followed based on the following properties or procedures:

(a)The same number may be added or subtracted from both sides of the inequality without changing the inequality. Example: $5 > -2 \Rightarrow 1 + 5 > -2 + 1, \Rightarrow 6 > -1$ and $7 \geq 4 \Rightarrow 7 - 2 \geq 4 - 2, \Rightarrow 5 \geq 2$.

(b)The sign of inequality is unchanged, if we multiply, or divide both sides by a positive number. Example: $4 > 3, \Rightarrow 4(2) > 3(2), \Rightarrow 8 > 6$

2.2.4 General Steps for Solving an Inequality

Kusi-Appau (2007) also listed four major steps of solving inequalities as:

1. Check if there are fractions. If there are fractions, multiply both sides of the inequality by the L.C.M. of the denominators to clear the fractions.
2. Check if there are brackets. If there are brackets, expand to remove the brackets.
3. Collect or group like terms on one side. Usually, we group all terms containing the variable on the L.H.S of the inequality.
4. Simplify both sides of the inequality and solve for the variable keeping in mind the above rules for solving an inequality. For example, solve the following inequalities.

1. $3x < 12$ (Divide both sides by 3)

   $\Rightarrow \frac{3x}{3} < \frac{12}{3}$

   $\Rightarrow x < 4$

2. $2x > 3 - x$ (Group like terms)

   $2x + x > 3$ (Simplify)

   $3x > 3$ (Divide both sides by 3)

   $\frac{3x}{3} > \frac{3}{3} \Rightarrow x > 1.$

3. $3x - 4 \leq 4(x + 3)$ (Expand to remove brackets)

   $\Rightarrow 3x - 4 \leq 4x + 12$ (Group like terms)

   $\Rightarrow 3x - 4x \leq 12 + 4$ (Simplify both sides)

   $\Rightarrow -x \leq 16$ (Multiply both sides by -1

4. $\frac{1}{3}(x + 2) > \frac{1}{4}(x - 1)$ (Multiply both sides by 12)

   $\Rightarrow 12 \times \frac{1}{3}(x + 2) > 12 \times \frac{1}{4}(x - 1)$

   $\Rightarrow 4(x + 2) > 3(x - 1)$ (Expand to remove brackets)

   $\Rightarrow 4x + 8 > 3x - 3$ (Group like terms)

   $\Rightarrow 4x - 3x > -3 - 8$ (Simplify both sides)

   $\therefore x > -11$

The authorities have come well about the way or approach in dealing with inequalities. I therefore suggested the use of beam balance which can also be used in teaching inequalities which emphasizes the basis for developing skills and meaningful way of teaching inequalities to arrest or solve the problem.

2.2.5 Developing Students' Knowledge of Linear Inequalities through Manipulative Materials (The Beam Balance Model)

According to Bishop (1998) as cited in Awanta (2005) a technique curriculum is a curriculum of procedures, methods, skills, rules and algorithms which portrays Mathematics as a doing subject. In this case, therefore, he said it is a curriculum in which „practice makes perfect" with examples to be emulated, and exercises to be carried out. Awanta (2005) in agreement with Mereku (2004) further contended that a technique curriculum involves impersonal learning, where a task is given to the learner. That is, what is considered important is that the learner learns the Mathematics, not that he strives for some personal meanings from the mathematics learnt.

Torrance (1988) as cited in Awanta (2005) has for example, noted that in assessment especially of public examinations, the results has impacted most positively on curriculum and teaching methods, when teachers have active role in the development process. He noted, for example that: Crude changes in curriculum content and teaching methods can be instigated, but the quality of these will depend on teacher perceptions of their purpose and knowledge of their broader curricular intentions.

In the process of making the learning of Mathematics simpler, clearer, less mysterious and therefore more accessible to learners, the use of manipulative materials and experiences that the students are familiar with and have encountered in the environment becomes inevitable for making sense in the learning of Mathematics (Mereku, 2001). Many studies have shown that the use of concrete materials found in the students" environment in the Mathematics classroom can produce meaningful use of notational systems and increase their concept development (Khoeng and Hoo, 1995).

In another review of activity-based learning in Mathematics, Nabie (2004) however suggests that the right materials must be used at the right time to teach Mathematical concepts. The use of such manipulative materials at the right times is in line with Brunner‟s (1966) theories of cognitive development. Brunner‟s (1966) theoretical perspective suggests that children are to be supported with the right manipulative materials for the teaching and learning of Mathematics concepts, depending on their developmental stage or level. Brunner‟s (1966) theory suggests children learn from the iconic stage (i.e. using of diagram, pictures) to symbolic of cognitive development.

At this stage, practical materials should be available in the instructional process for the child to bring out the Mathematical potential in him/her so to make its learning very interesting to the child. Fontana (1998) suggests that practical materials, notably from the children‟s own environment, help them to learn in their own way.

2.2.6 The need for using Concrete Materials

Constructivism, according to Eggen and Kauchak (2003), is a view of learning which suggests that learners create and build their own knowledge and knowledge of the topics they learn, rather than having it delivered to them by teachers with written materials such as textbooks and teaching syllabus. Children, also consciously or unconsciously look for new knowledge about things, some of which are not relevant to their level of development, by exploring their environment through play and interacting with materials in their miniature world (Nabie, 2001).

In such circumstances, where the child explored their environment through play and interacting with materials in their miniature world, as pointed out by Awanta (2003) asked whether teachers‟ classroom practices really meet the standards required by the curriculum.

Good and Brophy (1997) as quoted in Nabie (2001) are unanimous in their submission that learning activities based on constructivism, put learners in active roles, help them build new knowledge in the context of what they already know, apply their knowledge to authentic situations. According to them, learning through play and interacting with concrete materials helps children learn better whilst constructing their own mathematical meanings. This brings learning from a teacher-centered approach to a more learner-centered instruction.

Using concrete materials in the classroom according to Chowdhury (2001), helps students to see problem situations far better than a student using a calculator or a computer to do the visualization. Hence, the use of the beam balance model to teach linear inequalities with one variable would enable learners to visualize the relationship between school Mathematics and the Mathematics at home. However, some Mathematics teachers‟ actions seemed to suggest that concrete materials are meant to assist only the weak or handicapped ones who may experience extreme difficulty in knowledge Mathematics concepts (Nabie, 2004).

Also, many teachers forget that Mathematics teaching and learning are guided by theories of learning such as Brunner‟s (1966). Awanta (2004, 2005) agrees with Nabie (2004) in submitting that the mental development of learners passed through various stages of development none of which can be skipped or altered. This means that for teachers to effectively facilitate teaching and learning in Mathematics classroom, and assist learners to have a systematic and consistent build-up of Mathematical ideas, teachers must respond to the natural learning pathway of learners (Sarkodie, 2010). Hence, the need to use the beam balance model to teach the conceptual knowledge of linear inequalities in one variable becomes eminent, appropriate and justifiable.

2.3 The Beam Balance Model

According to the Wikipedia, the free internet encyclopaedia, and cited by Sanders (1960) as read from http://www.averyweight-tronix.com/download-aspx?did=6249 the **balance** (also called the *balance scale*, *beam balance* and *laboratory scale*) was the first measuring instrument invented for determining the *weight* or *mass* of an object. In its traditional form, it consists of a pivoted horizontal lever of equal length arms, called the *beam* with a *weighing pan*, also called *scale*, *scalepan*, or *bason* (obsolete), suspended from each arm (which is the origin of the originally plural term "scales" for a weighing instrument). The unknown mass is placed in one pan, and standard mass are added to the other pan until the beam is as close to equilibrium as possible.

The beam balance model or simply the balance model shows the representation of linear inequalities with one variable with the balancing of unknown masses with known weights on a physical scale balance. In a scale balance, if the two sides of the balance weigh the same, there will be no tilting. An equation is just like a balance in which the left-hand side should be equal to the right-hand side. Apparently, whatever is done to the left-hand side must be done to the right-hand side, to maintain equilibrium (balance/equality). The balance model enables students to see the concept of in one variable in concrete situations. The principles of the balance model relate children‟s idea to the game of seesaw activities children engaged in at the home.

The balance model also assist every child to work independently and in a group on meaningful Mathematics whilst the teacher provides attention to other students (Roschelle, Pea, Hoadley, Gordin and Means, 2007). Working independently with the balance model thus enables every student to derive maximum benefit whilst working in groups thus helping students to socialize and communicate meaningfully at their own level of knowledge. Roschelle et al (2007), further argued that learning is most effective when four fundamental characteristics are presented: (i) active engagement, (ii) participation in groups, (iii) frequent interaction and feedback, and (iv) connections with real- world contexts. These attributes suggest that when learners are involved in the use of the seesaw (balance) model for studying linear equations in one variable. Using the balance model in teaching linear inequalities could also present group members endless opportunities to investigate and reinforce knowledge of key algebraic concepts and ask questions freely without any panic, fear or alarm.

According to Roschelle et al (2007) performing a task with others provides an opportunity not only to imitate what others are doing, but also to discuss the task and make thinking visible. This again suggests that the use of the balance model to teach linear inequalities in one variable therefore promotes cooperative and collaborative thinking since learners work in groups.

Nonetheless, Roschelle et al (2007) strongly suggested the use of the balance model in teaching students linear inequalities. He says that "using something concrete and familiar help students understand unfamiliar and abstract ideas" (p.108). Thus, linking a new concept to the learner‟s past experience aimed at making that piece of Mathematics more secure and memorable. The figures below is the diagram of a beam balance representing the inequality: $\mathbf{2x + 3 \geq 19}$ and the equation $\mathbf{2x + 3 = 19}$:

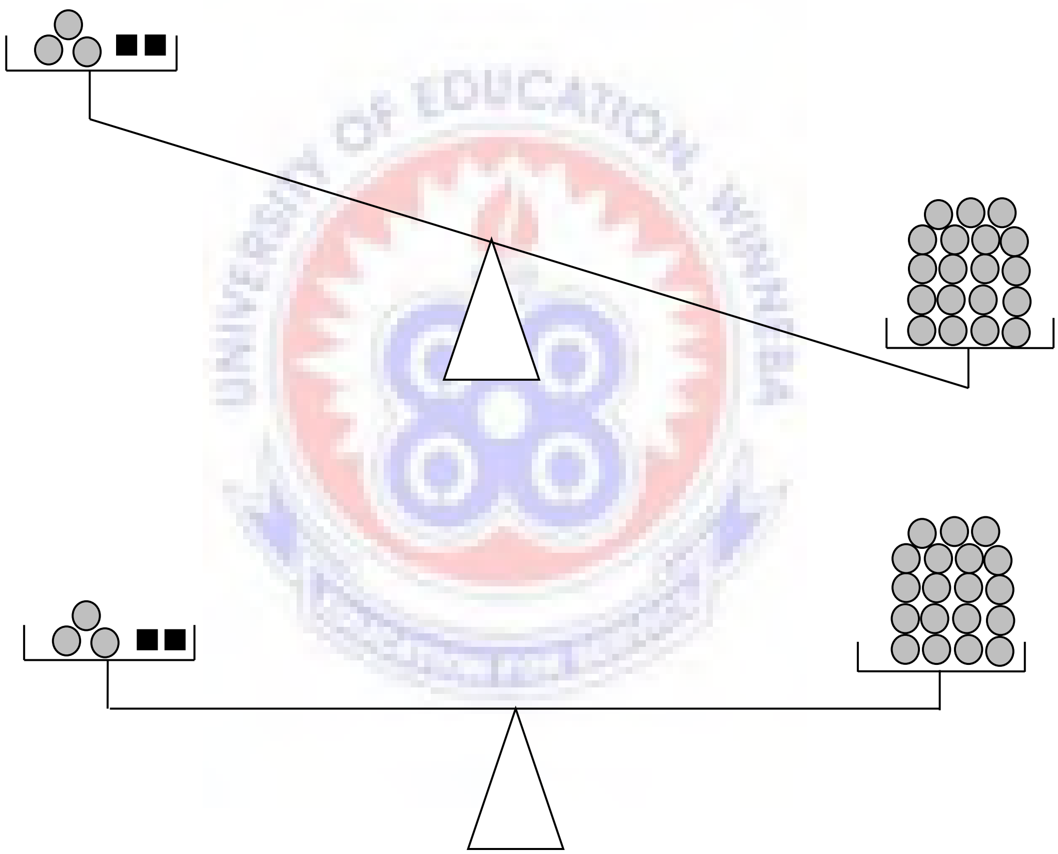


Fig. 2.1: The Beam Balance Model

Source: From Wikipedia, the free encyclopaedia: (http://www.averyweigh-tronix.com/download.aspx?did=6249)

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Overview

This chapter of the project work spells out how the study was conducted. The chapter dealt with the methods that I have employed to improve the conceptual knowledge of linear inequalities in one variable among DBE ONE students of St. Francis College of Education, Hohoe. The methodology would mainly be discussed under the following subheadings:

- Research Design of the study
- Population and Sampling selection techniques
- Administration of Research Instruments
- Pre-Intervention
- Interventions Implementations
- Post-Intervention
- Data presentation and data analysis plan

3.1 Research Design

Kannae (2004) described action research as a process by which practitioners" attempt to study their problems scientifically in order to guide, correct and evaluate their decisions and actions.

According to Kannae (2004), a research design indicates the basic structures of study, the nature of the hypothesis and the variables which provide the framework involved in the study. The type of research design I adopted in this study is an action research design in which a pre-test and post-test design with an intervention was used in collecting data. An action research is the kind of research activity in which the researcher works collaboratively with other people to solve perceived local problems.

3.2 Population and Sample

The target research population for this study is the entire DBE ONE students and teachers of St. Francis College of Education, Hohoe in the Hohoe Municipality of the Volta Region of Ghana. This school was chosen for the study because the researcher identified the problem with the students whilst as a tutor in the college. All the 200 DBE ONE students in the College, is made up of 80 ladies and 120 men all with the average of 18 years and above. I also considered this class because the students had attained some level of maturity required for self and cooperative use of the seesaw or the balance model with minimal tutor intervention and supervision, hence ensuring their full participation in the study.

The purposive sampling technique was used to select DBE ONE „A" students of St. Francis College of Education, Hohoe, since this was the school where I encountered the problem with the students. This procedure was also used because the students can be easily accessible for the data to be collected for the study. This technique is sometimes referred to as judgement sampling (Kannae, 2004). Kannae suggested that purposive sampling technique is used to select information for study in depth; that is participants who possess rich information on the case. Due to the large size of the population a total of 40 students which represented 20% of the 200 DBE ONE „A" students comprising of 15 ladies and 25 men were selected to represent the sample size of the study. Since the research intervention is designed to help all the students in the class to overcome the problem, there will not be the need for random sampling and therefore it became conveniently necessary for all the 40 students in the DBE ONE „A" science class to be taken as the sample size of the population.

3.3 Administration of Research Instruments

Test in the form of pre-test and post-test were the instruments used to collect data for the study.

3.3.1 Test Administration

A test is a structure situation comprising a standard set of questions to which an individual is expected to respond, and based on an individuals response, his or her behaviour is qualified, (Nworgu, 1992). The test which was conducted was to help me ascertain the level of skill and knowledge the DBE ONE students in at St. Francis College of Education have in inequalities. Diagnostic test was used to achieve this goal and has given me the general idea of the skill and knowledge level of the students in the topic.

A teacher made test was what I used to diagnose the perceived problem. There were 10 questions each on the pre-test and post-test each on linear inequalities in one variable (see Appendices A and B). The students were allowed to answer all the 10 questions within a time of 40 minutes. The pre-test was used to identify students" difficulties in the topic while the post-test was used to find out how the intervention used was effective in helping the students in learning the concept.

During the intervention process, the main intervention strategy/material that was designed and used was the beam balance model in the teaching of linear inequalities in one variable. Other strategies such as the guided discovery and an activity-based method of teaching and learning were also adopted and employed alongside the balance model. After 4 weeks of intervention, the post-test was administered to ascertain students‟ level of mastery and knowledge or improvement of the conceptual knowledge of solving linear inequalities in one variable. Each teaching and learning session lasted for an hour, with each week having 3 periods of Mathematical practical lessons with the intervention materials.

3.4 Data Collection Procedures

The data collection procedure was divided into three stages: (i) Pre-test data collection stage (ii) The Intervention stage and (iii) The Post-test data collection stage.

3.4.1 The Pre-Test Data Collection Stage

The Pre-test data collection stage was designed and used as a diagnostic instrument to ascertain the extent of students‟ difficulties in linear inequalities in one variable. The Pre-test was again used to find out the most efficient and appropriate method of intervening strategy to address students‟ difficulties. On 15th February, 2011, a pre-test was conducted on the topic "inequalities" to my students. The outcome of the students‟ responses revealed that, the problem involving simple questions on the topic existed among the pupils. The Pre-test items enabled me to determine the extent of the students‟ strengths and weaknesses on the concept.

After the Pre-test was conducted, it was found out that even though the students were taught linear inequalities in one variable, the results clearly indicated that the students did not understand the topic very well, hence the poor performance. It was also realized that students did not understand the topic because the lesson was delivered without the use of manipulative teaching learning materials. Therefore, the researcher has designed a balance model to be administered as an intervention strategy to address the problem identified. The results from the Pre-test indicated that, the problem identified earlier on existed among the DBE ONE „A" students of St. Francis College of Education, Hohoe.

3.5 The Intervention Implementation Stage

The Intervention stage was the period during which I applied and use the balance model to address the problem of students" conceptual knowledge of linear inequalities in one variable on the part of the students. The use of the beam balance model to address the problem of students" conceptual knowledge of linear inequalities in one variable was what Case et al (2003) referred to as relating classroom activities to learners" life experiences which enable them see the relationship between what is taught in school and what is done at home thereby facilitating transfer of learning.

The intervention lasted for four weeks with each containing an hour each of Mathematics lessons using the balance model. Cooperative and independent learning methods were employed throughout the intervention stage. The topics discussed were divided into four units for the four weeks of intervention. Intra-and-inter group discussions were highly employed among students; student-teacher and student-students interaction created a cordial learning environment for effective learning which sustains students" interest throughout the lessons. This was clearly manifested in students" active interactions and manipulation with the balance model assisting them developed abstract and logical thinking skills.

According to Brunner (1966), concepts of a higher order, other than those a person already has cannot be communicated to that person by a definition, only by arranging for the person to encounter a suitable collection of examples, can such a concept be communicated. Since in mathematics examples are almost invariably other than concepts, the concepts used in the examples must already be formed in the mind of the learner.

Many activities were designed during the intervention which help the students to solve simple questions based on linear inequalities in one variable correctly, thus using the beam balance model.

3.5.1 Step One: Students Ideas on Inequalities

On the 11th of January, 2011, I wanted to find out what pupils already know or have learnt about inequalities after what I taught them to do. Based on this, I gave series of questions based on inequalities of different types, thus $n - \frac{2}{3} > \frac{1}{3} - n$; $5x - 8 \geq 2x + 4$; $5(x - 1) \geq 39$ and $2x - 1 \leq 1$, to solve. These set of test items have been selected from students Mathematics Course Book for Diploma One. After I gave them enough time to work, I collected the scripts for marking. After I have finished marking I realized that, most of the pupils did not do well at all.

Most of the pupils did not know how to group like terms, if for example, terms of the same variable are on both sides of the inequality sign, did not know how to expand brackets first before proceeding, if the questions involves brackets and also did not know how to deal with fractions if the questions entail that. See appendix A for sample questions on the pre-test respectively.

Based on the facts above, I quickly go through with them by teaching the approaches involved in dealing with each type of inequalities. After this, I gave them similar questions to solve, but this time changing some figures but to my amazement, they did not do well. Hence, the problem earlier on identified still existed among the students.

3.5.2 Step Two: Explanation of the Concepts "Inequalities"

The concept of "Inequalities" has been explained to pupils on the 15th day of February, 2011. On this day, I used two periods which comprises 120 minutes. I explained to them that, any statement in which two algebraic expressions are not equal is said to be an inequality. For example, $x + 4 < 10$, $3y - 12 \geq 0$ and $1 \leq 2(p + 7)$. After I wrote these examples on the board, I asked the students what they have observed in the mathematical statements. One student stood up and said "I have realized that, in writing any of the statement, I have introduced a symbol". I quickly replied "yes". I therefore went on to tell them that, when writing inequality problems, we introduce any of these symbols $<, >, \leq, \geq$ and $\neq$.

From here, I asked pupils to cite more examples of inequality problems and some of their responses are: $2y + 10 > 20$; $3 + 5x \leq 33$; $2(k + 3) \geq 8$ and $2x > 16$.

I again proceeded by guiding the students to realise that:

i. $\Rightarrow a \geq b$ " a is greater than or equal to b"

ii. $\Rightarrow a \leq b$ "a is less than or equal to b"

iii. $\Rightarrow a \neq b$ "a is not equal to b"

iv. $\Rightarrow a > b$ "a is greater than b"

v. $\Rightarrow a < b$ "a is less than b"

vi. a < b ⇒ "a > -b".

3.5.3 Step Three: Using the Beam Balance to solve Simple Inequality Problems

Beam Balance model is a piece of equipment used for finding the mass of objects, consisting of a bar with a small dish at each end. The balance scale can be used for illustrating and solving inequalities. This was done on 22nd of February, 2011, during a 60 minutes lesson. Here, I asked the pupils to sketch a simple balance scale (Beam Balance) model on which they represent the above inequalities, thus $(\boldsymbol{\alpha})$: $\mathbf{3 + 2x \leq 19}$ as:

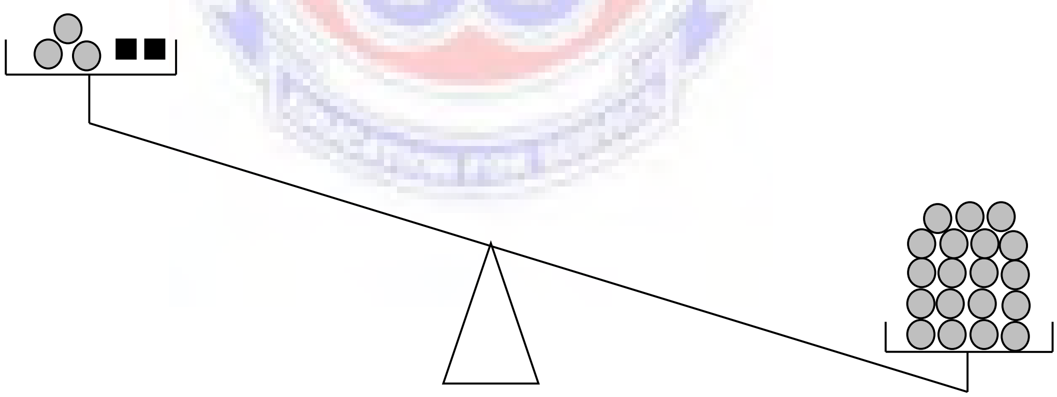


Figure 3.1: The Beam Balance Model

From the figure above, the circles represent chips (numerals) and the boxes represent the unknown variables. From here, it is clear that, the three chips and the two boxes represents the expression $\mathbf{3 + 2x \leq 19}$ on the left hand side of the inequality and nineteen chips representing nineteen on the right side of the inequality. Automatically, the nineteen chips on one side of the balance scale are heavier than the three chips and two boxes and that is why the balance tilted to the right.

For us to be able to balance the scale, I asked the pupils to replace each box on the scale by the same number of chips, keeping in mind the total number of chips on the left side of the scale, which must be less than or equal to nineteen. The pupils did that by removing three chips on both sides and this is illustrated below.

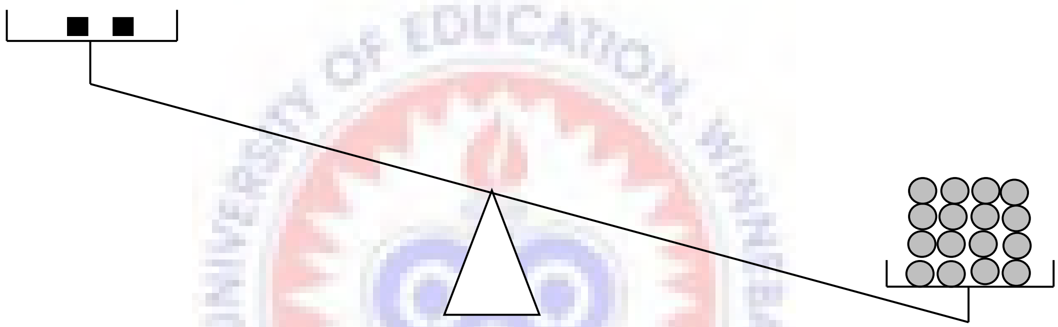


Figure 3.2: The Beam Balance Model

From the figure above, it is mathematically clear that, we subtract three chips from both sides as $3 + 2x - 3 \leq 19 - 3 \Rightarrow \mathbf{2\,x \leq 16}$. After this, I asked the pupils to divide the chips on the right hand side of the scale into two equal groups, one group for each box by seven or fewer chips will keep the scale tipped down on the right side that with eight chips this scale will be balanced. The figure is depicted exactly below.

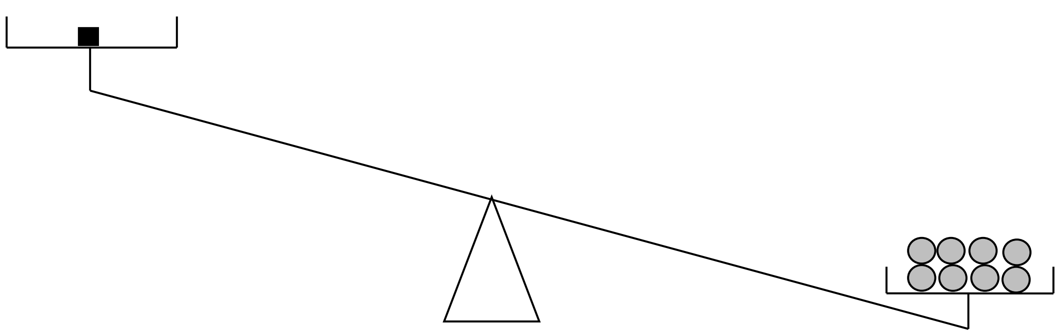


Figure 3.3: The Beam Balance Model

Mathematically, $\mathbf{2x \leq 16 \quad \Rightarrow \quad x \leq 8}$

Again, to the right of each balance scale above, there is a corresponding inequality. These inequalities are replaced by simpler inequalities to obtain $\mathbf{x \leq 8.}$ To make these inequality true, we must replace the variable by the number less than or equal to 8. The balance model uses the missing-addend form of subtraction to demonstrate the conceptual knowledge of solving linear inequalities by trading and moving equal quantities (objects) from both sides at the same time.

3.5.4 Step Four: Inequalities Involving Brackets Using the Idea of Beam Balance

On 28th of February, 2011, I led the students through series of examples of what we learnt previously. The outcome of their responses revealed that, they are ready fore the next lesson so I quickly introduced inequalities involving brackets. I gave an example as shown below: $8 + 4x < 3(x - 2)$.

- **Procedure:**

I asked the students to expand the bracket first. Thus, using the 3 outside the bracket to multiply each element in the bracket and by so doing, we have, $8 + 4x < 3x - 6)$. From here; I asked the students to group like terms and simplify the expression taking into consideration the signs of the figures. Also they should use the idea of beam balance to solve the rest. Thus, $4x - 3x <$ - 6 – 8, $\Rightarrow \; x < -14$. After this, students asked questions bothering them and I explained them to their satisfaction using more examples.

3.5.5 Step Five: Post-Intervention Stage

On the 14th of March, 2011, at a two- period lesson, I reviewed the students" knowledge on all that we have learnt concerning inequalities. After doing that, I asked them to take piece of paper each on which they will do test two (2) - (Post-test). I wrote the same selected questions from their mathematics textbook of four test items which involves all that we have learnt on inequalities and other aspect of it to test learners‟ ability.

I gave them enough time for the test and the scripts were collected at the end of the period for marking. The whole test was marked out five (50), thus fifty out of fifty. The results from the post-test indicated that, most of the students can now solve inequality problems correctly without any external help.

According to Skemp (1986), Mathematics learned relationally is easier remembered because the knowledge of inter-relations between concepts allows them to be remembered as part of connected whole instead of a list of separate rules.

CHAPTER 4

DATA ANALYSIS

4.0 Overview

This chapter discussed the results and findings of the pre-test and post-test scores to elucidate the main claim that the balance model enhances the conceptual knowledge of students in solving linear inequalities in one variable. The statistical tools adopted for analysing the data included statistical descriptions such as percentages, the mean, the standard deviations, of the pre-test and post-test results. The sequence of presentation and analysis of the results obtained in this study were discussed in accordance with the research questions formulated for the study.

The results were input into MS Excel software for descriptive statistical analysis and interpretation. The data would be compared, discussed analyzed using percentages, the mean, the standard deviations, of the pre-test and post-test results.

Table 4.1, below are Frequency distribution and the Percentages of the scores of the forty (40) students in the five essay test administered during the pre-test.

Table 4.1: Frequency Distribution and Percentages of Pre-Test of Students Scores

Scores	No of Students	Percentage Score
1-10	20	50.0%
11-20	9	22.5%
21-30	7	17.5%
31-40	3	7.5%
41-50	1	2.5%
	Total = 40	**100.0%**

4.1 Analysis of Data and Interpretation of Pre-Test

From Table 4.1, out of 36 students scored marks between 1-30 which is below the pass mark representing 90%. Only a handful of four (4) students scored the pass mark representing 10% of the total mark. This ascertained the existence of the problem. As many as twenty (20) students scored marks between 1-10 representing 50% of the students" population. Although enough time was provided only nine (9) students scored between 11-20 marks representing 22.5%, seven (7) students scored marks between 21-30 which is represented by 17.5% and only as many as one (1) student scoring marks between 41-50 representing 3.0%.

From the results of the findings above, the conclusion is that, there was a poor performance of DBE ONE „A" students of St. Francis College of Education in inequalities; hence the results justified the causes of the problem earlier on discussed.

Table 4.2, are the Frequency distribution and Percentages of the scores of the forty (40) students in the five essay test administered during the post-test.

Table 4.2: Frequency Distribution and Percentages of Post-Test of Students Scores

Scores	No of Students	Percentage Score
1-10	0	0.0%
11-20	2	5.0%
21-30	6	15.0%
31-40	8	20.0%
41-50	24	60.0%
	Total = 40	**100.0%**

4.2 Analysis of Data and Interpretation of Post-Test

From Table 4.2, the result of the post-test showed that no student scored a mark between 1-10, representing 0%, twenty-four (24) students scoring marks between 41-50 which represented 60.0%. Analysing the findings from the results further indicated that about only two (2) students scored a mark below the pass mark(1-20), representing 5.0% and thirty-eight (38) students representing ninety-five percent (93.0%) scoring the pass mark(21-50). This indicated that the intervention activities were relevant to the solutions to the problem and therefore there was a marked improvement in students" performance.

Table 4.3, showed the Mean and the Standard deviation of the scores of the forty (40) students in the Pre-test and Post-test Results of the MS Excel Output for Descriptive Statistics.

Table 4.3: Mean and Standard Deviation of the Scores of Forty (40) Students in the Pre-Test and Post-Test Results of the MS Excel Output For Descriptive Statistic

Test	N	Mean	SD
Pre-Test	40	13.58	10.45
Post-Test	40	39.25	10.14

From Table 4.3 of the MS Excel output for the descriptive statistic, it can be seen that the mean of the pre-test, 13.575 and the mean of the post-test, 39.25, with a gain score (that is difference in means), Gain score = (39.25 – 13.58) = 25.67, which showed that students performance was twice better after the intervention.

The standard deviation for the pre-test, of 10.45 was bigger than that of the post-test, of 10.14 which meant that the dispersion or the spread of the marks of the post-test was better than the pre-test, hence there was a marked improvement in students performance.

From the pre-test, 90.0% of students scored marks less than half the total mark. This ascertains the existence of the problem. During the first week of the implementation of the intervention, the 1st of the diagnostic test for formative assessment was conducted and about 70.0% of the students were able to solve all the items correctly. In the 2nd week, the second diagnostic test was conducted. About 80.0% of the students were able to solve all the items correctly. This trend was an indication that the students were improving gradually and hence the intervention activities should be effective, regular and monitored.

In the 3rd and 4th weeks, the last of the diagnostic test was conducted. In this, 95.0% of the students were able to solve all items correctly. Finally, this implied that from the post-test, about 95.0%, of the students scored half or more of the total marks. This showed a marked significant improvement in students‟ performance.

4.3 Findings the Study With Respect To the Research Questions

Research Question 1: To what extent will the use of the Beam Balance Model assist DBE ONE „A‟ students of St. Francis College of Education, Hohoe to use the correct inequality signs when solving problems on linear inequalities in one variable?

Data from Table 4.3 revealed the result of the intervention by comparing the pre-test scores of individual student‟s with their respective post-test scores. It showed a marked significant improvement in student‟s performance after the use of the beam balance model to teach linear inequalities in one variable.

The post-test mean score of 39.25 and a standard deviation of 10.14 are significantly higher than the pre-test mean score of 13.58 and standard deviation of 10.45. This shows that the use of the balance model in teaching linear inequalities in one variable brought about a tremendous improvement in students‟ conceptual knowledge of solving the problem.

Research Question 2: To what extent will the use of the Beam Balance Model of solving linear inequalities help minimise DBE ONE „A‟ students‟ errors in Mathematics at St. Francis College Education, Hohoe?

Results from the activities of students during the intervention and the post-intervention on the use of the Beam Balance model in solving linear inequalities in one variable (see Chapter 3 under Intervention), clearly indicated that majority of the students‟ errors has significantly reduced. There is therefore some evidence of improvement in students‟ performance in linear inequalities in one variable which was attributed to the use of the balance model in teaching the concept.

Findings from data collected from the research, clearly showed that the use of the balance model to teach students increases their conceptual knowledge of solving linear inequalities in one variable, which has had a significant impact on their performance and achievement, is explicably undisputed. That is the use of learned-centred strategies (such as the use of concrete materials) such as the beam balance is capable of effecting remarkable impact on students‟ performance.

The degree at which students have developed skills of answering problems after the post-intervention activities especially by the use of the beam balance model of teaching was positive. This was manifested in students‟ performance which had increased significantly, since about 95.0% of the students sampled were able to solve the post-test correctly, thus reducing their errors significantly. In fact, I must indicated that all my intervention activities that I have employed had actually answered the entire research questions posed in chapter one of the study.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter consists of the reflections thus, how I look at the way the study has affected my teaching of students, schools or even the school community (that is in the house). Also in this chapter, was the impact the research has on the problem, recommendations and suggestions for further research, for teachers, policy makers and curriculum developers.

5.1 Summary

Most non-mathematics students in Ghanaian schools and for that matter those in St. Francis College of Education, Hohoe struggled heavily to be able to pass in Mathematics. In most cases they fought so hard but nevertheless, they failed. The concerns of teachers, parents, guardians, even the student and other stakeholders in education were not too low for effective participation in remedial strategies.

I am also in support of the suggestions by Mark and that of Peggy, (Mark, 1990; Peggy, 1994) that well planned activities and practices are useful in ensuring proper teaching and learning of concepts and skills. Despite all these limitations, useful experiences were gained and I was happy for embarking on the study. This was as a result of the following:

- Students‟ comments of appreciation after they were led through the interventions activities and the comments of commendation from the school authorities and some other members of staff.

- The fact that the "expected change" was realised. The academic performance and attitudes of the students improved.

This research uses the beam balance model as the intervention material to assist DBE ONE „A" students at St. Francis College of Education, Hohoe to improve their conceptual knowledge on the concept of linear inequalities in one variable. The purpose of this study was to use the balance model to improve the conceptual knowledge of the principles of solving linear inequalities in one variable of the DBE ONE „A" students in the above named college. An intervention was designed and completed with success. Many related issues that were investigated included students in the subject, concept comprehension, scope of the syllabus, resources available, time, teaching methods class size among others.

The study revealed that students can perform badly or well base on certain factors prevailing. The balance model drew on the students" playground experience of the seesaw game to demonstrate the representation of an inequality as the balancing of unknown weights on each side of the beam.

The study was conducted on all the 40 students which were in three phases; the pre-intervention, the intervention and the post-intervention stages. At the pre-intervention stage, students were made to answer 8 questions on linear inequalities in one variable. The questions were meant to test student"s conceptual knowledge of the principles of solving linear inequalities in one variable. The students" responses were marked and scored over one fifty to determine knowledge and performance on the concept. Based on the students" poor performance at the pre-intervention stage, an intervention designed and put in place and the beam balance model was used to address the students‟ lack of knowledge of the principles of solving linear inequalities in one variable.

The intervention stage lasted for 4 weeks during which period the students were taken through a series of practical activities in the use of the beam balance model in solving linear inequalities in one variable. The smooth implementation of the intervention stage, coupled with the cooperation exhibited by the students in the use of the balance model for solving linear inequalities in one variable, brought in finally to the post-intervention stage.

During the post-intervention stage, the students answered 8 questions on linear inequalities in one variable. The structures of the post-intervention questions were basically the same as the pre-test. The results of both the pre and post-intervention tests were analysed using descriptive statistics. Generally, the means and the standard deviations were calculated and compared to determine the performance level of the students. The analysis of the study found out that the use of the balance model in teaching linear inequalities in one variable brought about;

- a marked significant improvement in students‟ conceptual knowledge of solving linear inequalities in one variable and
- a significant improvement in students‟ achievement and performance levels in solving linear inequalities in one variable.

Test in the form of a pre-test and a post-test were the major instruments used to investigate the issues that I confronted with during the study. In addition, in Chapter three (3) intervention activities were employed to tackle the major findings and bring fourth solutions. Students patterns of errors seems to reflect fundamental misunderstanding and misconceptions, rather than random mistake in carrying out basically correct procedures in which students frequently applied rules which were inconsistent with the existing standard rules. Students showed a mass misunderstanding of mathematical ideas and concepts and therefore lack the proficiency in using the associated techniques. The need to train mathematics teachers, specifically for that purpose was clear from the study.

5.2 Conclusions

I have carried out the study which has changed the perception of students about the problem perceived. Students found it very difficult to solve simple inequality problems. A teacher made test was used to diagnose the problem identified. From here, I developed a strategy of using Beam Balance model to arrest the situation of students not able to solve inequality correctly.

I stand to confess that, from all that have been read about the topic understudy, including the strategy and methods implemented by the researcher actually had a true influence on the students" academic work. This has reflected in the post-test organised for the students in which 95% can solve inequality problems correctly as compared to 80% who cannot solve inequalities correctly as ascertained from the pre-test. This has given me the proof that, the use of the intervention was practical, effective and successful.

5.3 Recommendations

The importance of mathematics in the life of a human could not be over-emphasised. Inequalities, for that matter is very important to students due to its varied applications in various areas of human everyday life. It was for this reason that governments all over the world, in their educational philosophies gave the study of mathematics a priority. The study also examined the benefits derived from the use of the beam balance model in the teaching of linear inequalities in one variable. By the completion of this action research study I became satisfied with many useful insights and therefore the following are the major recommendations derived from the study for teachers, curriculum developers, policy makers and for further researchers:

5.3.1 For Mathematics Teachers

- Education is a dynamic process and it involves a lot of changes. Students" aptitudes and abilities undergo changes all the time. The role of a teacher is to get students involved in learning activities so that they build up knowledge gradually and developed their own ways of thinking. Based on the findings of this study, it is recommended that all tutors at the Colleges of Education use the balance model in the teaching and learning of linear inequalities in one variable. The use of the balance model brings about cooperation and socialisation among students, making them to communicate effectively at their own level of knowledge. It could also enable the students to ask questions freely without fear and even imitate each other as they perform a given task, discuss salient points and make their thoughts visible.
- Teachers share some of the responsibilities for the consequences of the achievement of their students. Students need the type of Mathematics education that can assist them solve their daily life problems. Mathematics teachers are therefore encouraged and expected to explore instructional strategies such as the use of the beam balance model in the teaching and learning of linear inequalities

in one variable as this method eventually shifts learning from a teacher-centred to a learner-centred. By the use of the balance model, the teacher act as a facilitator of learning and not a transmitter of knowledge as students construct their own knowledge and Mathematical meanings. Good teachers become accountable to the student on these issues and adjust the curriculum accordingly.

5.3.2 For Policy Makers

The use of the beam balance model should be advocated by policy makers and planners because it helps students to cultivate abilities to think scientifically and critically and to develop practical skills leading to problem solving skills among the students. The use of models based on children‟s experiences makes teaching and learning of Mathematics more meaningful. Obviously more support, in-service training and resources should be provided for Mathematics teachers at all levels of education for classroom practice.

The findings of this study and the insight they offer for Mathematics teaching recommended that the curriculum places more emphasises on practical methods of teaching Mathematics. Curriculum developers should design the scope of the syllabus that can be completed and topics well taught. Teachers should effectively teach skills that will help students to determine the appropriate strategies to be used in solving specific problems.

5.4 Suggestion for Further Research

The beam balance model for the teaching and learning of linear inequalities in one variable was intended as an ideal learning resource material. This study therefore suggest that what the students learned would be remembered and would play a significant part in their future learning of algebra and higher Mathematics for science, technology and development. To make the balance model versatile, there is the need to further probe in much detail just how the model could be used in the study of linear inequalities of any form but not only linear.

Using the model showed a remarkable improvement and also has a positive effect on students‟ performance and achievement. Although this study would contribute remarkably towards the advancement of knowledge both scientifically and technologically, thus by inspiring other Mathematics educators to investigate and use manipulative materials in teaching mathematical concepts based on students‟ real life experience. It is however suggested that a direct empirical comparison between the balance model and other models for solving linear inequalities would be appreciated. The strength and weaknesses, similarities and differences that will bring of the various models for solving linear inequalities could then be explored further into detail, qualitatively and quantitatively.

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APPENDIX A

PRE-INTERVENTION TEST QUESTIONS

Instructions:

Simplify the following expressions:

1. $3x < 12$
2. $-5x \leq 30$
3. $2x > 3 - x$
4. $3x + 2 \geq 11$
5. $1 - x < 6$
6. $x + 3 > 19 - 3x$
7. $5 - 2x \leq x + 2$
8. $3x - 4 \leq 4(x + 3)$

APPENDIX B

POST-INTERVENTION TEST ITEMS

Instructions:

Simplify the following expressions:

1. $4x < 12$
2. $-6x \leq 30$
3. $3x > 4 - x$
4. $3x - 4 \geq 11$
5. $2 - x < 6$
6. $2x - 1 > 19 - 3x$
7. $5 - 2x \leq x + 2$
8. $3x - 4 \leq 4(x + 3)$