# Impact of Discovery Learning on Students' Achievement and Retention in Probability: A Case Study of Chinika Secondary School

Medson Maxalex Hamaila, Jacob Hamanenga
*The Copperbelt University, Kitwe, Zambia*

***Abstract:*** **- This study was an investigation on the impact of discovery learning on learners' achievement and retention in probability at Chinika secondary school of Lusaka district in Lusaka province of Zambia. The assumption behind this research is that pupils encounter difficulties in probability by not using the correct formula, not finding the correct probabilities and above all not drawing the probability tree diagrams correctly, leading to poor performance in probability and mathematics as a whole. To that effect, discovery learning approach was used in order to find out if it can have an impact on students' achievement and retention in probability. This study adopted the quasi-experimental non-randomised pre-test, post-test, post-test control research design in which two grade 11 classes, selected at random, one from the morning session and the other from the afternoon session were used in the study. The experimental group, which was the afternoon class had 65 participants and the control group which was the morning class had 65 participants making a total of 130 participants. The questionnaires, pre-test, post-test1 and post-test2 were used for data collection. Data obtained from the achievement and retention tests were analysed using descriptive statistics and the hypotheses tested using the independent samples mann-whitney u test. The Pupils Questionnaires which were open-ended were issued to the control group of 65 participants and teachers Questionnaires were issued to 10 teachers, but only 7 were responded to. The analysis of the Questionnaires was done by categorising the responses of the pupils and the teachers into two categories i.e. lack of understanding and lack of materials categories. The results of the study revealed that there was a statistically significant increase in achievement scores and retention scores in probability when discovery learning approach was used for the experimental group than the control group taught by direct instructions (traditional learning approach).The study, therefore, recommended the use of discovery learning approaches when learning probability at Chinika secondary school.**

***Key words:*** **discovery learning, traditional approach, achievement, retention.**

## I. THE INTRODUCTION AND LITERATURE REVIEW

### *1.1 Background*

Globally, Mathematics is perceived as an important academic subject in society and this could be attributed to the fundamental role it plays in modern scientific and technological developments Crockcroft, (1982).

Despite mathematics being the core subject in the world, a study by Camera (2016) found that in United States 26 % of students were low performers in Mathematics in general.

In Zambia mathematics covers a wide range of topics including: Numbers, Algebra, Geometry, Statistics and probability (CDC, 2012).

In the ECZ Examination's report (ECZ, 2015) it is revealed that most students lacked enough acquisition of skills such as ability to imagine the chances of something to happen, which are the essential components of probability.

Therefore, it could be argued that probability among other topics contributes to poor performance in mathematics.

This study therefore aimed at establishing the impact of discovery learning approach on high school students' achievement and retention in probability at Chinika Secondary school.

Discovery learning approaches, in particular are designed to engage students in inquiry through which guided by the teacher and materials, they discover the intended content (Hammer, 2012).

### *1.2 statement of the problem*

In São Paulo, Brazil, a study by Junior, Zamora, Oliveira and Souza (2017) indicated that students lack confidence in solving statistical and probabilistic problems.

In South Africa, the research Makwakwa (2012) on teaching statistics found that learners experienced difficulties in constructing and interpreting probability graphs and tables; and interpreting probability terminologies.

Questions on probability which constitutes 38% of the mathematics curriculum in Zambian secondary schools are the worst performed (ECZ reports, 2014, 2015). The academic performance of the pupils in the areas of probability seems to be poorer than in any other topic (ECZ 2015).

Furthermore, the result analysis of grade 12 mathematics results at Chinika secondary school showed as in table 1.1.

Table 1.1 CHINIKA SECONDARY SCHOOL GRADE 12 MATHS RESULTS 2014 TO 2017

| YEAR | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|
| PERCENTAGE | 48 | 39 | 55 | 51 |

SOURCE: CHINIKA SECONDARY SCHOOL STUDENTS RECORDS

This suggest that grade 12 pupils at chinika secondary school are finding it difficult to pass mathematics in general and most problems faced by pupils in probability questions include:-

(a) Failure to indicate the probabilities when the second piece is selected after no replacement of the first.
(b) Failure to derive the equations from the previous facts. This happens when a pupil just copy the same equation that they were asked to show in the previous situations.
(c) Failure to draw the tree diagrams correctly in situations where there is no replacement. This originates from the problems (a) and (b) above.

Due to these specific problems faced by the pupils at chinika secondary school, the study seeked the investigation of the impact of using guided discovery learning approach on students' achievement and retention in probability.Particular attention was paid on the drawing of the tree diagrams and the finding of the probabilities that follow them.

*1.3 Purpose*

The purpose of this study was to investigate the impact of using discovery learning strategy on school students' achievement and retention in probability studies.

*1.4 Research objectives*

The research objectives were set as follows

1. To determine the factors contributing to the pupils poor performance in probability at chinika secondary school.
2. To determine the impact of discovery learning on students' achievement in probability at Chinika secondary school.
3. To determine the impact of discovery learning on students' retention in probability at Chinika secondary School.

*1.5 Research questions*

This study endeavoured to answer the following questions:

1. What are the factors contributing to the pupils' poor performance in probability at Chinika secondary school?
2. What is the impact of discovery learning on students' achievement in probability at Chinika secondary school?
3. What is the impact of discovery learning on students' retention in probability at Chinika secondary School?

*1.6 Significance of the study*

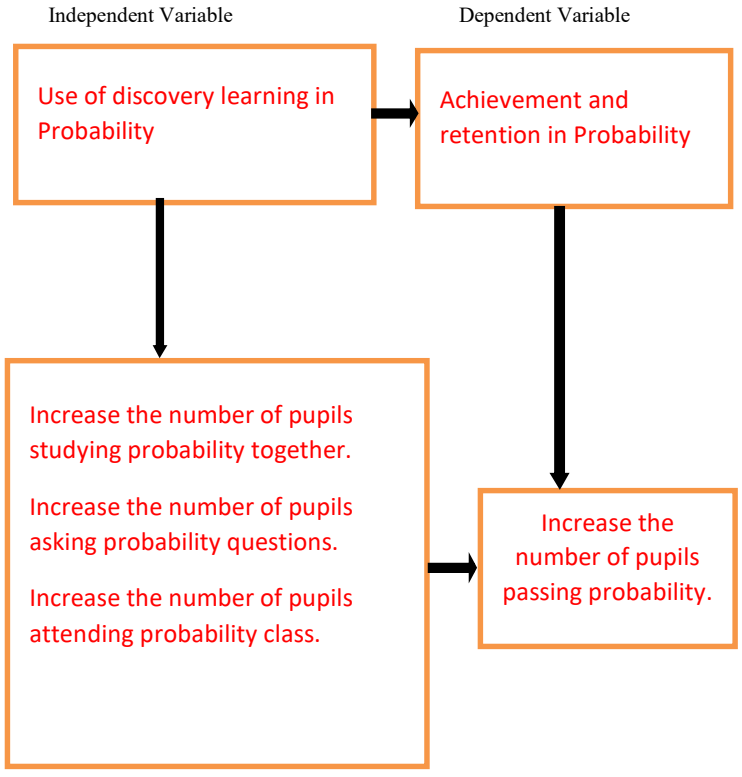
The significance of this study include the following:

1) Firstly, the findings of this study shall help teachers understand the challenges they face in the teaching of probability.
2) To help learners improve on their performances in mathematics and other science subjects.
3) Teacher education institutions may use the results as literature on which to base their planning and teaching of courses.
4) Book writers and publishers may use this literature in their writing of high school books in mathematics particularly on the topic of probability.
5) The finding may lead to further research in the teaching methods and even in other components of mathematics

*1.7 Conceptual framework*

The conceptual framework shows the linkage between independent and dependent variables. The interrelationship of the variables showed how discovery learning impacted students' achievement and retention in probability. The interrelation of variables is shown in the figure 1.1 below.

Figure 1.1 Conceptual Framework




Source: Author (2019)

*1.8 Operationalization of variables*

In this study the following terms meant:

*Discovery:* finding something on your own.

*Learning:* increase in knowledge.

*Achievement:* Gain thing in life.

*Retention:* Remembering something for a long time.

*Secondary School:* The learning institution that starts from grade 8 and ends in the 12$^{th}$grade in accordance with the education system in Zambian.

*Grade 11 learners:* The learners who are in their second year at a senior level which runs from grade 10 to grade 12.

*Morning Classes:* Are classes which starts at 07:00hours to 12:10hours at Chinika sec school.

*Afternoon Classes:* Are classes which starts at 12:15hours to 17:05hours at chinika sec school.

*Teaching Method:* Comprises the principles and Methods used for instruction to be implemented by teachers to achieve the desired learning by students.

## II. METHODOLOGY

*2.1 School setting*

Chinika secondary school is located in chinika light industrial area of Lusaka district near Kanyama Township.

The school has one grade eight and nine classes. The senior levels has 13 streams each. Seven streams each for morning sessions and six streams each for afternoon sessions.

Most of the pupils are selected from other private schools within the zone. The pupils who manage to reach the grade nine final examinations cut off point of the district are selected to the morning classes, whilst those selected with cut off points below the district cut off point are selected to the afternoon classes. The average number of pupils per class for all sessions is 65.

The school has a total of 74 teachers of which 10 belong to the mathematics department, with a minimum qualification of a diploma.

*2.2 Target population*

The target population of the research was the grade 11 classes which consists of 13 streams, 7 in the morning and 6 in the afternoon because the topic of probability is taught in grade 11 according to the Zambia secondary school curriculum. The total population of grade 11 is 845.

*2.3 Sampling Techniques*

In this research purposive sampling and random sampling were used. The research purposively had one grade 11 class from the morning and one grade 11 class from the afternoon sessions.

Each particular class was selected randomly by writing the names of each class on a piece of paper and then putting them in the morning and afternoon boxes, shuffling them and picking one paper from each box. The name of a class from the morning box was the one picked from the morning classes and that one from the afternoon box was the one picked from the afternoon classes.

All the 10 mathematics teachers were used in the study.

*2.4 Sample size*

A purposively sample size of 65 pupils from a morning class and 65 pupils from afternoon class were used as a control and experimental group respectively.

*2.5 Research Design*

The research design adopted by this research was a, non-randomised, pre-test, post-test1, post-test2, quasi-experimental, control group design.

$O_{1E}$ $X_E$ $O_{3E1}$ $O_{5E2}$

$O_{2C}$ $O_{4C1}$ $O_{6C2}$

$O_{1E}$ is the experimental group pre-test achievement mean score.

$O_{2C}$ is the control group pre-test achievement means score.

$O_{3E1}$ is the experimental group post-test 1 achievement means score.

$O_{4C1}$ is the control group post-test 1 achievement mean score.

$O_{5E2}$ is the experimental group post-test 2 retention mean score.

$O_{6E2}$ is the control group post-test 2 retention mean score.

$X_E$ is the Experimental group intervention (discovery learning method).

*2.6 Research Instruments*

The Research instruments used for data collection in this research were:-

*a) Tests*

Pre-test – was given to both the experimental and control groups to check the prior knowledge of the pupils in probability.

Post-test 1 – was given to both the experimental and control groups, after the interventions, which were discovery learning and traditional learning methods respectively, to test achievement.

Post-test 2 – was given to both experimental and control groups after 3 weeks to test retention.

The data collected from the tests was analysed and coded using the statistical package for social sciences (SPSS) software.

*b) The Questionnaires*

The study used a total of 72 questionnaires of which 65 were given to all the pupils of the control group and 7 to teachers. The study used open ended questions in semi-structured questionnaires. Purpose of these questionnaires was to find out the factors that might be contributing to the poor performance in the area of probability at chinika secondary school. The pupils Questionnaires were issued by the School Head Boy to the Control group after the pre-test was given.

*2.7 Instrument validity and Reliability*

Validity is a measure of the degree to which a research instrument yields constant results or data after repeated trial. The reliability of the research instrument is the level to which it give consistent steady effects / statistics after repeated trial (Mugenda & Mugenda, 2003).

Achievement test instrument used as the pre-test, post-test1 and post-test2 was validated by my research supervisor and the Head of Department of Mathematics at Chinika secondary school to check for pupils expected outcomes on the topic of probability. The achievement test was then pilot tested on 10 grade 12 pupils and then revised by the head of department and some mathematics teachers to check for appropriate changes which were made beforetesting it on boththe experimental and control groups of the research study. This was facilitated due to the fact that the current setting of the grade 12 final examinations in mathematics on the topic of probability requires a student to draw the tree diagrams and find the probabilities that follows.

Table 3 below is showing the percentage scores of the pilot test on 10 grade 12 pupils. Column 2 are the scores of the test instrument which was initially validated by the head of department. Column 3 and 4 is showing the scores of the revised test.

The results showed that pupils were able to draw the tree diagrams correctly and be able to find the probabilities that followed in line with the current mathematics curriculum.

**TABLE 2.1 VALIDITY TESTING**

| ID | TEST1 | TEST2 | TEST3 |
|---|---|---|---|
| $V_1$ | 75 | 100 | 100 |
| $V_2$ | 67 | 100 | 100 |
| $V_3$ | 75 | 100 | 100 |
| $V_4$ | 67 | 100 | 100 |
| $V_5$ | 50 | 100 | 100 |
| $V_6$ | 50 | 83 | 100 |
| $V_7$ | 33 | 100 | 100 |
| $V_8$ | 33 | 67 | 83 |
| $V_9$ | 67 | 100 | 100 |

*Source: Validity Testing Pupils Answer Sheets*

Spearman's Brown was used to test for reliability. Reliability=2r/1+r. Where r = actual correlation between the halves of the instrument. The r was found using the SPSS software by using the scores of test 2 and test 3 of the table 3 above and r was found to be 0.879.

Then reliability = 2x0.879/1+0.879=0.936.Which means that the test instrument was able to be consistent in measuring the outcome scores.

The Questionnaires of the teachers and pupils were validated by my research supervisor and the English department and then the pilot test was conducted on 10 grade 12 pupils and mathematics teachers to measure the validity and reliability of the questionnaires before they were given to the pupils and teachers in the research.

## III. FINDINGS

*3.1 Research question 1: What are the factors contributing to the pupils' poor performance in probability at chinika secondary school?*

This research question was aimed at finding out from both participating pupils and teachers the factors only which might be contributing to poor performance of pupils in probability at chinika secondary school through the questionnaires. The pupils and teachers questionnaires were issued immediately after the traditional teaching (direct instructions) approach intervention to all 65 pupils of the control group and 10 mathematics teachers but only 7 teachers questionnaires were responded to.

*3.2 Control Group Intervention (Direct instructions approach)*

The control group which was the morning class was taught probability using the traditional method of class discussion and teacher exposition.

*Objective:* pupils should be able to apply laws of probability in finding probabilities and draw the Probability tree diagrams correctly.

*Materials:* i) Lesson plan.

ii) Teachers hand book.

iii) Chalk.

*Pupils Activities:* Writing down notes, asking questions, answering questions.

All the responses of the pupils and the teachers concerning the research question were grouped into two categories:-
a) Lack of understanding category. b) Lack of material category.

Table3.1 Number of respondents on lack of understanding and lack of materials categories

| Category | N | Category | N |
|---|---|---|---|
| Lack of understanding (pupils) | 60 | Lack of materials (pupils) | 05 |
| Lack of understanding of pupils (teachers) | 05 | Lack of materials (teachers) | 02 |

*3.3 The Experimental Group Intervention (discovery learning activities)*

The experimental group which was the afternoon class was taught using the less guided method and practical activities of discovery learning where pupils were less guided in finding out for themselves the next outcome of the events after the first event was not replaced.

*Discovery learning activity in probability*

*Objective:* Pupil's should be able to draw the tree diagram when no replacement is done and find the probabilities.

1. *Materials:* i.10 stones, four red and six white.
   i. Tables.
   ii. Handouts on probability.

*Pupils Activities:* Tables provided to be filled in by pupils. Find the relationships and draw the tree diagram.

Pupils should be picking one stone after another and writing down the chances of picking a stone one after another without replacement.

Figure 3.1 pupils performing the activities and recording

DISCOVERY LEARNING ACTIVITY IN PROBABILITY

OBJ: Pupil's should be able to draw the tree diagram when no replacement is done and find the probabilities.

Materials: i. 10 stones, four painted red and six painted white

ii. Tables

Activities: Tables provided to be filled in by pupils. Find the relationships and draw the tree diagram.

TABLE 1

| Total Stones | Assertion of Picking | | | |
|---|---|---|---|---|
| | First red | Second red | Third red | Fourth red |
| 10 | $\frac{4}{10} = \frac{2}{5}$ | $\frac{3}{9}$ | $\frac{2}{8} = \frac{1}{4}$ | $\frac{1}{7}$ |

TABLE 2

| Total Stones | Freedom of Picking | | | |
|---|---|---|---|---|
| | First white | Second white | Third white | Fourth white |
| 10 | $\frac{6}{10} = \frac{3}{5}$ | $\frac{5}{9}$ | $\frac{4}{8} = \frac{1}{2}$ | $\frac{3}{7}$ |

TABLE 3

| Total Stones | Chance of picking a red stone | Chance of picking | | | | | |
|---|---|---|---|---|---|---|---|
| | $\frac{4}{10} = \frac{2}{5}$ | Red | White | Red | White | Red | White |
| 10 | | $\frac{3}{9} = \frac{1}{3}$ | $\frac{6}{9} = \frac{2}{3}$ | $\frac{2}{8} = \frac{1}{4}$ | $\frac{6}{8} = \frac{3}{4}$ | $\frac{1}{7}$ | $\frac{6}{7}$ |
| | Chance of picking a white stone | Chance of picking | | | | | |
| | $\frac{6}{10} = \frac{3}{5}$ | Red | White | Red | White | Red | White |
| | | $\frac{4}{9}$ | $\frac{5}{9}$ | $\frac{3}{8}$ | $\frac{5}{8}$ | $\frac{2}{7}$ | $\frac{5}{7}$ |

Pupils should now be able to fill in the tables above.

Figure 3.2 the good Filled in tables

During these activities the pupils mentioned some local games where there are some elements of probability such as chiyato, solo and round-us.

The specific research problems mentioned in the research problem were addressed by the processes that led to the drawing of the tree diagram correctly as follows:-

Taking $n_r$= number of red stones.

$n_w$= number of white stones.

N = total number of stones.

Picking first red stone= $\frac{nr}{N} = \frac{4}{10} = \frac{2}{5}$

Picking second red without replacing the first red

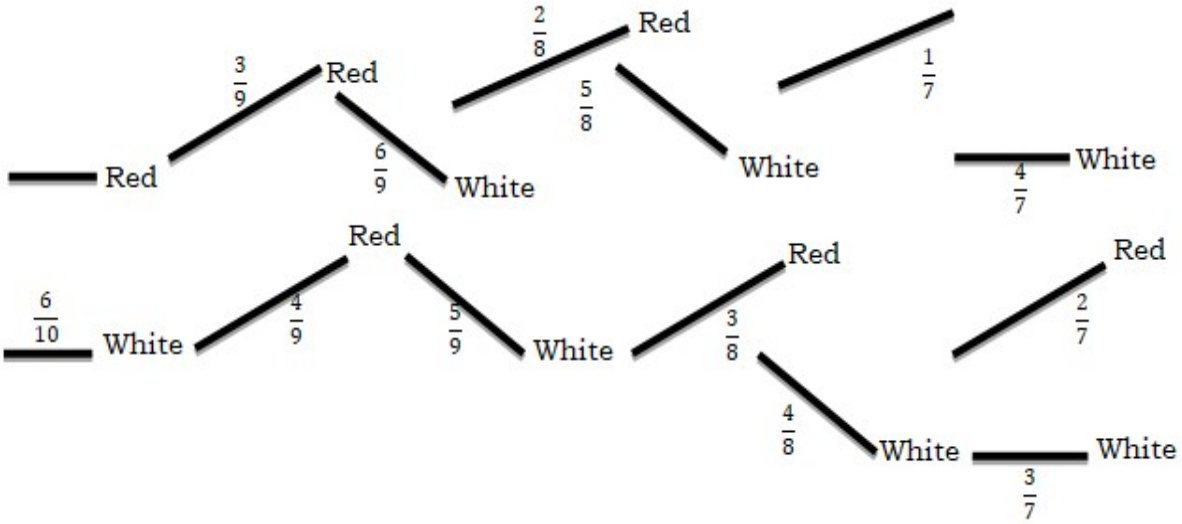
$$= \frac{nr-1}{N-1} = \frac{3}{9} = \frac{1}{3}$$

Picking second white without replacing the first red

$$= \frac{nw}{N-1} = \frac{6}{9} = \frac{2}{3}$$

This is what the pupils were doing when they were picking one stone, writing its chance of picking it, not replacing it, counting the remaining red or white stones, picking the second red or white stone and then writing down its probability.

These activities led to the coming up with the following branches.




These branches led to the drawing of the correct probability tree diagram as shown in the sample figures below.

Figure 4.8 the good drawn tree diagram

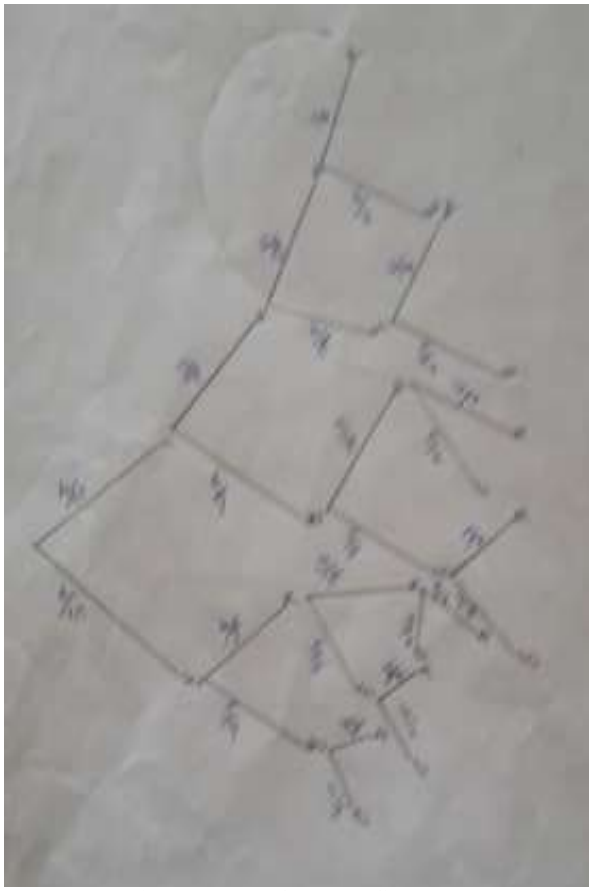


Figure 4.9 waste drawn tree diagram

The lack of understanding factor was addressed by the above learning activities by the Experimental group and the lack of books on probability was addressed by providing handouts on the topic of probability to all the 65 participants of the Experimental group, where the pupils were making references.

*3.4 The Quantitative Data*

The quantitative data in table 4.6 which included the pre-test, post-test1 and post-test2 achievement test scores were tested for normality to ascertain the type of analysis test to use, which could either be parametric or non- parametric and the normality tests are presented in the table 4.7.

Table 3.2: pre-test, post-test1 and post-test2 results

| EXPERIMENTAL GROUP | | | | CONTROL GROUP | | | |
|---|---|---|---|---|---|---|---|
| ID | PRE-TEST SCORE (%) | POST-TEST1 SCORE (%) | POST-TEST2 SCORE (%) | ID | PRE-TEST SCORE (%) | POST-TEST1 SCORE (%) | POST-TEST2 SCORE (%) |
| E1 | 0 | 53 | 55 | C1 | 33 | 43 | 40 |
| E2 | 0 | 83 | 83 | C2 | 33 | 73 | 70 |
| E3 | 25 | 78 | 78 | C3 | 25 | 52 | 50 |
| E4 | 17 | 45 | 50 | C4 | 25 | 68 | 60 |
| E5 | 0 | 53 | 52 | C5 | 33 | 35 | 30 |
| E6 | 33 | 70 | 70 | C6 | 33 | 43 | 40 |
| E7 | 8 | 78 | 77 | C7 | 0 | 35 | 35 |
| E8 | 33 | 70 | 70 | C8 | 0 | 77 | 70 |
| E9 | 50 | 100 | 100 | C9 | 8 | 27 | 20 |
| E10 | 0 | 78 | 78 | C10 | 33 | 60 | 55 |
| E11 | 33 | 37 | 37 | C11 | 25 | 35 | 30 |
| E12 | 0 | 87 | 88 | C12 | 0 | 68 | 60 |
| E13 | 0 | 70 | 70 | C13 | 42 | 52 | 50 |
| E14 | 33 | 53 | 53 | C14 | 8 | 43 | 40 |
| E15 | 25 | 28 | 28 | C15 | 33 | 35 | 30 |
| E16 | 17 | 50 | 48 | C16 | 8 | 35 | 30 |
| E17 | 8 | 37 | 37 | C17 | 25 | 35 | 28 |
| E18 | 17 | 53 | 52 | C18 | 17 | 18 | 18 |
| E19 | 33 | 87 | 87 | C19 | 33 | 27 | 20 |
| E20 | 0 | 70 | 70 | C20 | 33 | 73 | 70 |
| E21 | 8 | 45 | 45 | C21 | 25 | 18 | 18 |
| E22 | 33 | 87 | 87 | C22 | 58 | 52 | 50 |
| E23 | 8 | 87 | 89 | C23 | 33 | 90 | 80 |
| E24 | 17 | 78 | 78 | C24 | 33 | 60 | 55 |
| E25 | 0 | 53 | 53 | C25 | 33 | 35 | 30 |
| E26 | 8 | 45 | 45 | C26 | 25 | 35 | 28 |
| E27 | 17 | 75 | 78 | C27 | 25 | 35 | 28 |
| E28 | 8 | 20 | 35 | C28 | 33 | 52 | 50 |
| E29 | 0 | 62 | 60 | C29 | 25 | 35 | 30 |
| E30 | 58 | 70 | 70 | C30 | 17 | 35 | 30 |
| E31 | 8 | 100 | 100 | C31 | 8 | 35 | 30 |
| E32 | 8 | 45 | 50 | C32 | 33 | 67 | 60 |
| E33 | 0 | 20 | 30 | C33 | 25 | 27 | 20 |
| E34 | 0 | 83 | 83 | C34 | 0 | 35 | 30 |
| E35 | 25 | 100 | 100 | C35 | 42 | 68 | 65 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| E36 | 0 | 70 | 65 | C36 | 8 | 35 | 30 |
| E37 | 8 | 45 | 45 | C37 | 33 | 35 | 28 |
| E38 | 42 | 78 | 78 | C38 | 25 | 35 | 28 |
| E39 | 0 | 28 | 28 | C39 | 0 | 68 | 65 |
| E40 | 8 | 20 | 20 | C40 | 25 | 68 | 60 |
| E41 | 0 | 53 | 53 | C41 | 25 | 28 | 30 |
| E42 | 25 | 78 | 78 | C42 | 42 | 35 | 35 |
| E43 | 17 | 37 | 37 | C43 | 42 | 35 | 40 |
| E44 | 25 | 62 | 62 | C44 | 33 | 60 | 60 |
| E45 | 8 | 45 | 45 | C45 | 33 | 90 | 85 |
| E46 | 0 | 28 | 28 | C46 | 25 | 43 | 40 |
| E47 | 33 | 78 | 78 | C47 | 33 | 43 | 40 |
| E48 | 8 | 70 | 70 | C48 | 25 | 35 | 35 |
| E49 | 25 | 70 | 68 | C49 | 17 | 43 | 40 |
| E50 | 33 | 45 | 45 | C50 | 42 | 35 | 30 |
| E51 | 0 | 78 | 78 | C51 | 8 | 35 | 35 |
| E52 | 17 | 37 | 40 | C52 | 17 | 43 | 40 |
| E53 | 0 | 45 | 45 | C53 | 33 | 27 | 20 |
| E54 | 8 | 70 | 68 | C54 | 45 | 68 | 60 |
| E55 | 25 | 100 | 100 | C55 | 42 | 18 | 18 |
| E56 | 33 | 78 | 78 | C56 | 67 | 27 | 20 |
| E57 | 0 | 70 | 70 | C57 | 25 | 43 | 40 |
| E58 | 25 | 70 | 69 | C58 | 33 | 77 | 70 |
| E59 | 8 | 87 | 88 | C59 | 25 | 73 | 70 |
| E60 | o | 78 | 78 | C60 | 25 | 35 | 30 |
| E61 | 67 | 100 | 100 | C61 | 17 | 60 | 55 |
| E62 | 8 | 45 | 50 | C62 | 33 | 52 | 52 |
| E63 | 25 | 28 | 30 | C63 | 53 | 68 | 60 |
| E64 | 17 | 70 | 65 | C64 | 33 | 68 | 55 |
| E65 | | | | C65 | 25 | 68 | 56 |
| | | | | | | | |

*Source: Pupils score sheets*

**Table 3.3 Test for normality**

| | GROUP | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| PRETEST | EXPERIMENTAL | .217 | 64 | .000 | .863 | 64 | .000 |
| | CONTROL | .213 | 65 | .000 | .924 | 65 | .001 |
| POSTTEST1 | EXPERIMENTAL | .177 | 64 | .000 | .952 | 64 | .014 |
| | CONTROL | .221 | 65 | .000 | .911 | 65 | .000 |
| POSTTEST2 | EXPERIMENTAL | .110 | 64 | .051 | .962 | 64 | .048 |
| | CONTROL | .159 | 65 | .000 | .937 | 65 | .002 |

Since the sample size is less than 2000 (n<2000), shapiro-wilk normality test was used.

The research scores were all not normally distributed due to the fact that all the sig values were less than 0.05 (p<0.05). Therefore, descriptive statistics was used to analyse the data and non- parametric u-test was used to test the hypotheses of the data.

*3.5 Pre-test Results*

The probability prior knowledge of the participants and the groups' equivalence at the beginning of the study, a pre-test was administered to both the experimental and control groups. The descriptive statistics are as shown in the table 3.4.

Table 3.4 pre-test group statistics

| | Group | N | Mean | Std deviation | Std error mean |
|---|---|---|---|---|---|
| Pre-test | EG | 64 | 15.55% | 15.607 | 1.951 |
| | CG | 65 | 26.32% | 12.760 | 1.583 |

The experimental group (EG) had 64 participants, a mean of 15.55% and std deviation of 15.607, while the control group (CG) had 65 participants, a mean of 26.32% and std deviation of 12.760.

The results shows that the two groups were not equivalent since their means were statistically different.

To test the results from pre-test of the experimental and control groups the following hypotheses were tested at 0.05 alpha level.

$H_1$: There is a statistical difference between the pre-test scores of the experimental group and the pre-test scores of the control group.

$H_0$: There is no statistical difference between the pre-test scores of the experimental group and the pre-test scores of the control group.

Using the non-parametric independent samples mann-whitney u test, the results of the hypothesis test are presented in the table 4.6 below.

Table 3.5 pre-test, u-test hypothesis test

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of PRETEST is the same across categories of GROUP. | Independent-Samples Mann-Whitney U Test | .000 | Reject the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

Since the sig of .000 is less than .05, we reject the null hypothesis and conclude that the two groups were not equivalent.

In order to check the impact of the two teaching methods, the traditional and the discovery learning on pupils' achievement scores, the pre-test and posttest1 of both the experimental and control groups were compared as shown by statistics in table 3.5 and 3.6 respectively.

Table 3.6 Pre-test and Posttest1 statistics of experimental group

| | Group | N | Mean | Std deviation | Std error |
|---|---|---|---|---|---|
| Pre-test | EG | 64 | 15.55% | 15.607 | 1.951 |
| Post-test1 | EG | 64 | 62.70% | 21.945 | 2.743 |

The mean score of the pre-test was 15.55% and of the post-test1 was 62.70%, showing the mean increase of 47.15%.This means that, there is a difference in performance between pre-test and post-test1 for the experimental group.

Table 3.7 Pre-test and Post-test1 Statistics of control Group

| | Group | N | Mean | Std deviation | Std error |
|---|---|---|---|---|---|
| Pre-test | CG | 65 | 26.94% | 13.721 | 1.702 |
| Post-test1 | CG | 65 | 47.74% | 18.060 | 2.240 |

The mean score of the pre-test was 26.94% and of the post-test1 was 47.74%, showing the increase of 20.80%. This also means that, there is a difference in performance between pre-test and post-test1 for the control group.

Comparing the statistic results of table 3.5 and table 3.6, it shows that the increase in terms of the mean scores was much higher for the experimental group than the control group.

*3.6 RESEARCH QUESTION TWO:-What is the impact of discovery learning on students Achievement in probability?*

To answer this research question, first the statistics in table 4.12 were conducted.

Table 3.8 Post-test 1 statistics of experimental and control groups

| | Group | N | Mean | Std deviation | Std error |
|---|---|---|---|---|---|
| Post-test1 | EG | 64 | 62.70% | 21.945 | 2.743 |
| | CG | 65 | 47.74% | 18.045 | 2.238 |

The experimental (EG) had 64 participants, a mean score of 62.70% and Std deviation of 21.945, while the control group had 65 participants, a mean score of 47.12 and Std deviation of 18.060.The difference of the mean scores of the post-test1

of the experimental group taught using discovery learning approach and the control group taught using the traditional learning approach was 14.96%. This means that, there is a significant difference in post-test1 performance between experimental group and control group.

Secondly the following hypotheses were tested using the U test statistics.

$H_1$: There is a statistically significant relationship between discovery learning method and Students' achievement in probability.

$H_0$: There is no statistically significant relationship between discovery learning method and Students' achievement in probability.

These hypotheses were tested based on the achievement scores of the experimental and the control groups.

Table 3.9 Post-test1, U test hypotheses test.

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of POSTTEST1 the same across categories of GROUP. | Independent-Samples Mann-Whitney U Test | .000 | Reject the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

The null hypothesis is rejected, at .000 sig value ($p< 0.5$) since the distribution of post-test1 achievement scores of the experimental and the control groups are not the same. This is due to the impact differences of learning approaches on students' achievements which is high for the experimental group. Implying that there is a higher impact of discovery learning on students' achievement in probability, hence further concluding that there is a statistically significant relationship between discovery learning method and achievement in probability.

*3.7 RESEARCH QUESTION THREE:-What is the impact of discovery learning on Students' retention in probability?*

To answer this research question the post-test1 and post-test2 of both the experimental and the control groups were first compared to check the retention levels of each group.

Table 4.11 and Table 4.12 shows the statistics for the experimental and control groups respectively.

Table 3.10 post-test1 and post-test2 statistics for Experimental Group

| | Group | N | Mean | Std deviation | Std error |
|---|---|---|---|---|---|
| Post-test1 | EG | 64 | 62.70% | 21.945 | 2.743 |
| Post-test2 | EG | 64 | 63.23% | 21.067 | 2.633 |

Table 3.11 post-test1 and post-test2 statistics for control group

| | Group | N | Mean | Std deviation | Std error |
|---|---|---|---|---|---|
| Post-test1 | CG | 65 | 47.74% | 18.045 | 2.238 |
| Post-test2 | CG | 65 | 42.71% | 17.183 | 2.131 |

The mean scores of the experimental group increased from 62.70% for post-test1 to 63.23% for post-test2, giving an increase of 0.53%. Whilst that of the control decreased from 47.74% to 42.71%, giving a decrease of 5.03%. This means that, there is a significant difference between the post-test1 and post-test2 of the experimental group and the control, which is positive for the experimental group and negative for the control group.

The following hypotheses were tested, to check if there was a significant relationship between retention and the two learning approaches used in the experimental and control groups, by comparing the post-test2 scores of the experimental and control groups.

$H_1$: There is a statistically significant relationship between discovery learning method and Students' retention in probability.

$H_0$: There is no statistically significant relationship between discovery learning method and Students' retention in probability.

These hypotheses are tested based on the difference of post-test2 achievement scores between the experimental group and the control group.

Table 3.12 post-test2, u test hypothesis test

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of POSTTEST2 the same across categories of GROUP. | Independent-Samples Mann-Whitney U Test | .000 | Reject the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

Since the mean scores of the experimental group increased by 0.53% and that of the control group decreased by 5.03%, it means that the distribution of posttest2 scores are not the same for the experimental and control groups.

The experimental group managed to retain the mean score with an increase of 0.53% mean score, whilst the control group was unable to retain the mean score, but instead had a reduction of mean score by 5.03%.

The increase of 0.53% in retention mean scores for the experimental group was due to the discovery learning approach, whilst the decrease of 5.03% in retention mean scores for the control group was due to the traditional learning approach.

So we reject the null hypothesis and conclude that there is a statistically relationship between discovery learning approach and students retention in probability.

## IV. DISCUSSIONS

### *4.1 Factors Contributing to Poor Performance in Probability at Chinika Secondary School.*

*a) Lack of understanding category*

Understanding in mathematics is the comprehension of mathematical concepts, operations and relations-knowing what mathematics symbols, diagrams and procedures means. This refers to learners' grasp of fundamental mathematics ideas. (National research council 2005).

Table 3.1 shows that 60 pupils out of a total of 65, which is 92% of all the pupils from the control group taught using the traditional method, did not comprehend the mathematical concepts, operations and relations. It also shows that 5 out of 7, which is 71% of the teachers who responded to the questionnaires and 50% of the total number of mathematics teachers at Chinika secondary school, responded that pupils do not understand the concepts and procedures of solving probability problems.

According to Nyaumwe, Bappoo, Buzuzi and kasujandima (2004:33), traditional approaches, which involves, teacher-centred instructional methods that do not make learners develop conceptual understanding of mathematics, have been criticized because they do not encourage problem solving skills in learners.

This type of learning based on teacher talk does not involve much individual development of understanding. In contrast a learner-centred teaching approach is one that supports learners in developing mathematical reasoning, while encouraging them to perceive the teacher as someone who is there to help them develop meaning in mathematics (Brodie, 2006:543; yashau, Mji and messels, 2005: 20).

Pupils at Chinika secondary school are not understanding probability, mainly due to the fact that they are taught using the teacher- centred approach, in which they are not involved much in conceptual developments and finding relationships between the concepts, hence the need to involve all the learners in the learning processes by all teachers in order for all the learners to understand probability.

*b) Lack of educational materials category*

Teaching materials refers to a spectrum of educational materials that teachers and pupils use in a classroom to support specific learning objectives as set out in lesson plans. These can be text books, games, videos flashcards, project supplies and more (Beth Lewis 2019).

A Significant features of most educational resources is that they are restricted to many and can cost a lot to gain access to. This is largely because of a market economy around educational resources (liyoshi and kumar 2008:149).

Table 3.1 shows that 5 out of 65 pupils which is 8% of the total participants from the control group responded that they do not have enough educational materials for them to do better in probability and Table 4.2 show that 2 out of 7 teachers which is 29% of the total participating teachers responded that there is lack of educational materials for teachers to enhance the teaching and learning of probability at the school.

In view of this category of lack of educational materials and with regard to poor performance of pupils in probability at the school, pupils and teachers seems to believe that it's only the manufactured educational materials such as the textbooks and playing cards that can enhance the teaching and learning of probability without appreciating other locally and naturally given materials such as stones, sticks and games, to enhance the teaching and learning of probability at Chinika Secondary School.

### *4.2 Impact of Discovery Learning on Students Achievement in Probability*

The analysis of the results from table 4.10 for the pre-test and post-test1 for the experimental group showed that these learners taught using discovery learning approach, scored 15.55% pre-test mean score and 62.70% as post-test1 mean score.

The analysis of the results from table 4.11 for the pre-test and post-test1 for the control group, showed that these learners taught using traditional learning approach scored 26.94% as pre-test mean score and 47.74% as post-test1 mean score.

Table 4.12, shows the post-test1 results of the experimental group and the control group after their treatments. The experimental group which was taught using the discovery learning approach performed better, showing their mean score of 62.70%, whilst the control group taught using the traditional approach scored only a mean score of 47.74%.Giving a difference of 14.96% between the experimental group and the control group. This significant performance of learners in the experimental group taught using discovery learning approach can simply be explained by the fact that discovery learning created a conducive learning environment for the learners to be active and interactive, which made them to discover the concepts and the

relationships between the concepts by themselves, leading them to fully understanding of the concepts, resulting into higher achievement scores.

This confirm with what Bruner wrote, that practice in discovery for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving (Bruner 1961,p.26).

Dewey (1963) also advocated, placing the learner at the Centre of the learning process.

Probability is an applied subject which combine theory with practice. Pupils need to be encouraged to be practical as they explore the concepts of probability for them to achieve in terms of scores in either tests or final examinations.

*4.3 Impact of Discovery Learning on Students Retention in Probability*

The analysis from table 4.14 for the post-test1 and post-test2 results of the experimental group showed the post-test1 mean score of 62.70% and post-test2 mean score of 63.23%, giving an increase of 0.53%.

The analysis from table 4.15 for the post-test1 and post-test2 results of the control group showed the post-test1 mean score of 47.74% and the post-test2 mean score of 42.72%, giving a decrease of 5.03%.

This increase of performance mean score by 0.53% by the experimental group from post-test1 to post-test2 in a space period of 3 weeks was as a result of pupils engagement in the entire process of learning, which made it possible for the pupils to be able to retain the knowledge acquired before the post-test1 through to post-test2. On the other hand the decrease of 5.03% mean score by the control group from post-test1 to post-test2 in the same period of 3 weeks was as a result of pupils not being engaged in the learning processes by the teacher.

This is in agreement with Jew (2012) who says that the discovery learning model can improve the mastery of material, retention, transfer of knowledge and more significant learning and on contrary, if pupils learn through a teachers talk approach (traditional method), pupils will be unable to master and be able to retain the knowledge acquired for a certain period of time.

These increase of results from post-test1 to post-test2 of the experimental group of this study suggests an impact of discovery learning approach on students' retention in probability at Chinika Secondary school.

## V. CONCLUSION

Pupils at Chinika secondary school are failing probability because of lack of understanding of the probability concepts and lack of materials such as textbooks, playing cards and dice. Hence the need to engage them in other forms of learning activities such as discovery learning in which pupils can learn probability by the use of locally and naturally made materials such as stones and sticks.

The experimental group (afternoon class) taught using discovery learning approach was more successful than the control group (morning class) taught with traditional instructions in both the achievement scores and the retention scores.

This significant academic achievement of the learners in the experimental group is by the fact that discovery learning approach created a learning environment in which learners were able to be practical in discovering on their own with little guidance, the concepts and relationships between concepts, leading to masterly of the procedures and concepts in probability.

## VI. RECOMMENDATIONS

The following are the recommendations, based on the findings and results at Chinika Secondary School, concerning the poor performance in Probability:-

a) The guidelines and direction, concerning the use of constructivist approaches such as discovery learning, should be provided in the curriculum. This should be included in the mathematics syllabi, textbooks and at lesson planning level.
b) The mathematics teachers should be teaching probability by the use of stones or sticks, in the absence of other materials such as playing cards, marbles and dice.
c) The school should consider buying some teaching-aids such as playing cards, marbles and dice. The school should also consider buying more textbooks of probability for pupils to refer to when learning probability.
d) A further research on the use of games in the teaching of probability, such as Solo, Chiyato and Round-us, mentioned by pupils of the experimental group of this study.

## REFERENCES

[1] Alfieri, L Brooks, P.J, Aldrich. N.J & Tenenbaum, H.R (2011). Does discovery based instruction enhance learning? Journal of education psychology, 103(1), 1- 1.
[2] HotmikaSihombing."The Effect of Discovery learning model to students' mathematical concept mastery,"Jose Journal of Research method in Education (JOSR-JRME), vol 7, no 5, 2017, pp,18.
[3] Thomas A. Romberg and jack shepler .Retention of Probability Concepts: A pilot study into the Effects of Mastery learning with sixth Grade students," Journal for Research in mathematics Education, vol4, no1(jan 1973), pp 26-32.
[4] Odette Umugiranza and Sarah Bansilal. Exploring teachers practice in teaching mathematics and statistics in Kwa Zulu natal schools, South African journal of Education, vol 37, no2, may, 2017.
[5] Junior, A.P.O. ,Zamora P. R., Oliveira L. A. D and Souza, T.C.D (2017) Student's Attitudes Towards Probability and Statistics and Academic Achievement on Higher Education, ActaDidacticaNapocensia, 11(2), 43-56

[6] Ogbe Alphonsus Okori and Omenka Jerry. Improvisation and utilisation of Resources in the Teaching and learning of science and mathematics in secondary school in cross River State.
[7] Nkopodi Nkopodi and Mogege Mosimege. Incorporating the indigenous game of murabaraba in the learning of mathematics, South African journal of Education 2009, vol 29.
[8] T.Martaida, N.Bukit, and E.M.Ginting," The Effect of discovery learning model on students critical thinking and cognitive ability in junior high school." josr journal of Research and method in Education (JOSR-JRME), vol 7(6) pp. 1-8, 2017)
[9] Thomas A.Romberg and jack shepherd, Mastery learning with sixth- Grade Students." Journal for Research in mathematics Education. Vol 4, no 2 (jan 1973) pp 26-32.
[10] Berding, J.W.A (2000). John Dewey's Participatory Philosophy of Education: Education, experience and Curriculum [online]. Available: http: // www.socsci. Kun.nl/ ped/ whp/hisleduc /misc /deweyol. Html.
[11] Bruner, J.S (1961). "The act of discovery". Harvard educational review 31(1): 21-32.
[12] Cockcroft, W.H. (1982). Mathematics Counts. A report of the committee into the teaching of mathematics in schools, London: Her Majesty's stationary office.
[13] Curriculum Development Centre (CDC.2012) 'O' Level Mathematics (corades 10 to 12) Lusaka CDC.
[14] Dewey, John (1916). Democracy and Education: An introduction to the Philosophy of Education New York: Macmillan. Retrieved 4 may 2016- via internet Archive.
[15] Devos, S., Strydom, H., Fouche C., & Deport, C. (2005). Research at Grassroots for the Social Science and Human Services Professions. 3rd edition, Pretoria: Van Schalk Publisher.
[16] Examinations Council of Zambia (2008), Examiner's Report on 2007 Joint School Certificate and General Certificate of Education Examinations.
[17] Examinations Council of Zambia (2011), Examiner's Report on 2010 Joint School Certificate and General Certificate of Education Examinations.
[18] Examinations Council of Zambia (2012), School Certificate and General Certificate of Examinations Mathematics Examiner's Report: Lusaka.
[19] Examinations council of Zambia (2014), Examiner's Report on Joint School Certificate and General Certificate of Education Examinations.
[20] T.Martaida, N.Bukit and E.M.Ginting( 2017). The Effect of Discovery learning model on students Critical thinking and cognitive ability in junior high school, JOSR journal of research and method in Education (JOSR-JRME),Vol 7(6) pp 1-8.
[21] Mayer, R. (2004). "Should there be a three- strike rule against pure discovery learning? The case for guided methods of instruction". American Psychologist 59 (1): 14-19.