Impact of PBLA in the Instruction of LP in Comparison to the Traditional Methods: A Case Study of Kalonga Secondary School Grade 12 Learners

Teddy Malupande[1], Ellena Kumar[2]

[1]*Kalonga Secondary School, P.O Box 80925, Kabwe – Zambia*

[2]*The Copperbelt University, School of Mathematics and Natural Sciences, P.O. Box 21692, Jumbo Drive, Riverside, Kitwe – Zambia*

Abstract: **- The study was undertaken to explore theImpact of PBL in the Instruction of LPin Comparison to the Traditional Methods. The design used was a Pre-test and Post-test control group Quasi Experimental research design. This study involved two grade12 classes such that one was an experimental group (55 pupils) and the other class was a control group (56 pupils).**

Before the treatment the two groups were given a pre-test in order to establish the equivalence as well as the homogeneity of the two groups and the post-test was used to assess the Impact of PBLA in Learning LP. The experimental group was treated with PBLA and the control group was taught using the traditional or lecture method. An achievement test was employed as the instrument which was given as a pre-test and post-test. A questionnaire was also used to determine the attitudes of the learners of the experimental group towards PBLA.

Data was analyzed using descriptive statistics: frequency, mean, standard deviation and skewness. Furthermore, data was analyzed using inferential statistics with independent sample t-test statistics and Mann -Whitney U test. The results of the study provided overwhelming evidence that the use of PBLA had an impact on learners in learning LP. After the intervention, it was found that there was a statistically significant difference in LP achievement post-test in favor of the experimental group and that gender factor did not affect the performance of students in the achievement of LP post-test. Moreover, the study found that experimental group students' attitude towards learning LP through PBLA improved as well. The researcher concluded that PBLA was an effective Approach for teaching LP.

Keywords: **PBLA is the Problem Based Learning Approach; LP is Linear programming; ECZ is Examination Council of Zambia; MOE is the Ministry of Education and CDC is Curriculum Development Centre.**

I. INTRODUCTION

Mathematics education is an essential part to our lives which we cannot do without. Every child should study Mathematics as it is regarded the mother and bedrock of all sciences, (Cockcroft, 1982). Mathematics helps to develop analytical, logical and critical thinking skills which is useful in all spheres of life. The main goal of mathematics education is to provide the quality education to every learner, and to equip learners with useful knowledge, skills and values (MoE, 1996). Ahmad (2009) said that neglect of Mathematics is an injury to all knowledge since ignorance of it connotes ignorance in a science world.

There have been many concerns for many years about learner's poor performance in Mathematics. According to the highlights of the 2014 Grade 12 Examination Results Statistics, and a report prepared by the Research and Test Development Department (2015), the poor performance on the overall was recorded in Mathematics, which was below 60 percent. It was observed that Mathematics seem to be problematic to many learners either because the subject is difficult or teachers do not teach adequately by using the most effective teaching approaches. One such topic in Mathematics learners face problems is Linear Programming and definitely contributes to poor results.

In its quest to improve the quality of teaching and learning, The Ministry of Education, Science, Vocational Training and Early Education, has over the years been trying to find ways of improving the teaching and learning of Mathematics in Zambian schools. Being concerned with the low academic performance in Mathematics and science subjects altogether, the Zambian government has directed in the revised curriculum and syllabus (MOE 2013) the use of learner centred approaches such as PBL as a way to improve students' performance in Mathematics.

Problem Statement

The study arose as a result of some problems observed, such as the continuous poor performance of students in Mathematics at Kalonga Secondary School. Table 1.0 below shows information from Mathematics department of Kalonga Secondary School in Kabwe District of central Province from 2012 up to 2018 Grade 12 Examination Result Analysis. The result has been below 60% raising a great concern to stakeholders in the MOE.

Table 1.0: Kalonga Secondary School Pass percentage from 2012 to 2018

Year	2012	2013	2014	2015	2016	2017	2018
Pass%	35.3	38.9	52.4	54.3	54.6	53.9	52.8

The poor performance was as a result of improper understanding of concepts by learners which could be attributed to poor approach of teaching Mathematics at Kalonga Secondary school. Ogunkunle (2009) established in his study that school teachers could be ineffective in teaching Mathematics as they apply conventional approach in almost all topics taught including LP. If the teachers do not use effective teaching approaches, learners will develop misconceptions which will lead to poor performance, Evbuomwam (2013). The challenges learners face in Linear Programming was as a result of insufficient learners' involvement and exposure to instructional materials.

The current situation could be improved by the use of PBLA. PBLA is a classroom strategy that organizes Mathematics instruction around problem solving activities and affords learners more opportunities to think critically, present their own creative ideas, and communicate with peers Mathematically (Krulik & Rudnick, 1999). Proponents of PBL believe that when learners develop methods for constructing their own procedures, they are integrating their conceptual knowledge with their procedural skill. Therefore, the study endeavoured to establish the Impact of PBL in learning LPby Grade Twelve Learners of Kalonga Secondary School.

Theoretical Framework

The study made use of constructivism theory of learning, John Dewey's Cognitive theory and Jean Piaget's cognitive learning theory. Constructivists proponents such as J Brunner, (1966) posited that human beings generate knowledge and meaning from interaction between their experience and ideas. Thus, to the constructivists, learning is simply the experience gained by learner's interaction with the environment.

Constructivists see learners as active creators of knowledge. In the constructivist theory, teachers' role is to guide, monitor, coach and facilitate. Hence, learning activities are interactive and student centered. Constructivism theory has direct implications in the use of PBL as a mode of instruction in learning Linear Programming. The use of PBL in teaching creates a continuum for the learners' social life in the classroom while at the same time imparting the desired knowledge.

Another theory is that of John Dewey (1963), who stated that "knowledge emerges only from situations in which learners have to draw them out of meaningful experience". He argued that,"education and learning are social and interactive processes and that the school as a social institution provides an environment in which social reforms should take place". He sees the classroom as a social context where students can take part in manipulating materials and thus form a community of learners who construct their knowledge together. Dewey, advocated placing the learners at the center of the learning process.

Piaget believed that children construct an understanding of the world around them, experience discrepancies between what they already know and what they discover in their environment, and then adjust their ideas accordingly (Baldwin, 2005). Moreover, Piaget claimed that cognitive development is at the center of the human organism, and language is contingent on knowledge and understanding acquired through cognitive development. Child-centered classrooms and open education are direct applications of Piaget's views which are in line with PBL. PBL is a classroom strategy that organizes mathematics instruction around problem solving activities and affords learners more opportunities to think critically, present their own creative ideas, and communicate with peers which is related to the theories discussed above.

Purpose of the Study

The purpose of the study was to investigate theImpact of PBL in the Instruction of LP in Comparison to the Traditional Methods by Grade Twelve (12) students of Kalonga Secondary School in Kabwe District of Central Province.

II. RESEARCH DESIGN AND METHODOLOGY

The study adopted the pre-test post-test randomized group design and questionnaire were used to determine the impact of PBL on students' achievement in LP and their attitudes towards learning Mathematics with this approach. In short, the study employed aquantitative research methodology.

Participants

The participants in this study were purposively selected i.e. two grade 12 classes one being experimental and the other one being a control group. Purposive sampling was opted because both classes happened to be at senior secondary and take Ordinary Mathematics and hence possess the information that was necessary for the study. The two classes consisted of fifty-six (56) in the cont. grp and fifty-five (55) in the Exp. grp bringing the total number of participants to hundred and eleven (111)out of five classes of grade 12 of about three hundred and sixty (360) total population of the grade twelve.

Both groups were given the Pre-Test so as to correct for any possible difference in their ability and knowledge before the intervention, together with the survey of attitude towards the Impact PBLA in learning LP. Following the pre-test, LP was taught to the experimental group using PBLA while the control group was taught using traditional Lecture method. The teaching to both groups was done by the researcher. After the conclusion of the teaching process to both groups, the Post Test was administered of different but equivalent questions was given as post-test. The research design is summarized below in Table 1.1.

Table 1.1: Summary of a research design for the study

Group	LP Pre-tests	Intervention	LP Post-tests
Experimental	LP Pre-Test	Teaching using PBL	LP Post-tests
Control	LP Pre-Test	Teaching with Traditional/Lecture methods	LP Post-tests

Research Instruments/ Tools

The researcher used three research instruments for data collection i.e. LP Pre-Test, LP Post Test and a questionnaire to measure the attitude of students towards PBL as instruments for data collection.

LP Pre-Test

This was a pre-test that consisted five item questions picked from the 2018 paper two grade 12 Final Examination paper based on the revised Mathematics Syllabus and was given to both groups, one being experimental group and the other control group. The test covered areas of knowledge, comprehension and application levels.

LP Post -Test

This was a post-test that consisted of different but equivalent questions and was picked from 2017 past paper two grade 12 Final Examination. The test covered areas of knowledge, comprehension and application levels. This same test was given to both groups, one being experimental group and the other control group after teaching the experimental group using PBLA and the control group using traditional lecture method.

Survey of attitude toward PBL

Survey of attitudes towards teaching and Learning of LP was a measurement tool that was used to examine the attitudes of Learners towards the PBL approach.

Limitations of the Study

The first limitation of the study was that being a case study the research was only conducted at Kalonga Secondary School and therefore, the results of the study could not be generalised to other schools. The time framework for data collection was also another limiting factor the researcher had no control of and so data had to be collected within the stipulated time frame.

Data Analysis Procedures

First, data was explored and analysed in terms of group statistics, normality, Mann-Whitney U test and independent t tests by using the statistics software SPSS version 20.0. Normality of the data was tested using Kolmogorov test of normality in terms of the histograms and q-q normality plots. Quantitive statistics were used to analyse the data in order to have a better understanding of how the participants performed in both LP Pre-Test and LPPost-Test.

The Mann-Whitney U test was conducted for LP Pre-Test while independent t-tests for LP Post-Test scores for both groups.

In order to determine whether there was a statistically significant Impact of the intervention on the students' achievement in learning Linear Programming with PBL, independent samples t-tests was conducted for LP post-test scores to find the size of the impact for control and experimental groups

III. DATA PRESENTATION, INTERPRETATION AND ANALYSIS

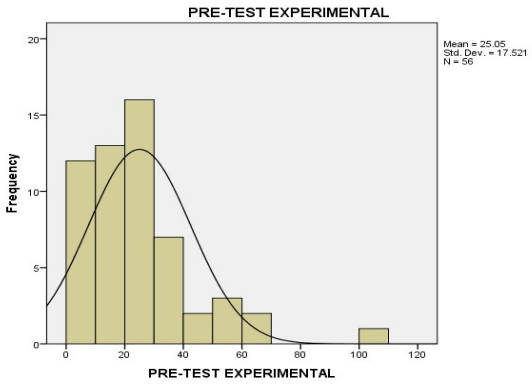
The same LP pre-test was given to both groups to determine their achievement and equivalence in intellectual abilities. The LP pre-test was undertaken to confirm the status quo of the participants both in the experimental and control groups in terms of how much knowledge they had about LP to ascertain whether they had the same intellectual abilities before the intervention was done. The results of the group statistics and subsequent t test to determine theImpact of PBLA in Learning LP, independent samples t-test statistics conducted for both LP Pre-Test scores and LP Post-Test scores are given below

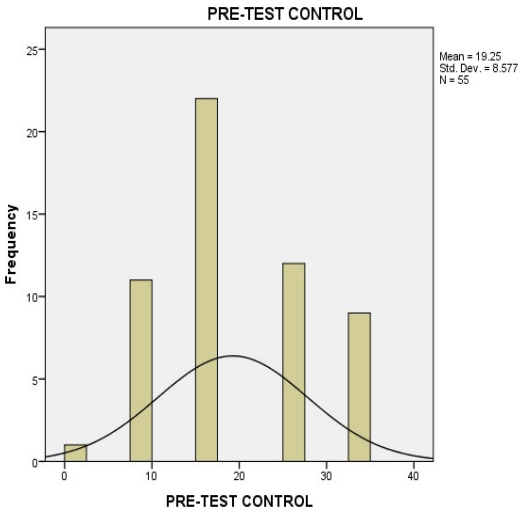
Table 1.2: Achievement of students in LP Pre-Test

	Group	*N*	*Mean Score%*	*Std. Deviation*
LP Pre-Test	Experimental	55	25.05	17.521
	Control	56	19.25	8.577
	Total	111		

In Table 1.2 above, the mean achievement of students in the experimental group in LP Pre-Test was 25.05% whereas the mean achievement of the students in the control group was 19.25%. Table 1.2 also indicated that the mean achievement of all students was 22.15%. The lowest mark in the control group was 0 % and the highest mark was 33% obtained by nine candidates. In the experimental group the lowest mark was 0% and the highest mark was 100% obtained by one participant. The standard deviation in table 1.2 in the experimental group was 17.521 and the standard deviation in the pre-test control group was 8.577.

Histogram 2.0 graphs showing pre-test score

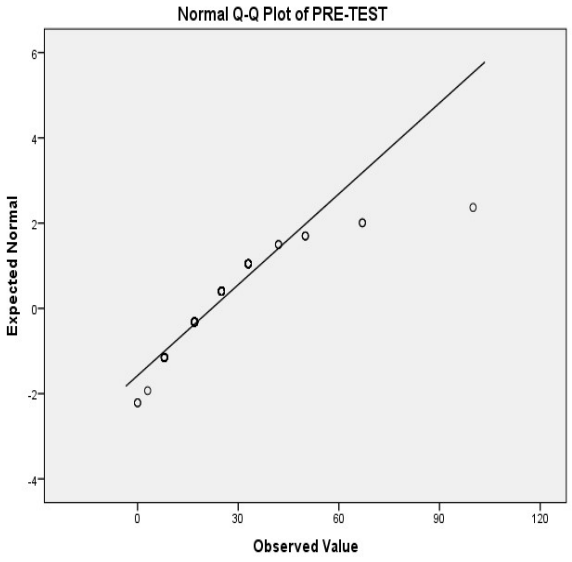


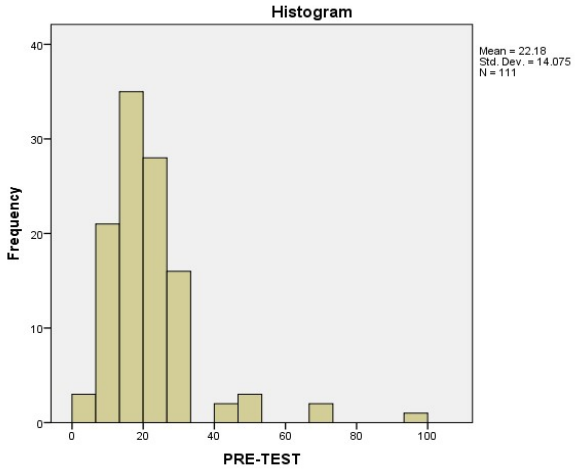


From the Histograms 2.0 with the Normal curves above the experimental group is skewed towards the right and the control group is close to normality. This clearly shows that more students scored below the mean in the experimental group whereas students in the control group scored uniformly around the mean score

A normality test with Kolmogorov was done and the results were displayed in the histogram as well as q-q plots as shown in the diagram 1.1(c) below. The results showed that the data for LP Pre-Test for both groups were not normally distributed as the dots are not close to the line and the histogram showed that the scores for LP Pre-Test for both groups were not normally distributed.

Diagram 2.1: Test for Normality





So, the researcher used the Mann-Whiney U test and the results were as follows:

Pre-test Scores Analysis using Mann Whitney U test

Pretest

Mann-Whitney U=51.69, N(exp)=56, N(cont.) =55 and P-value(2-tailed) =0.129

p =.129, which is greater than α-level at 0.05, Since p>α, (.129> 0.05) it indicates that the difference in mean scores were not statistically significant. This result illustrated that both students in the control and experimental group were similar in their intellectual abilities before the treatment was administered.

According to this finding, the researcher failed to reject the null hypothesis and concluded that there was no statistically significant difference between the experimental and control groups in the LP Pre-Test scores on average.

Post test result analysis

Independent Samples t- test was conducted to ascertain if there was a significant difference in the mean test scores between the students who were taught using PBLA and the students who were taught by traditional Lecture Method. Group statistics comparing scores achieved by learners in the experimental group using PBLA and traditional Lecture method scores were conducted and are presented in Table 1.3.

Table 1.3: Achievement of students in LP Post-Test

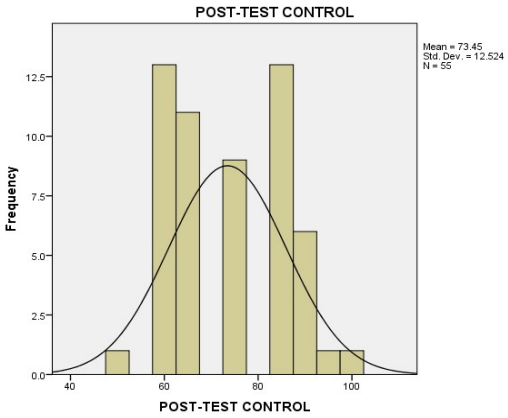
	Group	*N*	*Mean Score%*	*SD*
	Experimental	55	85.23	16.047
LP Post-Test	Control	56	73.13	12.716
	Total	111	79.18	

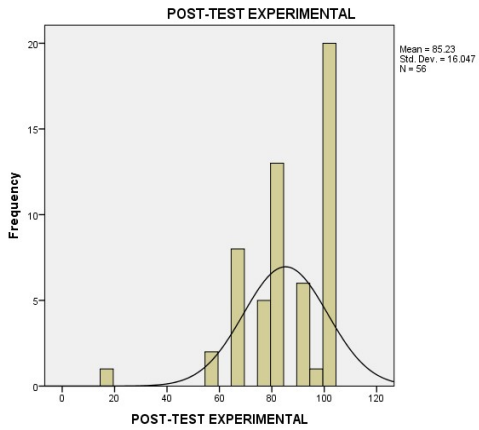
Table 1.4: Post-test scores Analysis using t - test

	Levene's Test for Equality of Var.		t-test for Equality of Means						
	F	Sig.	t	Df	Sig.(2-tailed)	Mean Diff.	Std. Error Diff.	95% Conf. Interval of the Diff.	
								Lower	Upper
Equal Var. assumed	.17	.368	-4.400	109	.000	-12.105	2.751	-17.558	-6.652

From the Histograms with the Normal curves below the experimental group is skewed towards the left and the control group is close to normality. This clearly shows that more students scored above the mean in the experimental group whereas students in the control group scored uniformly around the mean score.

Diagram 2.2: Histograms with normal curve graphs showing post-test scores





In Table 1.3 shows that there was a statistically significant difference between the experimental and control group with respect to the LP Post -Test scores on average. The mean achievement of students in the experimental group was 85.23% while the mean achievement of students in the control group was 73.13%. Also, Table 1.3 shows that the mean achievement of all students was 79.18%. The lowest mark in the control group was 50% obtained by one candidate and the highest mark was 100% obtained by one candidate. In the experimental group the lowest mark was 17% obtained by one candidate and the highest mark was 100% obtained by twenty students. The standard deviation in table 1.3 in the experimental group post-test was 16.047 and the standard deviation in the post-test control group was 12.716.

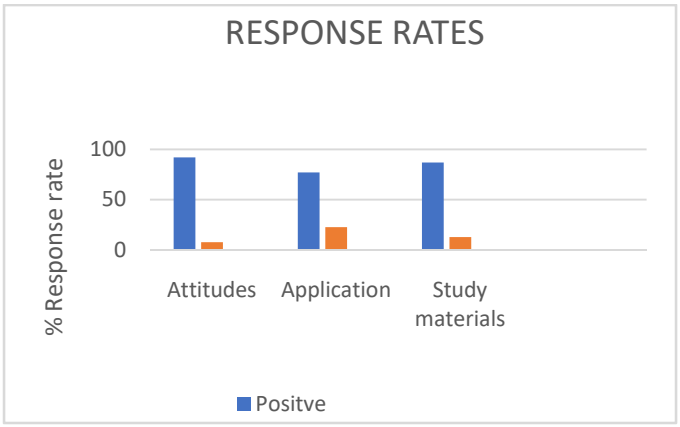
Diagram 1.3 shows that there was a statistically significant difference between the experimental and the control group with respect to the LP Post-Test scores on averageat $\alpha = 0.05$ level, $t = -4.40$, $p = .000$ which is less than $\alpha = 0.05$ ($p < 0.05$), indicating that the difference in the mean score of the two groups was statistically significant.

According to these findings, the researcher rejected the null hypothesis in favor of the alternative hypothesis and concluded that there was a statistically significant difference between the groups in LP Post-Test in favor of the Experimental Group. Thus, it was found that the students in the experimental group had a better achievement in LP post-test at the end of the intervention.

From the above it can be observed that students performed better in LP Post -Test than in LP Pre-Test and students in the experimental group performed much better than students in the control group. This was as expected because students in the control group were not exposed to PBLA but were taught using the traditional lecture method whereas students in the experimental group were taught using PBLA. The researcher therefore, concluded that there was a statistically significant difference between the groups in LP Post-Test in favor of the Experimental Group. In short Students in the experimental group had a better achievement in LP post-test scores after the intervention.

Summary of Students Response Rates from the Questionnaire

Figure 2.3: Summary of attitudes



Response rates from the questionnaire for the learners' attitudes towards the teaching and learning approach was that 92% of the experimental group said they had positive attitude where as 8% had a negative attitude.77% realized the application of LP in real life and 23% were still skeptical and 87% realized that there is a positive relationship between study materials and achievement in LP and 13% were still skeptical.

Correlation Matrix

Correlation analysis was used to determine the strength and direction of the relationship between the variables in the study. A look at the correlation matrix for the four variables (attitudes towards linear programming, Application of Linear programming to real life, Qualified Math Teachers and Availability of study materials) in relation to the dependent variable is indicated in Figure2.3 below.

Figure 2.3: Correlation Matrix

		Attitude of learners towards learning LP	Application of LP to real life	Qualified mathematics teachers	Adequate study materials
Attitude of learners towards learning LP	Pearson Correlation	1	0.12	0.412	-.102
	Sig.(2 tailed)		.954	.041	.629
	N	92	92	92	92
Application of LP to real life	Pearson Correlation	0.12	1	-0.355	0.300
	Sig.(2 tailed)	.954		0.081	.145
	N	92	92	92	92
Qualified mathematics teachers.	Pearson Correlation	0.412	-0.355	1	-0.119
	Sig.(2 tailed)	.041	0.081		.571
	N	92	92	92	92
Adequate study materials	Pearson Correlation	-.102	0.300	-0.119	1
	Sig.(2 tailed)	.629	.145	.571	
N		92	92	92	92

Figure 2.3:indicates that, there was a moderate relationship between attitude of learners in the experimental group towards linear programming and application of Linear Programming to real life (r=0.12> 0.05,p=0.954> 0.05. The table also indicates that, there was a moderate relationship between having qualified mathematics teachers and adequate study materials for the learners (r=0.412, p=0.041).

IV. DISCUSSION OF THE STUDY FINDINGS

The main objective was to compare the performance of students in the experimental and control groups in LP Pre-Test and LP Post-Test. The findings of the study in summary are that students performed better in LP Post -Test than in LP Pre-Test and that students in the experimental group performed much better than students in the control group on average in terms of scores and attitudes. When independent samples t-test statistics was conducted for LP Post-Test, there was a statistically significant difference between experimental group and control group in favour of the experimental group. This means that after teaching LP using PBLA to the experimental group, students understood the concept much better than those learners in the control group who were taught by the traditional/lecture method.

In the pre-test most learners both in the experimental and control groups had challenges in answering test item questions as compared to the post test results after the administration of the interventions. When independent samples t-test statistics was conducted for LP Pre-test there was not a statistically significant difference between experimental group and control group ($p=0.129 > 0.05$). However, there was a tremendous improvement in scores in the LP Post-Test among students in the experimental group of this study indicating that there was a statistically significance difference in the performance between the two groups as $p=.000 < 0.05$. This simply shows that PBLA has an impact in the learning of LP.

For example, students in the experimental group worked in groups to come up with inequalities representing the conditions, they were able todraw x and y axes for the given ranges and also shade the unwanted region to indicate clearly

the region where (x, y) the wanted region must lie**.** Students were able to make interpretations and answer the questions by working together in groups and with guidance from the teacher and other peer students with better dexterity and acumen in the topic. PBLA affords learners more opportunities to think critically, present their own creative ideas, and communicate with peers Mathematically (Krulik & Rudnick, 1999).

Mathematics demands creativity, collaboration and discussions more than memorization, drills and just hurrying to get the right answers (Martin ,2006). Proponents of PBL believe that when learners develop methods for constructing their own procedures, they are integrating their conceptual knowledge with their procedural skill. Additionally, the teacher and more competent students also played a part in helping and guiding other learners.

Students in the experimental group outperformed those in the control group on average in terms of achievement scores in LP post-test.

V. CONCLUSION AND RECOMMENDATIONS

The main purpose of this study was to evaluate theImpact of PBL in the Instruction of LP in Comparison to the Traditional method. The experimental group on which PBLA was used appreciated it well. It was also revealed that the use of this pedagogy as a classroom instruction significantly improved the performance of the achievement results of the LP post-test for the experimental group on which PBL was used.

Students in the experimental group who were taught by PBLA performed better than those students in the control group who were taught by traditional lecture method. It can be concluded therefore, that PBLA had an impact in Learning LP. There was no significant difference between students in scores for LP pre-test in the experimental group and the control group.

However, students in the experimental group performed better than those in the control group on average in terms of their achievement in the post-testscores as well as in attitude towards learning LP. This is because PBLA facilitated learning and students found learning LP to be easy and straight forward. Furthermore, it can be concluded that PBLA enhances better understanding and easy grasping of concepts with reduced difficulties.

The results of this study showed that PBLA had significant effects on student's positive achievement and attitude towards learning LP. Students were active throughout the lesson time because of the way the lesson was organised

Based on the above discussion of the results obtained, the researcher makes the following conclusions to the study:

1. That using the PBLA to LP involves the learners and therefore makes the topic easier to understand. Learners are able to express their views and experiment using different concepts unlike in the traditional approach which is teacher centered.
2. That the lecture method of teaching LP do not help the learners in the understanding of the topic and its concepts. Because of this, both the students and teacher were quick to point out that lecture methods should not be used to teach other topics in mathematics because it does not involve the learners.
3. PBLA makes the learning of LP a lot more meaningful and relevant asit encourages thought processes, problem solving skills and decision making in the classroom. The attitude of learners in the experimental group towards LP improved and their interest was stimulated when LP was taught using PBLA.

Recommendations

Based on the above conclusions, the researcher recommends the following:

- That the PBLA to LP involves the learners and therefore makes the topic easier to understand. Hence PBLA should be implemented as an approach to teaching the topic LP and perhaps other topics in Mathematics.
- That deliberate policies should be put in place by the MOE to ensure that Problem-Based Learning Approach is adopted to teach Mathematics.

Recommendation for further research studies

Looking at the findings of this study, the researcher made the following recommendation for further research studies:

The study restricted itself to use of PBLA in the instruction of LP as compared to the traditional method, there is need for further studies to be done to ascertain whether PBLA will be effective in other topics of Mathematics.

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APPENDICES

APPENDIX 1

LP Pre-test

The following pre-test was aimed at obtaining information about how much knowledge the learners had on LP before exposing them to the intervention with traditional lecture method of teaching.

Answer the whole of this question on a sheet of plain paper.

A tailor at a certain market intends to make dresses and suits for sale.

(a) **Let x represent the number of and y the number of suits. Write the inequalities which represent each of the following conditions below.**

(i) **The number of dresses should not exceed 50** **(1)**

(ii) **The number of dresses should not be less than the number of suits** **(1)**

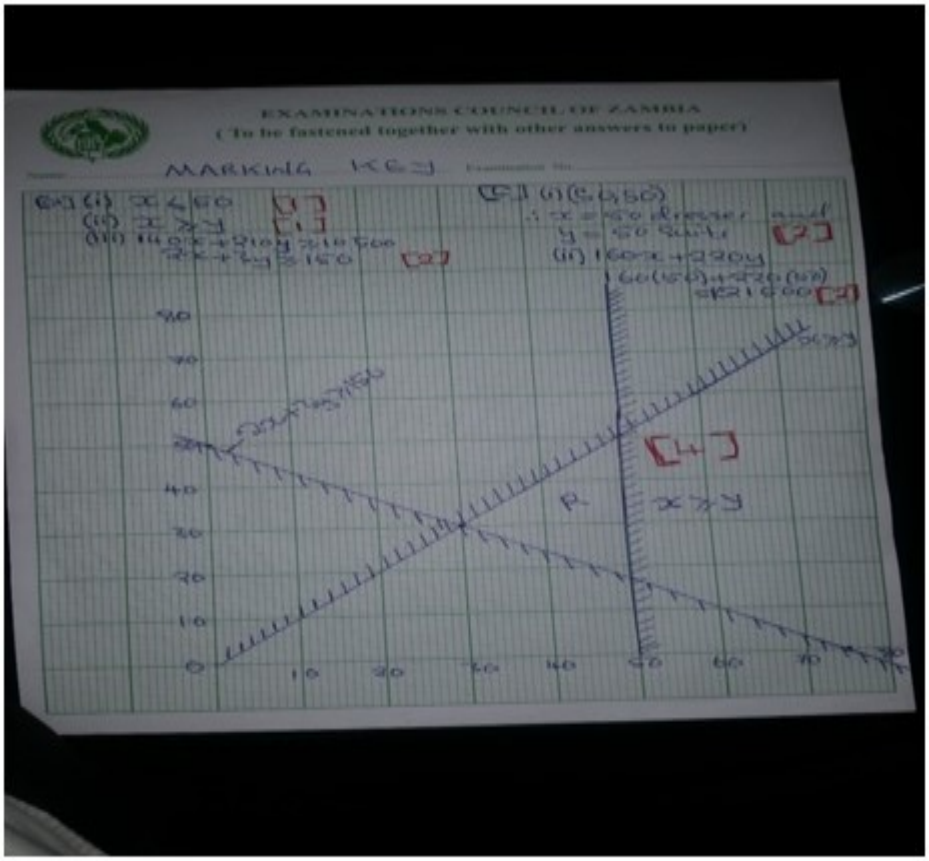
(iii) **The cost of making a dress is K140.00 and that of a suit is K210.00. The total cost should be at least K10 500.00** **(2)**

(b) **Using a scale of 2cm to represent 10 units on both axes, draw x and y axes for $0 \leq x \leq 60$ and $0 \leq y \leq 80$. Shade the unwanted region to indicate clearly the region where (x, y) must lie.** **(4)**

(c) **(i) Th profit on a dress is K160.00 and on a suit is K270.00. Find the number of dresses and suits the tailor must make for maximum profit** **(2)**

(ii) calculate the maximum profit **(2)**

APPENDIX 2



APPENDIX 3

Answer the whole of this question on a sheet of plain paper.

Himakwebo orders maize and ground nuts for sale. The order price of a bag of maize is K75.00 and that of a bag of groundnuts is K150.00. He is prepared to spend up to K7,500.00 altogether. He does not want to order more than 70 bags altogether.

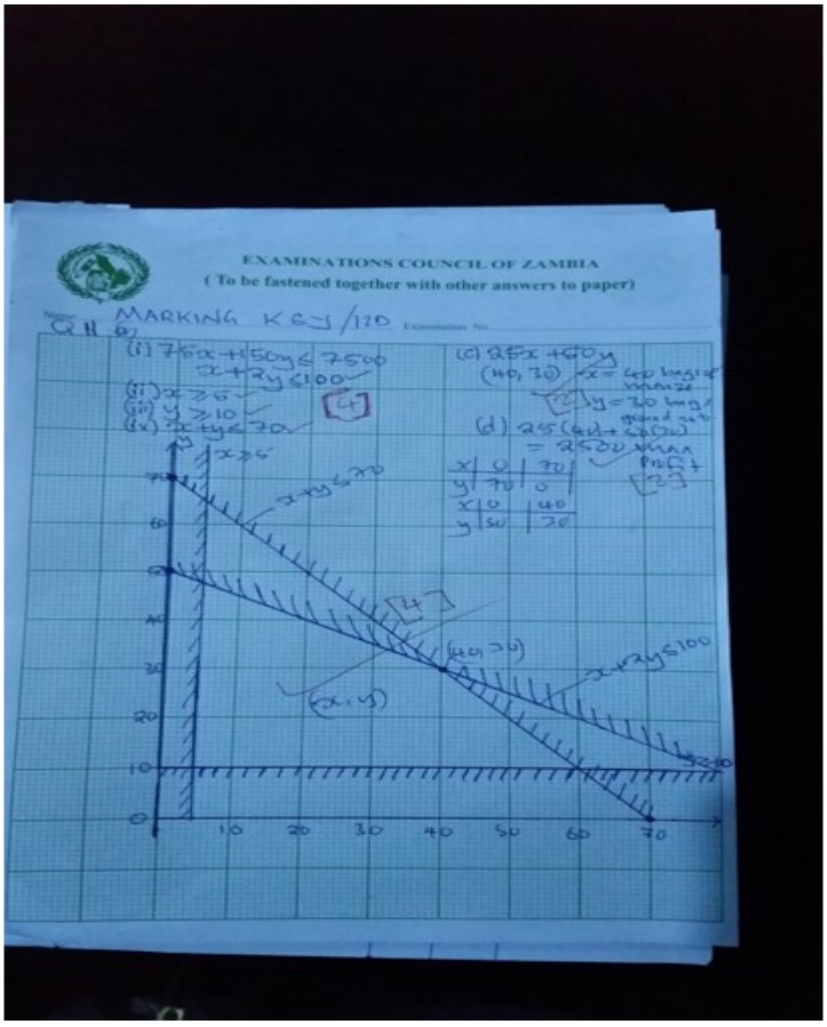
(a) If x and y are the number of bags of maize and groundnuts respectively, write four inequalities which represent this these conditions. (4)

(b) Using a scale of 2cm to represent 10 bags of maize on each axis, draw x and y axes for $0 \leq x \leq 70$ and $0 \leq y \leq 70$ respectively and shade the unwanted region to show clearly the region where the solution of the inequalities lie (4)

(c) Given that the profit on a bag of maize is K25.00 and on a bag of groundnuts is K50.00, how many bags of each type should he order to have maximum profit? (2)

(d) What is this estimate of the maximum profit? (2)

APPENDIX 4



APPENDIX 5

SURVEY OF ATTITUDE

THE COPPERBELT UNIVERSITY

SCHOOL OF GRADUATE STUDIES

Dear respondent,

Re: Impact of Problem-Based Learning Approach in Learning Linear Programming by Grade Twelve Learners.

I am a postgraduate student at the Copperbelt University pursuing a degree in Master of Science in Mathematics Education and due for graduation in 2019. As part of the fulfilment of the award of Master's degree, it is required that one undertakes a research project in the field of study.

Therefore, you have been identified as a respondent to this study to help and offer data that is relevant to this study for the success of my report. Please answer questions administered to you in a very honest manner. The information being collected shall be used purely for academic purposes and shall be treated in a very strict and confidential manner. Your identity can not be disclosed if you wish so throughout the interview.

Your cooperation in this regard will be highly appreciated.

Yours faithfully,

A: PERSONALDETAILS

Please, circle ○ your response.

1. Gender:
   Male
   Female

2. Age:
   14 – 17
   18 – 21
   22 and above

B: ATTITUDES TOWARDS THE TEACHING AND LEARNING APPROACH

In this section, please express what you feel about the approach used when teaching linear programming. Indicate your choice by circling ○ the number: 1 = Strongly Disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); 5 = Strongly Agree (SA).

Example

Girls like mathematics more than boys do.

If your answer is strongly agreed, put a circle as shown below:

STATEMENT	SA	A	N	D	SD
Girls like mathematics more than boys do.	5	4	3	2	1

S/NO.	STATEMENT	SA	A	N	D	SD
1.	The approach used to teach linear programming concepts enhanced my interest in the topic.	5	4	3	2	1
2.	The steps involved in the teaching approach can help in understanding linear programming	5	4	3	2	1
3.	The approach used in teaching linear programming should not be used to teach other topics in mathematics.	5	4	3	2	1
4.	The approach used actively involved the learners in learning the course.	5	4	3	2	1
5.	The approach used made it easier for me to understand linear programming.	5	4	3	2	1
6.	The approach used to teach linear programming creates interest in the topic.	5	4	3	2	1
7.	The steps involved in the teaching approach helped me in understanding linear programming.	5	4	3	2	1
8.	The approach used made it easy to understand difficult concepts in linear programming.	5	4	3	2	1
9.	The technique used in teaching linear programming helped to grasp the concept.	5	4	3	2	1
10.	The teaching approach used in teaching linear programming should be used to teach other topics in mathematics.	5	4	3	2	1

C: ATTITUDES TOWARDS THE TOPIC LINEAR PROGRAMMING

In this section I want to know what you feel about the topic and ideas on linear programming, indicate your answers by circling using the following key: 1 = Strongly Disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); 5 = Strongly Agree (SA).

S/NO.	STATEMENT	SA	A	N	D	SD
11.	It is easy for me to draw graphs of linear equations and inequations in one variable.	5	4	3	2	1
12.	Drawing graphs of linear equations and inequations in two variables is confusing.	5	4	3	2	1
13.	Shading the unwanted regions is interesting.	5	4	3	2	1
14.	Describing the unwanted regions is confusing.	5	4	3	2	1
15.	Determining the maximum and minimum values is easy.	5	4	3	2	1
16.	Using the searching method to determine the maximum and minimum values i.e. profit/loss is easy.	5	4	3	2	1
17.	Learning linear programming should be given more time because I have enjoyed it.	5	4	3	2	1
18.	Formulating the inequalities from given conditions is not difficulty.	5	4	3	2	1
19.	Formulating the inequalities from given conditions is difficulty	5	4	3	2	1
20.	Finding the wanted region is interesting.	5	4	3	2	1
21.	Learning linear programming should not be given more time because I have not enjoyed it.	5	4	3	2	1

D: APPLICATION OF LINEAR PROGRAMMING IN REAL LIFE.

This section explores your feelings towards linear programming in real life. Indicate your answers by circling◯ using the following key: 1 = Strongly Disagree(SD); 2 = Disagree(D); 3 = Neutral(N); 4 = Agree(A); 5 = Strongly Agree(SA).

S/NO.	STATEMENT	SA	A	N	D	SD
22.	Working with real life situations makes me enjoy the lesson on linear programming.	5	4	3	2	1
23.	There are careers in the society that need knowledge on linear programming.	5	4	3	2	1
24.	I have realised that linear programming concepts are useful in real life situations.	5	4	3	2	1
25.	Mathematical models are very important to planners.	5	4	3	2	1
26.	The linear programming subject is connected to real life situation.	5	4	3	2	1
27.	I have not realised that linear programming concepts are useful in real life situations.	5	4	3	2	1
28.	There are no careers in society that need knowledge in linear programming.	5	4	3	2	1
29.	Mathematical models are not important to planners.	5	4	3	2	1
30.	Working with real life situations make me like the lessons on linear programming.	5	4	3	2	1
31.	Other mathematics topics should be connected to real life situations.	5	4	3	2	1

E. ADEQUATE STUDY MATERIALS

In this section I want to know what you feel about the availability of study materials in the teaching and learning of Linear Programming by circling◯ using the following key: 1 = Strongly Disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); 5 = Strongly Agree (SA).

S/NO.	STATEMENT	SA	A	N	D	SD
32	Adequate study materials is important in learning LP	5	4	3	2	1
33.	Adequate study materials is not important in learning LP	5	4	3	2	1
34.	Availability of study materials helped in learning about shading the unwanted regions.	5	4	3	2	1
35.	Availability of study materials did not help in learning about shading the unwanted regions.	5	4	3	2	1
36.	With adequate study materials learning about formulating the inequalities from given conditions was not difficulty.	5	4	3	2	1
37.	Learning linear programming with availability of study materials was easy	5	4	3	2	1

F: YOUR COMMENTS ABOUT THE TEACHING AND LEARNING APPROACH.

Is there anything you would like to say about the teaching and learning of the topic linear programming and the way it was taught?

.....
.....

APEENDIX 6

EXPERIMENTAL GROUP ARCHIEVEMENT TEST RESULTS

S/No	SEX	PRE-TEST	POST-TEST
1	F	25	58
2	M	8	67
3	F	33	100
4	F	25	100
5	F	8	100
6	M	17	75
7	M	25	100
8	F	25	83
9	M	25	100
10	F	17	67
11	M	17	67
12	M	25	100
13	M	8	75
14	M	25	67
15	M	25	83
16	M	8	92
17	M	67	100
18	M	8	75
19	M	42	92
20	M	25	67
21	M	67	100
22	M	3	100
23	M	50	67
24	M	8	83
25	F	17	100
26	M	17	83
27	M	100	100
28	M	42	100
29	M	50	100
30	M	33	100
31	F	8	58
32	M	25	100
33	M	25	83
34	F	0	17
35	M	17	67
36	M	33	83
37	F	8	75
38	M	17	93
39	M	25	100
40	M	50	100

41	F	33	93
42	F	17	100
43	F	33	92
44	F	33	93
45	F	17	83
46	M	17	100
47	F	17	100
48	M	8	83
49	M	25	83
50	M	25	95
51	M	17	83
52	M	25	83
53	F	25	83
54	M	17	75
55	F	8	67
56	M	33	83

APPENDIX 7

CONTROL GROUP ARCHIEVEMENT TEST RESULTS

S/NO	SEX	PRE-TEST	POST -TEST
1	F	25	75
2	M	33	83
3	M	25	67
4	M	33	83
5	M	17	75
6	M	17	67
7	M	8	58
8	M	17	67
9	F	17	58
10	M	17	58
11	F	17	83
12	F	17	92
13	M	25	83
14	M	25	58
15	M	17	100
16	M	33	92
17	M	25	83
18	F	8	75

19	F	33	75
20	M	25	83
21	M	17	67
22	M	8	75
23	M	17	83
24	M	25	67
25	M	17	58
26	F	33	75
27	F	17	92
28	F	8	58
29	F	25	93
30	F	17	67
31	M	33	83
32	M	25	58
33	M	17	67
34	F	8	58
35	F	17	58
36	F	17	67
37	M	17	58
38	M	33	92
39	M	25	83
40	M	25	75
41	M	8	58
42	M	17	67
43	M	8	58
44	M	8	67
45	M	8	92
46	F	17	58
47	M	17	75
48	F	8	75
49	M	17	83
50	F	8	67
51	M	33	83
52	M	17	83
53	F	33	92
54	M	0	50
55	M	25	83

APPENDIX 8

THE COPPERBELT UNIVERSITY
SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

P.O. BOX 21692, Jumbo Drive, Riverside
KITWE – ZAMBIA

Tel/Fax: +260-212-228214

29th June, 2017

KALONGA SECONDARY SCHOOL
P.O Box 80925
KABWE.

Dear Sir/Madam,

REF: INTRODUCTORY LETTER: TEDDY MALUPANDE

This letter serves to introduce **TEDDY MALUPANDE** to you. Mr. MALUPANDE is a full-time student at The Copperbelt University, CBU, pursuing a Master's degree in Mathematics Education. He is in the second year of his studies. It is a requirement by the institution that in second year, students conduct an educational research as a partial fulfilment for the requirement for the award of the masters' degree. Mr. MALUPANDE would like to collect data for his research at your institution. His study has been approved by his supervisor. As such, I am writing to you requesting that you give him any necessary help he may need.

I look forward to your favourable response.

Yours sincerely,

Asiana Banda, PhD
Postgraduate Studies Coordinator

School of Mathematics and Natural Sciences

THE END!!!