Investigating the Impact of Problem Based Learning Method on Pupils' Performance in Permutation and Combination: A Case of Dominican Convent Secondary School in Ndola District

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Abstract
The aim of this study was to investigate the impact of Problem Based Learning teaching method on pupils' performance in permutation and combination. The study also investigated the influence of Problem Based Learning method (PBL) on attitude of learners. The study was conducted in Ndola district on the Copperbelt province of Zambia with a four-week intervention program at Dominican Convent Secondary school. Participants consisted of 69 Grade 11 Additional Mathematics learners. A quasi experimental design consisting of a pre-test and post-test measure was employed. A pre-test and post-test was given before and after the intervention respectively to ascertain change in participants' performance in Permutation and Combination over a four-week intervention period in comparison to those who were exposed to conventional methods of teaching. An independent samples t-test was conducted to analyse the results of the pre-test and post-test scores. Results indicated that was a statistically significant difference ($p<0.05$) in the post-test scores for control with average of 55.47%, and experimental with average of 69.14%. It was therefore concluded that PBL had a significant influence on improvement in learner academic performance and their attitude in the mathematics subject.

Keywords: Problem Based Learning, performance, permutation and combination, attitude

1. INTRODUCTION

Mathematics has been recognized as an important area of learning aimed at driving economy and technological transformation of any society. Therefore, the promotion of the subject is of paramount importance to the development of human kind. Mathematics is an embodiment of knowledge, skills and procedures that can be used in a variety of ways, [1]. [1] pointed out that, mathematics can be used to describe, illustrate and interpret, predict, explain patterns and relationships in numbers in order to convey and clarify meaning of various issues in life.

However, in schools' advancement in teaching mathematical concepts, they faced with the challenge of poor performance [11]. Despite the important role that Mathematics plays in society, there has always been the challenge of performance in the subject. This calls for urgent need to address the problem in schools. Various studies and reports have identified some of the causes that influence the teaching and learning of Mathematics. Some of the factors brought out include teaching methods and approaches, lack of teaching aids and learner perception towards the subject. [27]), added that the learners' performance in certain subjects depends on their attitude towards the subject. Positive attitude towards the subjects would encourage a person to learn the subject much better. In a study conducted by [21], have found that the interest has a positive influence on students' performance in Mathematics. On the other hand, Permutation and Combination (PnC) is considered to be one of the challenging topics in additional mathematics (ADDMA), [18]. Such perceptions have led to negative attitudes towards mathematics hence result in poor performance in the subject.

According to Examinations Council of Zambia (ECZ) performance reports, the general performance in ADDMA has had a low mean performance. The years 2014, 2015, 2016 and 2017 had a mean percentage of 43.6% ,47.4%,50.14%,49.94% respectively. The chief examiner highlighted that the performance in ADDMA is still poor considering the quality of candidates that take the subject. Another highlight was that the performance in combination in paper 2 was poor despite recording better performance in the same paper.

[6] added that, in understanding permutation and combination, pupils need real-world problems in the form of more relevant one to stimulate learning and retaining knowledge. However, In the modern era the teaching and learning of Mathematics has been considered to be largely teacher-centered [24]. On the contrary, the postmodern era has brought with it alternative ways of teaching and learning Mathematics that are learner-centered [24]. According to [17], Froebel developed a teaching method that recognized child's play as one of the main ways that facilitates learner centered lessons. Since mathematics is an abstract subject, it may be learnt through similar principles of play and interaction with the pupils around.

It is for this reason that this research uses Problem-Based Learning (PBL) method to help in improve pupils' performance in ADDMA. According to [23], PBL is a learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem.

[17] added that Problem-based learning as a pedagogical approach has been used successfully over the years and continues to gain acceptance in multiple disciplines. For example, Socrates presented pupils with problems that through questioning enabled him to help them explore their assumptions, values and understanding. In more modern times PBL as a general model, was developed in medical education in the early 1970s and since that time it has been refined and implemented in many different educational contexts [5].

[8] have summarized the methods used in PBL and the specific skills developed, and these include the ability to think critically, analyze and solve complex, real-world problems, to find, evaluate, and use appropriate learning resources; to work cooperatively, to demonstrate effective communication skills, and to use content knowledge and intellectual skills to become self-directed learners.

1. 1 PROBLEM STATEMENT

In many Zambian schools, many pupils taking the subject Additional Mathematics (ADDMA) are struggling to understand the topic of permutation and combination due to the fact that there is little or no teaching and learning strategies that is best for the learners' understanding. Examination Council of Zambia (2017) reports that, the general performance in ADDMA has been low from 2014 to 2017 despite the quality of candidates that take the subject.

Many Pupils are not performing as expected in Additional Mathematics despite the programs provided for mathematics teachers to improve and raise the status of the teaching profession, such as the continuing professional developments(CPDs) and the benefits of problem based learning in teaching and learning, its use in Zambia has not been fully explored.

The other area is that, learners fail to distinguish between Permutation and Combination when given a question (Chief Examiner's Report, 2014). Subsequently, there would be need to carry out the study on the teaching and learning of PnC using Problem-Based Learning (PBL). This study attempt to use PBL improve academic performance in grade 11 pupils of Dominican convent secondary school of Ndola district.

1.2 SIGNIFICANCE OF THE STUDY

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.This study would serve as a reference point for teachers, teacher educators, education administrators, curriculum developers, policy makers and other stakeholders who may find this information relevant. It would help in adding to the effective teaching strategies to improve the pupil academic performance.

1.3 RESEARCH QUESTIONS

This study sought to address the following research questions:

1. What is the impact of using problem based learning method on learners' performance in permutation and combination?
2. What is the effect of using Problem Based Learning on learners's attitude towards mathematics?
3. What are the challenges faced by pupils in the learning of permutation and combination using problem based learning method?

2. LITERATURE REVIEW

Problem based learning originated in the 1960s at McMaster University Medical School in response to low enrollment, general student dissatisfaction with the educational experience and improve their clinical reasoning and problem-solving skills [5]. It is now used in many disciplines and educational contexts [22] & [8]; [25], even with some success as a practical

strategy in K12 education [15]. Over the years, institutions have implemented PBL in various ways, altering the approach to meet their own particular needs in terms of delivery method or general educational approach [27]PBL is most generally known as a learner centered approach to learning that originates with an authentic and ill-structured problem [5].

Problem-based learning (PBL) is a method of learning or teaching that encourages learners to apply problem solving, critical thinking and life-long learning skills to address real-world problems [4] & [6]. This pedagogy differs from the traditional lecture-based approach, where teachers primarily provide learners with information. On the other hand, problem-based learning to mathematics teaching and learning is based on the approach in which the teacher "expects learners to solve problems or make sense of mathematical situations for which no well-defined procedures exist" [13]. This entails part of the shift from the teaching paradigm to the learning paradigm [5]. The focus is on what learners are learning rather than what the teacher is teaching [1]. Problem based learning begins with the presentation of an ill structured problem to be solved that has potentially multiple solutions. Teachers act as facilitators throughout the process, guiding learners with meta-cognitive questions, and learners actively construct knowledge by defining learning goals, seeking information to build upon prior knowledge, reflecting on the learning process, and participating in active group collaboration [5]. He further stated that the teaching of problem solving falls under group work which tasks a team of learners to work together and work out an assignment outside the classroom environment. Such a task takes days to be accomplished and every participant has a role to play. Additionally, Problem based learning refers to "methods that provide learners with realistic problems that do not necessarily have "right" answers." [26]. This approach requires that learners are faced with real life mathematics problems to process.

2.1 Studies on Problem Based Learning

A study was conducted by [25] on a topic entitled 'problem- based learning in mathematics topics in Alexandria. The sample size of 20 consisted of primary school going children from about grade five to seven was used. The findings pointed out a number of obstacles to effective problem based activities teaching in Egyptians mathematics classes. They cited obstacles like teachers not considering learners to be able to apply mathematics to real life situations effectively, because they were not given enough time to practice. The findings also showed that learners could not fully explain simple mathematical procedures to solve problems and also could not fluently put across their thought. In other words, they could not solve their problems using mathematics through formal interaction in their community and school life. These obstacles can be genuinely attributed to the sample chosen for the study, primary school going pupils. However, this study took a different sample which involved high school learners, the grade 11 pupils in secondary school of Ndola District. Subsequently, the research by [25] had helped draw valid conclusions regarding the usage of problem based learning techniques in the teaching of ADDMA in senior secondary school of Ndola District.

Another researchers [18], have investigated learners' mathematical thinking when solving problems. They indicated that the learners could explore problem situations and 'invent' ways to solve the problems. They also found that those learners who made use of invented strategies before they learned standard algorithms demonstrated better knowledge of base-ten number concepts and were more successful in extending their knowledge to new situations than those learners who initially learned standard algorithms.

[19] also stressed that invented strategies during problem-solving could serve as a basis for the learners' understanding of mathematical ideas and procedures, but was quick to point out that this was based on their level of understanding, and that the learners should be guided to develop efficient strategies. This study hypothesized that one way of assisting learners to invent their own strategies is to develop problems that are familiar to them and with which they can easily identify. In this study, the research would try to use a more specific method called problem based learning that will allow learners to contract knowledge through interaction.

2.2 Learners' Performance in Permutation and Combination

[13] conducted a research titled 'Learners' Errors in Solving PnC using Problems Based according to Polya's steps. [21] set out four steps that could be done to make learners focus more on solving mathematical problems, namely the ability to understanding the problem, devising plan, carrying out the plan and looking back.

The findings of this research indicated that some students had difficulties in solving the questions in permutation and combination. In which 60% of students made a mistake in implementing the problem solving, 62% made mistakes in noticing the problems,57% made mistakes in making plans and 51% made mistakes in understanding the problem. Based on all things mentioned above, it could be seen that the Students' errors in solving the problems of PnC according to [21] was due to the lack of students 'ability in understanding the context problems related to PnC. It was also seen that that PnC were taught separately.

However, Problems of PnC presented in the form of context are usually in the word problem forms. To solve the words problems, it needs problem solving capabilities appropriate to the context [23]. In this study, the topic, PnC was taught separately but in an integrated way so that the learners could distinguish the concept of PnC simultaneously. On the other hand, a different procedures outlined by [4] was used in this study in order for learners to contextualize the concepts in PnC in more logical and interactive way.

Another research in titled 'Teaching PnC Using Play-Way Method' was conducted by [2] at Obafemi Awolowo University in Nigeria. In this paper, a play way method was defined as learning that occurs through play. The purpose of the study was to demonstrate how play-way method was used to teach the concept of PnC in Secondary schools and even in tertiary institution. The findings of this study observed that learners performed better in the concept of PnC when adopted the play-way method despite the topic being difficult to learners. However, in this current study the researcher tried to use problem based learning and took a different Geographical area, Zambia. This was done in order to see if problem based learning could equally have an impact on pupils' performance in PnC as it was in a play-way method.

2.3 Learners' Attitudes Towards Learning Mathematics

The behavioral aspect of attitude is the tendency to respond in a certain way towards learning mathematics [2]; [19]. Behavioral attitude is also influenced by affective attitude. Learners' feeling confident in doing mathematics is linked with being successful in mathematics, which is regarded as a positive behavior. If learners are not confident in doing mathematics, they may not experience success, and unsuccessful behavior is regarded as negative feelings [30]. Hence the behavioral component of attitude impacts on the cognitive component of attitude as well. When learners see the importance of mathematics in real lives, they feel engaged, confident and connected to their learning [3]. As such, the three

components of attitude, confidence, importance of mathematics and engagement are interrelated [19].

Researchers [3] & [17] haveidentified important factors that contribute to learners' attitudes towards learning mathematics. These include the learners themselves, the school, the teachers' beliefs and attitudes [7] and their teaching methods. The teachers' teaching method have a major influence on learners' attitudes [2] & [19]. Teachers can do many things to facilitate the classroom learning to alleviate learners' engagement level and confidence in learning mathematics [3]. According to [27], teachers can find ways to encourage learner engagement and confidence in learning mathematics. This can be achieved by implementing meaningful activities embedded in real-life contexts [14].

3. RESEARCH METHODOLOGY

3.1 Target Population and Sampling Procedure

The population of the current study consisted of all grade eleven pupils taking ADDMA at Dominican convent secondary school in Ndola district. Purposive sampling was also used to select the two classes 11G and 11CO and they were randomly assigned to experimental and control respectively. A total sample of 69 grade eleven pupils was used to seek answers to the research problem.

3.2 Research Design

This study followed a mixed method research approach which included a quantitative and qualitative research approach [22]. The mixed method approach was considered appropriate for this study because the researcher wanted to use both the quantitative approach which involved the use of a quasi-experimental design, and the qualitative approach which followed an enquiry research design.

3.3 Quasi-Experimental Design

The quasi-experimental design involved a pre- and post-tests matching control research design in which the pre-test was used to measure the prior knowledge of the study participants before the intervention, as well as a basis on which to measure the performance of the study participants after intervention, while the post-test was used to measure their performance after intervention.

Table 1: Illustration of the Matching Control Causal-Comparative Design

Experimental Group	O1	X	O2
Control Group	O1	----	O2

O_1: Pre-test

O_2: Post-test

X: Intervention

Table 1 indicates that the pre-test (O1) was administered to both the control and experimental groups at the start of the investigation. The intervention (X) was organized only for the experimental group, which means there was no intervention for the control group. Both groups took the post-test (O2) at the end of the investigation. It is also important to note that the items of O1 and O2 were the same, but with different item numbers.

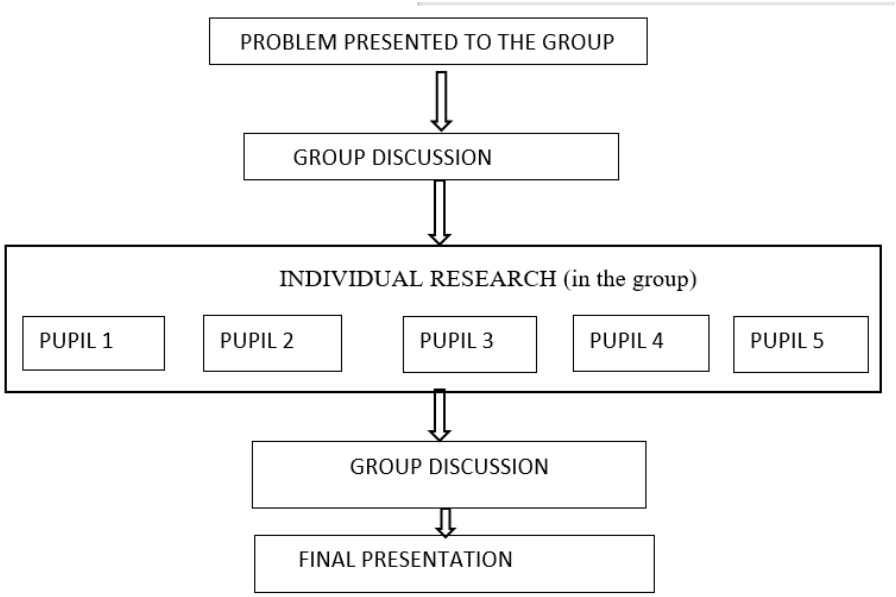
The pre-test/post-test design allowed the researcher to gather data on the study participants' performance in a class test. A pre-test was administered on all the groups (experimental and control) after which all the groups were taught permutation and combination for four weeks. At the end of the intervention, a post-test was administered (the post-test items were the same as the items in the pre-test but the items were shuffled around so that question items did not retain the same item numbers).

3.4 Intervention

3.4.1 Problem Based Learning Teaching Design

The researcher started by dividing the learners into seven groups denoted by the letters A, B, C, D, E, F and G, each comprised of about five members. Purposive sampling technique was used to assign learners to the groups. This was done in order to have equivalent groups in terms of ability using previously written tests. After assigning learners to groups, the researcher introduced the first set of problem solving skills, to help stimulate their courage to solve problems involving permutation and combination. The learners were allowed to discuss within the classroom. In a case where learners had failed to find correct answers for the questions under discussion, they were allowed to go and research either in the library, databases, the internet or resource people individually. When they had come back to their respective groups, they presented their findings through peer teaching. While working on the problem, each group presented its final solution to the rest of the class and discussed upon with the teacher as the facilitator. The facilitator(teacher) is in continuous dialogue with the learners. Hence, rapport was created between learners and teacher to increase learners' freedom to express their views and to expose their feelings and response to the intervention. This information is summarized in figure 1.

Figure 1: Model of how Group Activities Were Conducted During the Lessons



3.4.2 Enquiry Design

The enquiry design involved structured questionnaire. The structured questionnaire was used to Scrutinize the responses of the study participants in the experimental group. The

purpose for this was to gather qualitative data that could be used to justify the results from the quantitative data. This was only administered to the experimental group before and after the intervention. In addition, another type of questionnaire was used only to an experimental group after an intervention was carried out, to gather information on the effectiveness of the implementation of problem based learning.

3.4.3 Performance Tests

There were two types of performance tests that were used in this study and these were the pretest and the posttest. The purpose of the pre-test and the post-test in this study was to determine whether problem-based learning has an impact on the learning of permutation and combination. The pre-test and the post-test questions were drawn by the researcher from different sources that were past questions or text books on the concept of permutation and combination and were administered to both control and experimental groups. The questions were of reasonable level of difficulty and their solutions would demand a variety of strategies.

The pre-test was administered at the beginning of the intervention while the post-test was administered at the end of the intervention to the learners in both groups.

4. DATA PRESENTATION AND ANALYSIS

The impact of using Problem Based Learning on learners' performance in permutation and combination

Before the application of the intervention which was use of PBL, two groups (experimental and control) were given a pre-test to find out if their initial performance in mathematics was the same. The results of this test are shown in table 1.

Table 1: Independent Samples T-Test for Pre-Test (n=69)

Group	Number of pupils (N)	Mean Scores	Std Deviation	t-value	df	sig	Mean difference
Experimental	35	26.40	11.998	0.207	67	0.837	0.606
Control	34	25.79	12.323				

In Table 1, the mean score for the experimental group and control group was 26.40 and 25.79 respectively. The statistical t-test provided sufficient evidence that the results in the two groups were the same, $p>0.1$. The result confirmed that the average performance in permutation and combination for Grade 11 learners in the control group and Grade 11 learners in the experimental group was the same.

Analysis of Post-Test Scores Between Control and Experimental Group

The post-test scores of the control and experimental group were also analyzed to determine whether the difference recorded after the PBL method was administered to the experimental group was statistically significance. Results of the post test are shown in table 2.

Table 2: Independent Samples T-Test for Post-Test (n=69)
Group

Group	Number of pupils (n)	Mean Scores	Std Deviation	t-value	df	p-value	Mean difference	Effect size
Experimental	35	69.14	15.688	3.646	67	0.001	13.672	0.8978
Control	34	55.47	15.449					

The mean score of the experimental group was 69.14 and that for the control group was 55.47, this shows that there was a difference in means which was 13. 672. On the other hand, the p-value is less than the alpha level (0.05). In view of the preceding statements, the null hypothesis was rejected because the p value was found to be less than 0.05 ($p = .001 < 0.05$) and the t-statistic (3.646) was found to be greater than the t-critical (1.99). Effect size was calculated using Eta squared and it was found to be 0.8978 which translates to be large magnitude according to Cohen1988. In simple terms, the results from the independent t test indicate that there was statistically significant difference in the conceptual ability and the knowledge of the learners (in the control and experiment groups) before the treatment was carried out. As a result, any statistically significant difference in performance after treatment was viewed to have had resulted from different teaching methodologies.

Table 3: Group Statistics for Pre-Test/post-Test(N=69)

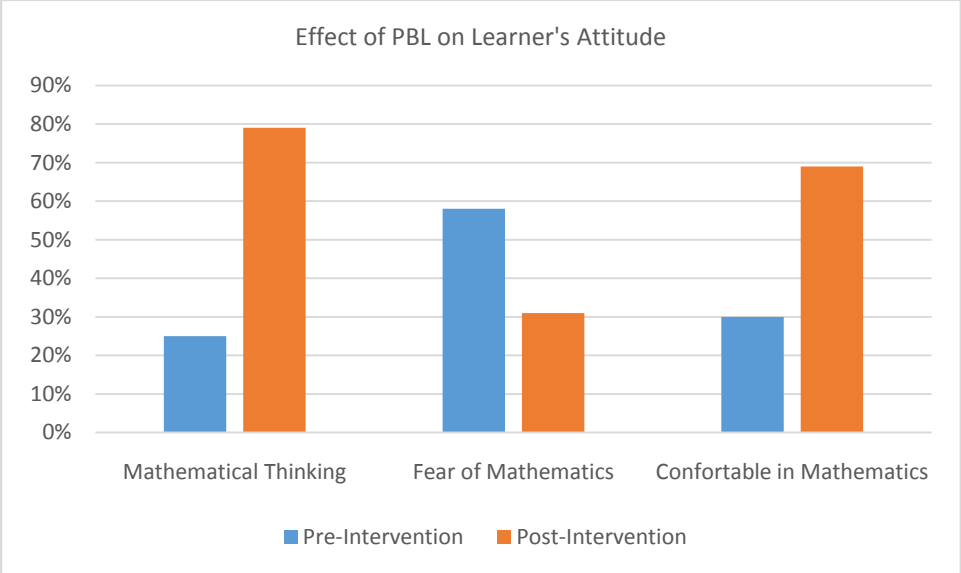
	GROUPS	N	Mean	Std. Deviation	Std. Error Mean
PRETEST-SCORES	EXPERIMENTAL	35	26.40	11.998	2.028
	CONTROL	34	25.79	12.323	2.113
POSTTEST-SCORES	EXPERIMENTAL	35	69.14	15.688	2.652
	CONTROL	34	55.47	15.449	2.650

Table 4.3 shows that the mean score of the experimental group increased by 42.74 (from 26.40 to 69.14), while the standard deviation of the experimental group increased by 3.69 (from 11.998 to 15.688). The mean score of the control group increased by 29.68 (from 25.79 to 55.47) while the standard deviation increased by 3.126 (from 12.323 to 15.449).

The mean score for the experimental group increased more than that of the control group indicating that learners' performance in the experimental group improved more than in the control group. The standard deviation of the experimental group had a smaller increase as compared to that of the control group indicating that the gap between learners who understood permutation and combination and those who did not was bigger in the control group than in the experimental group.

4.1 Impact of PBL on Learners, attitude towards mathematics.

Data on learner's attitude toward mathematics was collected using a questionnaire which had questions divided into three sections namely: Confidence in mathematics, Importance of mathematics and Engagement in mathematics. Results of scores rated in percentage of responses on attitude from the experimental and control groups are shown in figure 2.



Results in figure 1 shows the mathematical thinking category indicating an increase of 64.2% in the number of students feeling satisfied with solving a mathematics problem after applying the Problem Based Learning method. Learners were also asked if they wanted to develop my mathematical skills and whether Mathematics helps develop the mind and teaches a them to think deeply in problem solving. Results showed an increase of 64.3% and 75.1% respectively in acceptance of the positive effect of mathematics after application of PBL. Figure 2 shows the overall scores (percentage) obtained after the intervention. The summary of results in figure 2 is as follows:

In the mathematical thinking category, there was an increase of 54% in the number of learners feeling satisfied with solving a mathematics problem. In the category of fearing mathematics, there was a decrease of 27% the number of learners fearing mathematics in context form. In the category feeling comfortable while learning mathematics, there was an increase of 39% the number of learners with self-confidence, their ability to solve mathematics problems without facing difficulty, being confident about learning advanced mathematics in the context and comfortable in expressing their own ideas.

5. DISCUSSIONS OF RESULTS

5.1 Impact of PBL on learners' performance in permutation and combination

At the beginning of the research, the participants in the experimental and control groups were given the same pre-test. The pre-test scores were analyzed using SPSS on independent sample test and the results showed that the mean performance score of the experimental group was not significantly different from the mean score of the control group indicating that the two groups were comparable, at the initial stage of the study.

At the end of four-week period of study, participants in both groups were given the same post-test. The experimental group were exposed to the use of problem based learning method for learning permutation and combination, while the control group used the traditional method. The results indicated that the mean performance score for the experimental group ($\bar{X}$=69.14) was significantly higher than that of the control group ($\bar{X}$=55.47).

From the findings of the study, it is evident that learners who were exposed to problem based learning method (experimental group) performed better in permutation and combination compared to those who were not exposed to based learning method (control group). Hence, this finding suggests that the use of based learning method in the teaching and learning of permutation and combination enhanced learners' performance and achievement in permutation and combination. This finding is in line with the findings of [20] on the effectiveness of problem based learning in teaching and learning mathematics. Furthermore, the findings of this study agreed with [18], added that learners who explored problem situations and 'invent' ways to solve the problems were more successful in extending their knowledge to new situations than those learners who initially taught standard algorithms. The learners in the experimental group were exposed to an innovative way of learning PnC through the use of problem based learning method, which most likely captured their attention and interest during mathematics lessons. In line with [16], in understanding permutation and combination, pupils need real-world problems in the form of more relevant one to stimulate learning and retaining knowledge. As a result, while using problem based learning the learners had more time to answer higher order questions and this could have contributed towards the higher achievement scores in the experimental group.

Based on these results the conclusion could therefore be made that the use of problem based learning method had positive effect on the learners' understanding of permutation and combination.

5.2 Effect of PBL on attitudes of learners towards mathematics

In this study, learners' attitude towards performance in permutation and combination using problem based method was regarded as an intervening variable, which the research felt would affect the research. This question was answered using learners' questionnaire based on attitudes divided into three sections namely: Confidence, importance and engagement in learning mathematics.

In the confidence category, the percentage of learners feeling positive about learning mathematics using PBL showed an overall increase. These findings resonate with the conclusions reached by a number of writers [30] who pointed out that If learners are not confident in doing mathematics, they may not experience success, and unsuccessful behavior is regarded as negative feelings. They further added that learners tend to feel at ease and are comfortable in answering or solving mathematical problems when taught in a context. The learners' confidence towards learning mathematics using PBL was associated with developing mathematical thinking. The findings from this study show that the PBL method may have allowed learners to express their mathematical ideas more comfortably giving them more confidence. With an increase in the percentage of learners seeing the usefulness of mathematics outside of school, it can be stated that PBL made it possible for these.

6. CONCLUSION

The findings of this research will benefit everyone interested in the improving of the teaching and learning of Mathematics not only in Zambia but the world at large.

The main aim of the study has been realized and it became clear that: In order for mathematics to be meaningful to learners, it should be taught through the problem- based approach. This approach develops learners' problem solving and critical thinking skills which will be helpful in solving problems at school and from their everyday lives. The researcher strongly thinks that for successful implementation of this approach, teachers need much support from their fellow teachers, parents and the Department of Education. Learners lack problem solving skills, as such explicit instruction in problem solving strategies is critical. From the findings it can be concluded that instruction in these strategies through a problem-based approach improves learners' problem solving performance. It also affects positively learners' attitudes towards word problems in particular and mathematics in general. Emphasis is made on problem-based approach because instruction through other approaches may yield different results.

The study established that problem based learning has a significant impact on learner academic performance in permutation and combination. If learners are given an experience, learning will be very effective because learners will not only see mathematical concepts from an abstract point of view but they will marry to an experience given to them.

Furthermore, findings of this study revealed that learners viewed problem based learning with a positive attitude as they enjoyed the lesson progression and want to learn other mathematics topics using this mode of instruction. In general, the study established that problem based learning has a significant impact on learner academic performance in permutation and combination concepts in [8].

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