Impact of Problem Based Learning on Learner Achievement and attitude in Animal Taxonomy: A case at Kasama College of Education

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Abstract

This study investigated the impact of Problem-Based Learning on students' achievement and attitude towards Animal Taxonomy. The study adopted a quasi-experimental design. A sample of 74 first year students was purposively selected from the three cohorts of the Secondary Teachers' Diploma programme at Kasama College of Education, in Northern province of Zambia. Data was collected through a Biology Achievement Test at pre and post- test stage and an Attitude Questionnaire which measured students' attitude towards Animal Taxonomy. The results were interpreted by comparing the means and by using the t-test and Mann - Whitney U test at P < 0.05, level of significance. A 2-tailed level of significance or P – value after treatment was 0.001 which is below 0.05 for the t-test, which revealed that the experimental group where Problem Based Learning was used, performed better than the control group where Lecture-Based Learning was used. The 2-tailed level of significant of 0.003, which is less than the alpha value (0.05) for the Mann-Whitney U test suggests that there is a significant difference in the attitude of the students towards Animal Taxonomy after using Problem-Based Learning. Problem-Based Learning promotes active and transferable learning and it has the potential of motivating students and assist them develop flexible understanding of Animal Taxonomy as well as attaining lifelong learning skills.

Key words: Problem-Based Learning, Animal Taxonomy, Learner performance, attitudes.

1.0 Introduction

Biology is a branch of science that studies life and living organisms. Knowledge learned from Biology is increasingly applied to solve various human problems, such as issues of health, agriculture, livestock, and other vital areas (Reece et al., 2011). Despite its ability to help solve some of the human problems, it is one subject students find hard to understand its topics. Çimer, (2012) argues that many students find this subject to be difficult due to the conceptual nature of the content. Chiappetta and Fillman (1998) further add that, because it is very conceptual, it requires an immense amount of time and effort to learn the material which is so extensive from molecular biology to human body systems. These difficulties have made biology gain a reputation of being an overly complex subject that can cause some students to quickly lose motivation and interest. These findings that describe how students perceive biology as a subject are not very far from how students perceive Animal Taxonomy.

Animal Taxonomy is one of the topics in biology that has been observed to have students' performance, perception and attitudinal challenges and literature on this subject is very scanty. It has received little attention scholarly and much of the literature is old even though it is as important to the general understanding of life as any other topic in biology. Chyleńska (2018) describes it as a branch of biology that shows interconnections between groups of organisms and a logical basis for the synthesis of all animal biological knowledge. It is a useful tool for naming populations of animals and drawing conclusions on traits such as morphology, physiology, behavior, and distribution. The value that Animal taxonomy has, as a component of the study of life, does not stimulate learners and educators to learn the topic with eager and to prepare for it as could be the case with the other topics. This is because they lack motivation and interest as noted by Chyleńska (2018) that learning the taxonomy of animals, can be appreciated and valued if learners develop interest, get highly motivated and exhibit the right attitude towards the topic as well as the animals.

Cardak (2009) points out that the fact that science and in particular Animal Taxonomy is generally made up of abstract concepts, many students are likely to experience difficulties in assimilation of the

concepts if they are not able to effectively understand epistemology of Animal Taxonomy. The abstract nature of the concepts has affected students' perception and attitude towards Animal Taxonomy and this has led to low learner performance. This study examined the impact of employing Problem-Based Learning (PBL), to ascertain its impact on performance and attitude towards Animal Taxonomy of the learners in Biology. Major (2002) describes Problem Based Learning (PBL) as an innovative educational frame work designed to help students improve critical thinking and problem-solving, team skills, and communication skills. PBL allows students define the problem, identify action steps, create solution and hence develop a high level of metacognition. Many learner centered methods have been used all in trying to improve student understanding of scientific concepts and eventual improved performance but Problem-Based Learning does not just allow learners improve performance but imparts some skills.

This paper is structured as follows: in the proceeding section the paper discusses the concept of Problem Based Learning (PBL) drawing on literature about the concept. The third part situates the study in the theory of Constructivism and integrates PBL within this theory. The fourth part presents the study's objectives and questions with its hypothesis. The fifth part outlines the study's methods and materials. It then turns to the discussion of the finding of the study in the sixth part and concludes that active learning methods can improve student attitude towards the material being learnt in the seventh part. The eighth section provides recommendations drawn from the study.

2.0 Problem Based Learning in Literature

The modern history of Problem-Based Learning (PBL) begins at McMaster University's Clinical Medical Department in Ontario, Canada in the early 1970's (Rhem, 1998). This was in response to its medical students that were able to learn and recall knowledge learned through course work, but not able to put the knowledge they had learned into application (Albanese & Mitchell, 1993). PBL is now used in many disciplines and educational contexts (Duch, 2011) and 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 (walker, 2009).

Abubakar (2015) adds that PBL is not just as a student-centered approach but it is on kind of approach where students determined key issues of learning and solve a real-world problem through collaborative and self-directed learning activities under the guidance of a teacher. PBL represents a dramatic shift from the traditional, lecture-based instructional paradigm as pointed out by Major (2002) on bases that learning is a constructive rather than a receptive process. This instructional approach focuses on real-life problems and exploration of relevant information across disciplines making students to develop flexible knowledge and effective problem solving skills (Abubakar, 2015). Critical thinking, team skills, and communication skills are other attributes students may acquire from PBL as an innovative educational framework (Major 2002).

The PBL process comprises of seven (7) steps. These are as follows: (1) identify the problem, (2) explore pre-existing knowledge, (3) generate learning hypotheses, (4) identify learning issues, self-directed study, re-evaluation and application of new knowledge to the problem, assessment, and (5) reflection on learning. Through these steps, the teacher who is supposed to be a facilitator guides the learners' on areas where they face challenges. Wirkala and Kubn, (2011) contend that problems in PBL are ill-structured and that it does not have a single, clear-cut or formulaic solution, nor motivates students to ask questions and to seek additional information. These, according to Wirkala and Kubn (2011), are the features that distinguish PBL from other instructional methods that are not necessarily problem focused such as project-based learning, inquiry learning and cooperative learning.

A study conducted at a secondary school in Ndola where PBL was used in comparison to conventional methods of teaching using a quasi-experimental design to ascertain change in participants performance, showed that PBL had a significant influence on improvement in learner performance and attitude (kapolyo, 2019). In another study, a randomized controlled trial to investigate the effectiveness of PBL in comparison with Lecture Based Learning (LBL), find out that the performance indicator scores increased in

both LBL and PBL groups but significantly more in the PBL group and thus it was concluded that PBL appeared to be more effective than the LBL in improving performance (see also Smits et al, 2003). Additionally, these two studies and others done on PBL point to important gains for students, such as the establishment of an intellectually challenging, flexible and enjoyable learning environment marked by camaraderie and collaboration (Ribeiro, 2011) but as regards to teachers, Albanese and Mitchell's (1993) meta-study indicates that most of them consider PBL a gratifying instructional methodology, despite the fact that it takes considerable time and makes it difficult to cover a pre-defined syllabus. Despite these results, it appears that the influence of PBL on teachers' practice has been less examined than its effects on students' training.

2.1 Learners Performance and attitude in Animal Taxonomy

Wafula in 2016 conducted a study in Kenya to determine the effect of project based method on learner performance in classification of organisms. The study was necessitated by poor performance of the learner due to inability to understand concepts in classification of organisms, use of negative statements, spelling errors of scientific terms, inability to follow instruction and use of non-conventional ways of writing the steps. Wafula pointed out that inappropriate teaching methods were the main causes of poor understanding and performance in classification of organisms. The study employed a quasi-experimental design and the findings showed that understanding of concepts improved students developed positive attitude towards the topic hence improved performance. If a particular student learns about different animal taxons far away from wildlife, and their only source of information are textbooks, it is not surprising that their mental models are incomplete or just wrong (Bizzo et al, 2012). Therefore, it can be assumed that a lack of direct experience can be an important obstacle in understanding animal classifications besides the factors that Wafula identifies in the study above. It was shown that contextual teaching is far more effective than teaching and learning without context (Ruiz-Mallen et al, 2009). In another study Chyleńska (2018), obtained results that helped understand the idea of teaching about animal classification, that it should be based on/and relate to students' ideas and interests about it and therefore

concluded that to know something and understand its value, one has to be interested in the topic.

3.0 Theoretical placement of the study

This study is rooted in the theory of constructivism which is based on the premises that learning is an active process in which learners construct new ideas or concepts based upon their current and past knowledge and that students construct and build their own knowledge of the world around through experience (Piaget, 1970; Vygotsky, 1978; Bruner, 1960). The leaner selects and transforms information, constructs hypotheses and makes decisions relaying on the cognitive structure. The cognitive structure provides meaning and organization to experiences and allows the learner to learn beyond the information given as Ausubel (1963) puts it that a cognitive that is clear and well organized facilitates the learning and retention of new information. Bruner (1961) proposed that leaners construct their own knowledge and do this by organizing and categorizing information using a coding system which he believed that the most effective way to develop a coding system is to discover it rather than being told by the teacher. The role of the teacher therefore should not be to teach information by rote learning but help students discover the relationship between concepts.

The implication of the constructivism theory to this study may rest on four principles of Problem-based learning which are contextual, constructive, collaborative and self-directed. Constructivists believe that learning is affected by the context in which an idea is taught as well as by students' beliefs and attitudes (Bada, 2015). The learning process in a PBL class is stimulated by a Problem and usually these are real everyday problems and aspect that make learning materials more relevant and easier for learners to apply on real situations. Learners directly develop knowledge by experiencing things and by reflecting on such experiences. This study provides an opportunity for learners to learn animal taxonomy in the actual habitats of the arthropods. Learners can actively learn through cognitive processes, constructing an understanding of the world around them (Piaget, 1970; Vygotsky, 1978). The teacher, who according to this theory should be a facilitator, should design a problem that will give learners real world experiences for them to see relevance in what they are learning.

In a constructivist classroom, learners construct their own knowledge, students learn by fitting new information together with what they already know, and as they perceive each new experience, learners will continually update their own mental models to reflect the new information, and will, therefore, construct their own interpretation of reality (Bada, 2015). Students already know aspects of animal groupings, but they need to assign scientific names onto these groupings. The role of the teacher therefore should be probing or challenging students' thinking, keeping students involved in the learning process, monitoring and adjusting levels of challenges, thereby creating a conducive environment for knowledge construction and retention.

One of the principles of PBL is collaboration which requires that students share ideas and appreciate each other's reasoning. Constructivism promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas where students to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing in group projects. Students exchange ideas and learn to "negotiate" with others as well as evaluate their contributions in a socially acceptable manner. This is key to succeed in the real world, where they will always be exposed to a variety of experiences in which they will be required to cooperate and navigate among the ideas of the other people (Bada, 2015).

Active learning brings about self-directed learning from which students develop the ability to plan, reflect, evaluate their understanding and ability to manage information as well as resources. BL environment as one that is more likely to engage learners in the learning process through identification, formulation and restructuring of goals; planning; development and execution of plans; self-monitoring; and appropriate use of resource management strategies. These are valuable skills that the education system today should be able to impart in a 21st century leaner. The purpose of education according to (Bruner, 1961) is not to impart knowledge, but to facilitate a learners' thinking and problem-solving skills which can then be transferred to a range of situations.

4.0 Research Objectives and Questions

This section outlines the study's research objectives and question and the study's hypotheses.

4.1 Research Objectives

1. To assess the Impact of Problem-Based Learning on Students' Academic Performance in Animal Taxonomy.
2. To examine Students' Attitude towards Animal Taxonomy before and after using Problem-Based Learning

4.2 Research Questions

1. What is the impact of Problem-Based Learning on Learner Performance in Animal Taxonomy?
2. Is there a significant difference in the Attitude of the Leaners towards Animal Taxonomy before and after using Problem-Based Learning?

4.3 Research Hypotheses

Ho_1: There is no significant difference between the Leaner Performance of students taught Animal Taxonomy using Problem-Based Learning and those taught using Lecture-Based method.

Ho_2: There is no significant difference in the attitude of the students towards Animal Taxonomy before and after using Problem-Based Learning.

5.0 Method and Materials

The study was conducted at Kasama College of Education, (KACE) in the Northern part of Zambia. The population of the college is about 2 000 and the target population was 300 Biology students. A Non-randomized Experimental Research Design also known as quasi-experimental design of non-equivalent groups was used. This design was adopted because Kasama College has two classes of first year students, and these are the only classes that had not learnt Taxonomy.

5.1 Sample and Sampling Technique

Purposive sampling was used in this study to get these classes as research participants to reduce treatment diffusion. Random

assignment was used to assign the two classes to experimental and control groups. Purposive sampling technique assumes that a sample is selected in a nonrandom manner, based on member characteristics relevant to the research problems. Kombo and Tromp (2006: 82) states that, "the power of purposive sampling lies in selecting participants who will provide the richest information for in-depth analysis related to the central issue being studied". The sample for the study was 74 first year science student teachers from which 35 constituted the control group and 39 the experimental group.

5.2 Data Collection Techniques

Data for the first research question of this study were collected through, Pre and Post Biology Achievement Tests each with 20 short answer items giving a total of 30 marks. Questions were set on taxonomy of animals, specifically from the Phylum Arthropoda. Pre-test was administered to both classes before implementation of the Problem-Based Learning (PBL) Method to the experimental group comprising 39 students and Lecture-Based Learning (LBL) to the control group which had 35 students. This was in order to ascertain the knowledge base for both classes. The post-test was administered in a space of 3 weeks from the time the pre-test was given. This meant to assess the impact of both methods on learning.

The Attitude Questionnaire was used to collect primary data to answer the second research question. An *Attitude Questionnaire* (AQ) was administered to 74 respondents to establish their attitude toward Animal Taxonomy before use of PBL and a **post attitude questionnaire** after the use of PBL and LBL. The attitude questionnaire used a five point Likert scale of measurement with mostly structured questions ranging between (1) representing strongly Disagree and (5) representing strongly agree were used.

Both groups were met for three weeks, but the 35 students in the control group were exposed to LBL. All activities for this group were organized in a way that lectures are presented in college. As part of this study a presentation on Animal Taxonomy looking at the phylum Arthropoda was done to explain the content to students and on a few occasions they asked questions. The lectures went straight into explaining what Animal Taxonomy is and how the classification system is done. They were given activities which they were supposed

to do individually or in groups if they chose to and they did the work at their own convenient time and place. They were asked to identify the number of classes that are found in the phylum Arthropoda and the kind of Arthropods that constitute each of the classes.

The 39 students in the PBL class were taught the same topic but designed differently. They were given a problem which they needed to work on. Students were required to find ways and means to come up with information on alternative sources of protein that is cheap in Kasama considering the ever increasing prices of beef, chicken meat, fish, pork and others. Under the topic Taxonomy, sub-topic Animal Taxonomy, looking at the phylum Arthropoda they were expected to construct a dichotomous key of the specimen collected at the end of the period. The working environment was restricted to Kasama College Campus. More time was allocated to PBL class because of the nature of the method. Four (4) hours period was given to this class to conduct practical work and group work and two (2) whole days in a week. However, time when need arose was given to groups to conduct field work within the grounds of collage.

5.3 Data Analysis Techniques/Methods

The data collected for the two research questions were analyzed quantitatively and qualitatively. Learner performance from the Pre and Post equivalent Biology Achievement Tests were analyzed using descriptive statistics: mean scores, standard deviations, and mean gains. Ho_1 was tested using independent t-test statistic while Ho_2 was tested using Mann Whitney U test statistic to indicate if the effect is statistically significant at alpha = 0.05. Nachar (2008) permit this even if the data is ordinal.

6.0 Finding and Discussion

This section presents a discussion on the findings of the study. The discussion is presented on the basis of the research questions. *What is the impact of Problem-Based Learning on Learner Performance in Animal Taxonomy?*

In answering this question data was obtained through the Pre and Post Biology Achievement Tests. An independent t-test statistic was used to test the Ho_1.

Table 2.1: T-Test Results of the Experimental and Control Group before Treatment (N=74)

Group	N	Mean	Df	t-value	Sig. (2-tailed)
Experimental	39	13.49	72	9.845	0.786
Control	35	12.12			

**. Significant at <0.05 level of significance (2-tailed).

Table 2.1 show t-test Results for Experimental and Control Group before Treatment whose 2–Tailed level of significant was 0.786 which is greater than 0.05. Meaning that before treatment, neither experimental nor control group showed no significant difference in the performance with regard to Animal Taxonomy. Their knowledge level was similar.

Table 2.2: T-Test Results of the Experimental and Control Group after Treatment (N=74)

Group	N	Mean	Df	t-value	Sig. (2-tailed)
Experimental	39	57.05	72	-1.78	0.001
Control	35	49.96			

**. Significant at <0.05 level of significance (2-tailed)

From Table 2.2., the experimental group attained a mean score of 57.05 while the control attained a mean score of 49.96. The difference in the mean show an increased performance by the PBL group. A 2-tailed level of significance or P – value after treatment was 0.001 which is below 0.05, this meant that there was a significant difference between the learner performance of students taught Animal Taxonomy using Problem-Based Learning and those taught using Lecture-Based Method. Both methods showed an increase in knowledge acquisition in the control and experimental groups but those taught using PBL gained more knowledge than the control group, reasons being that they were involved in the learning process, they generated their own knowledge unlike Lecture Based Learning which did not promote active learning. This however, resonates well with Ganyaupfu (2013) who said that a lecture neither promotes

learner participation nor build the required level of reasoning among students and further added that students build a better understanding of the main concepts more effectively when they are engaged to solve problems during class activities.

Is there a Difference in the Attitude of the Leaners towards Animal Taxonomy before and after using Problem-Based Learning?

In answering this question data was obtained through a pre and post-Attitude Questionnaire that was given to both control and treatment group. Values were assigned to each response (strongly agree = 5, agree = 4, undecided = 3, disagree = 2 and strongly disagree = 1) so that a higher score reflect a level of agreement or significant difference in the attitude of the students towards Animal Taxonomy before and after using Problem-Based Learning. Value of 3 reflects a level of participants who neither agreed nor disagreed to Likert items.

Table 2.3: Students' Questionnaire Responses on Attitude towards Animal Taxonomy before Treatment (N=74)

	Frequency		Percentage	
	Control	**Experimental**	**Control**	**Experimental**
Strongly Disagree	50	23	14	06
Disagree	107	153	31	39
Undecided	19	07	05	01
Agree	143	161	41	41
Strongly Agree	31	43	09	11

Source: Field data 2019

Table 2.3., shows that a total of 50% of the students showed a positive attitude towards animal Taxonomy in the control group while a total of 52% in the experimental group showed a positive attitude towards the topic. 7% and 1% were undecided in the control and experimental groups respectively. A total of 45% in the control group 45% in the experimental group showed a negative attitude towards Animal Taxonomy.

Table 2.4: Students' Questionnaire Responses on Attitude towards Animal Taxonomy after Treatment (N=74)

	Frequency		Percentage	
	Control	**Experimental**	**Control**	**Experimental**
Strongly Disagree	35	21	10	05
Disagree	117	80	33	21
Undecided	17	1	04	00
Agree	157	209	45	54
Strongly Agree	24	85	09	22

Source: Field data 2019

From the Table 2.4, 53% in the control group showed a positive attitude towards the learning of Animal Taxonomy while a total of 76% in the experimental group showed a positive attitude towards Animal Taxonomy. The positive attitude could have been that learners developed interest and were motivated to work more on their assignment as PBL is able to provide such an environment which is in line with what Silvia (2006) stated that when interested, students persist longer at learning tasks, spend more time studying, read more deeply, remember more of what they read, and get better grades in their classes. This increases self-efficacy and perceived relevance.

In the control group 4% were undecided and 0% were undecided in the experimental group. A total of 43% showed a Negative attitude in the control group while 26% in the experimental group had a negative attitude towards the learning of Animal Taxonomy. Even though the performance for control increased after the treatment, the difference in attitude before and after is minimal, an implication that Lecture-Method did little to help learners develop interest, self-efficacy and relevance aspects that resonates well with what Massolt and Borowski, (2020) said that a lower perceived relevance can have a negative effect on academic achievement and on the retention of knowledge and Harris, and Mackay, (2003), also added that when

knowledge gained is not directly relevant or applicable to the topic contexts, it is lost rather quickly. When knowledge is easily lost it becomes difficult for an individual to remain positive. The 26% from the PBL class showing negative attitude even after the treatment could be those students that prefer to sit in class and listen. They do not like activity oriented lessons for reasons given by Marmah, (2014) that the teacher should provide all the knowledge related to the topic, it is a time saving method and students listen to the lecture attentively and take notes.

The Results from pre and post test showed that there was an increase in the attitude of the students in the experimental group from 52% to 76% while the increase in the control group was from 50% to 53%. This result explains that Problem Based Learning did not just improve understanding of Taxonomic concepts but helped the students get motivated and learn more.

Ho_2 was tested using Mann Whitney U test statistic to indicate if the effect of PBL was statistically significant at alpha = 0.05 and confidence level 95%.

Table 2.7: Mann-Whitney Test Rank U-Test Scores on the Attitude Scale before the Treatment (n=74)

Ranks

Group		N	Mean Rank	Sum of Ranks
PRE-TEST	Experimental Group	39	39.18	1917.50
	Control Group	35	36.18	783.50
	Total	74		

Table 2.8: Test Statistics[a]

	PRE-TEST
Mann-Whitney U	2030.50
Wilcoxon W	1917.500
Z	-.540
Asymp. Sig. (2-tailed)	.589

a. Grouping Variable: Group

The tables 2.7 and 2.8 show the scores of the experimental group and

the control group of students' attitude towards Animal Taxonomy before using Problem-Based Learning. Where the P – Value to be 0.589 which is greater than alpha level (α=0.05) hence, we accept the Null hypothesis (**Ho_2**) which states that, "There is no significant difference in the attitude of the students towards Animal Taxonomy before treatment". In this case, the alternative hypothesis (**Ha_2**) was rejected which suggest that "There is a significant difference in the attitude of the students towards Animal Taxonomy before treatment". Their view of the topic was the same as these students had similar academic background.

Table 2.9: Mann-Whitney Test Rank U-Test Scores on the Attitude Scale after the Treatment (N=74)

Ranks

	Group	N	Mean Rank	Sum of Ranks
POST-TEST	Experimental Group	39	39.48	2092.50
	Control Group	35	30.43	608.50
	Total	**74**		

Table 2.10: Test Statistics[a]

	POST-TEST
Mann-Whitney U	398.500
Wilcoxon W	608.500
Z	-1.631
Asymp. Sig. (2-tailed)	.003

a. Grouping Variable: Group

Tables 2.9 and 2.10 show a 2-tailed level of significant of 0.003 which is less than alpha value (0.05). In this case null hypothesis (**Ho_2**) which states that, "There is no significant difference in the attitude of the students towards Animal Taxonomy after treatment" is rejected. While accepting alternative hypothesis which states that, "There is a significant difference in the attitude of the students towards Animal Taxonomy after using treatment".

7.0 Conclusion

From the study findings the following conclusions can be drawn. From the pre-test and post test results both methods appeared to have positively affected student performance. The experimental group however, performed better than the control providing evidence and basis for concluding that the use of Problem—Based Learning facilitates improved level of learning and understanding of concepts of animal taxonomy.

The findings of this study demonstrate that Problem-Based Learning an active learning approach improves student attitude towards the material being learnt. The positive change in attitude of the students towards animal taxonomy also contributes to improved performance.

8.0 Recommendations

The following are the recommendations raised from the study:

- The Colleges of Education CPDs should include lessons that will encourage Lecturers to use teaching methods that will encourage active learning such as Problem-Based Learning as opposed to lecture method only.
- Problem-Based Learning should be one of the teaching methods which must be included in the syllabus, which trainee teachers are expected to go and use in their teaching career. If PBL is introduced in Colleges of Education, it will easily get introduced in schools where students will go and teach.

Further research can be conducted on why teachers in secondary schools do not teach Animal Taxonomy and Taxonomy in general. There is need to do more research on learner attitude towards Animal Taxonomy both at secondary and College level.

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