

**A COMPARATIVE STUDY OF THE EFFECTS OF PROBLEM BASED LEARNING,
DEMONSTRATION TEACHING METHOD AND LECTURE TEACHING METHOD
ON STUDENTS' ACADEMIC ACHIEVEMENT IN SECONDARY SCHOOL
AGRICULTURE IN NDHIWA SUB COUNTY, KENYA**

PETER OYIER OGWENO

**A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements
for the Doctor of Philosophy Degree in Agricultural Education of Egerton University**

EGERTON UNIVERSITY

OCTOBER 2021

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this University or any other for the award of a degree.

Signature...



Date ...17/5/2021

Peter Oyier Ogweno

ED11/04073/14

Recommendation

This thesis has been submitted for examination with our approval as University Supervisors.

Signature ...



.....

Date11th June 2021

Dr. Agnes O. Nkurumwa, Ph.D.

Department of Agricultural Education and Extension

Egerton University

Signature



Date



Prof. Nephath J. Kathuri, Ph.D.

Kenya Methodist University

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DEDICATION

The study is wholeheartedly committed to God for granting me good health and intellect to undertake and complete this worthy task.

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ABSTRACT

The academic achievement of students in the Kenya Certificate of Secondary Education (KCSE) Examination, particularly, agriculture subject has been below expectation. The unsatisfactory performance is traceable partly to the teaching methods and other factors not examined in this study. Lecture Teaching Method (LTM) alone does not adequately deliver the content to the students. Therefore, the study sought to explore alternative and effective teaching methods, such as, Problem Based Learning (PBL). The methods has been tested and validated in other places and found outstanding in increasing learners' academic achievement. The purpose of the study was therefore to determine whether teaching through PBL and Demonstration Teaching Method (DTM) would improve students learning outcomes in agriculture. The study used Quasi-experimental design, specifically Non-equivalent Control Group Pretest-Posttest research design while Constructivist Learning Theory was applied to guide the study. Two treatments, PBL and DTM were used to teach Form Two students. LTM was used as a control teaching method. The target population was composed of 7124 students taking agriculture and 52 teachers of agriculture in Ndhiwa Sub County. Stratified random sampling was utilised to sample 18 schools. Two sets of six schools each, were subjected to PBL and DTM treatments, respectively, while the remaining six schools acted as control. The sample size was 779 Form Two agriculture students and 18 teachers of agriculture. Data was collected using agriculture achievement test by the teachers and the researcher. Descriptive statistics, T-test and analysis of covariance (ANCOVA) were used in data analysis. PBL method was established to be powerful in enhancing students' achievement in agriculture subject with a mean score of (57.47) compared with DTM (48.4) and LTM (43.76). The PBL and DTM teaching methods significantly ($p < .05$) improved the student performance in agriculture. Similarly, female students achieved a better mean score (51.356) compared to male students mean score (48.852). The results have important implications in informing practicing teachers on the need to adopt PBL and DTM teaching methods, considering that the two methods have demonstrated superiority in delivering content. The results may inform teacher preparation programmes at the tertiary institutions and universities in Kenya regarding application of PBL and DTM to pre-service teachers in order to improve students' achievement in agriculture and other applied subjects.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAT	Agriculture Achievement Test
CBC	Competency Based Curriculum
CDE	County Director of Education
DTM	Demonstration Teaching Method
IMSA	Illinois Mathematics and Science Academy
KCSE	Kenya Certificate of Secondary Education
KIE	Kenya Institute of Education
KICD	Kenya Institute of Curriculum Development
LTM	Lecture Teaching Method
MoE	Ministry of Education
NACOSTI	National Commission for Science, Technology and Innovation
NRC	National Research Council
OECD	Organization for Economic Co-operation and Development
PBL	Problem Based Learning
SCDE	Sub County Director of Education
SDG	Sustainable Development Goals
SID	Society for International Development
STEM	Science, Technology, Engineering and Mathematics
UNDESA	United Nations Department of Economic and Social Affairs
UN	United Nations
YFC	Young Farmers Club

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Agriculture is a somewhat unique industry due to the different forces that affect agricultural production. Rapid population increase and climate change have exacerbated the dynamics. The dynamism may be seen in the production of sustainable food, which is influenced by social and cultural considerations, economic resources, and environmental concerns (Moradabadi *et al.*, 2020). The changing nature of the industry necessitates a significant investment in education in order to advance in the information, skills, and competence required in production processes (Peters, 2009). Agriculture should be viewed as a knowledge industry that requires trained and skilled people that can handle both the basics of production, such as sociology and economics of their businesses, as well as, the use of new technology that boost crop yields and reduce environmental impacts, in order to feed the world's population (Cribb, 2008).

The rapid change in agriculture witnessed today is due to rapid technological innovations and expanding international trade in the global arena. In this regard, there is a strong belief that agricultural education should transform if it has to remain relevant in American education system and the rest of education at large (Roberts & Dyer, 2003). These rapid changes in agriculture and education sectors have been occasioned by critical changes in communication technology, innovations, as well as, the rapid expansion of international trade (Frankel, 2000). Indeed, the world has become a global village. As such, teachers are faced with numerous and challenging expectations because of changes in society as a result of technology (Moeini, 2008). Furthermore, the change has been more sudden and irresistible than earlier thought due to globalization and technological advancement (Sweat, 2010). Therefore, all the sectors of the economy are influenced by the prevailing directions in development (Smith *et al.*, 2010). In this regard, globalization has been the driving force in shaping governments, businesses, organizations and individuals who operate to remain relevant (Lundy *et al.*, 2005).

In the present information age, it is very easy for companies to sub contract labour to the most competitive people across the globe. As a result, there is increased demand to adequately prepare students to have required skills that can make them competitive (Duncan, 2010). Shannon's (2007) Review of Tough Choices or Tough Times advocated a number of improvements in areas such as high school graduation requirements, the implementation of strict academic performance standards, and teacher preparation. These suggestions were

made in order to ensure that American students are capable of competing effectively in the global economy. Teachers, business owners, and policymakers all agreed that students should be adequately prepared with 21st-century skills in order to thrive in this rapidly changing society (Rotherham & Willingham, 2009). As a result, teachers should embrace instructional strategies that can help students improve their problem-solving skills so that they can thrive in today's fast-paced world.

To achieve this change, there is a great need to alter the viewpoint frequently labeled non educational and unskilled (Stephenson *et al.*, 2008). Agriculture is regarded as low skilled profession in the society (Peters, 2009; & National Farmers' Federation, 2008). The discipline should conceal the poor representation of low status occupation and strive for a scholarly position (Cribb, 2008). Knowledge based and teacher centered learning was highly appreciated and acceptable to everyone, especially during the 20th Century. The school was used as the only source of information in a more or less straightforward society. In this way of learning, there was one teacher for the whole group of students. Although traditional education offered valuable learning, apparently, it is no longer suitable for young people living in the technological world. Indeed, many students today do not have the same reasons for learning as students did 30 years ago (Beus, 2007).

The social and economic growth of a nation is usually dependent upon the standards of teaching offered to students. Therefore, developing human capital plays an integral part in the growth of a nation. That is why Akanle (2007) indicated that an investment in formal education influences social and economic development. The Organization for Economic Co-operation and Development (OECD), (2001) during its survey on parameters contributing to low performance of students, noted that 26% of secondary school students in Spain failed to attain their diploma. The report also observed that determination of students' academic failure always occur as a reaction to certain situations like intention to change education system and a reaction to similar circumstances (OECD, 2001).

In any academic setting, all the students require an education that will make them competitive in the ever changing global economy. As a result, the students should be prepared for higher demands of post-secondary education and employment (Bray *et al.*, 2010). Therefore, it is important to integrate skills and technical education in students to make this a reality (Bray *et al.*, 2010). That is why the ultimate goal of teaching at different levels of education has been to transform the student (Tebabal & Kahssay, 2011). Focus for training students should be the development of integrated knowledge, skills, and attitudes to minimize rote learning (Stoof *et al.*, 2002). Such focus has created an enabling environment

for students to develop their capacity in managing and solving future problems as observed by Stoof *et al.* (2002). If that is not done, the students might experience some difficulties in developing problem solving skills, if their learning is based on recall of knowledge (Birenbaum & Dochy, 1996).

Instructional methods used by the teachers are broadly grouped as expository and heuristic methods. The expository methods are teacher centred methods involving direct instruction. The method is also called lecture method of teaching. The use of lecture method make learners less active during the teaching and learning process. This has led to rote learning as emphasis is placed on theory (Wachanga & Mwangi, 2004). Teaching students using the lecture method can make students to become bored during the instructional process, as a result, students may dislike the subject (Ogunniyi *et al.*, 2000). The heuristic methods of instruction are learner-centred; that is why emphasis is placed on learners' active participation during instruction process. Learning, therefore, becomes enjoyable to the learner, making the learner to use new ideas and methods during problem solving process (Oakley *et al.*, 2004).

As observed by Adunola (2011), use of ineffective methods of instruction often results in substandard performance in different subjects. Auwal (2013) noted that overdependence on teacher centred methods has led to memorization of information based on repetition, resulting into poor performance in science subjects in Nigeria. Emphasizing on the importance of instructional methods, Auwal (2013) citing Achor *et al.* (2009), stressed that teachers of agriculture should teach the subject using diverse methods.

Therefore, teachers should strive to implement the use of active teaching methods to cater for diversity witnessed in students, as noted by Olatoye and Adekoya (2010). Notably, conventional teaching methods have not contributed to development of essential skills in students (Blair *et al.*, 2007). In another study, Uloko (2006) advocated for the use of active teaching methods that transform the learner from being passive to an active participant in the learning continuum. In a related study, Wood & Gentile (2003) noted that lifelong learning can be achieved by students if they can learn through better methods other than conventional methods.

Problem Based Learning (PBL) is one of the active learning strategies that aims to involve students. The Problem Based Learning method encourages students to participate fully in the learning process. As a result, it has been discovered that using activity stimulating instructional methodologies to teach science-related subjects improves students' participation in the learning process (Osborne & Dillon, 2008). The documentation of

effective PBL qualities is critical for the integration of innovative ideas and the acquisition of problem-solving skills (Hmelo-Silver, 2004).

Most of the research activities involving PBL have been documented in higher institutions of learning settings (Hmelo-Silver, 2004 & Savery, 2006). Therefore, this is a confirmation that very little research has been done regarding student's achievement in agriculture in secondary schools setting, regarding PBL method. Scholars, including Albanese and Mitchell (1993), and Hmelo-Silver (2004) in their research studies conducted using medical students found that medical students who were given instruction using PBL method had developed better attitudes and problem-solving skills than otherwise. Similarly, a research study combining data from multiple studies established a powerful practical outcome on development of students' skills, which was not correlated to knowledge acquisition (Dochy *et al.*, 2003). Although, mixed results were obtained at high school, significant differences in acquisition of knowledge were not established amongst students given instruction using PBL and conventional methods respectively (Gallagher & Stepienm, 1996), however, Liu *et al.* (2006) reported evidence of an increase in knowledge acquisition.

Research findings by Mabrouk (2007) indicated that PBL is handy in improving learners' performances, especially in topics of biochemistry and bio analytical chemistry. In a related study, Abanikannda (2016) found that continuous use of PBL increased chemistry achievement of students in contrast to conventional methods. Similarly, Shikuku and Amadalo (2015) results on linear programming skills in secondary schools in Kenya indicated that learners who were exposed to PBL teaching method achieved better results compared to students who were taught using conventional lecture teaching method.

In a study involving chemistry practical and calculations, Goldstein (2009) found that male students outperformed their female counterparts. Similarly, Olaoye and Adu (2015) study on students' gender differences in academic achievement established a higher level performance of male gender in comparison to female students in chemistry. In addition, Moronfolla (2012) found that female students had difficulties in plotting graphs, as well as, solving problems involving calculations. Furthermore, Moronfolla (2012) argued that this might be as a result of the abstract nature of some chemistry concepts. However, Omosewo (2012) study did not find significant gender differences attributed to academic achievement in chemistry.

One of the notable active instructional methods used by teachers is demonstration teaching method. This teaching method casts the instructor as principal actor as learners diligently observe teachers' actions. The students are expected to repeat what was done by

the teachers later. Ameh *et al.* (2007) observed that the method allows the teacher to explain to the learners how a process is procedurally done in a stepwise manner. Likewise, one study succinctly reported that demonstration is an exhibition that is often carried out by the instructor, as the students look at the procedure with intention to act later (Mundi, 2006). In most cases, demonstration may include illustrative materials, such as, diagrams and charts which are followed by a verbal presentation (Seevers & Graham, 2012).

Considering the context of the current study, incorporating demonstration teaching method may improve students' cognitive skills, as well as, psychomotor skills especially when the students are allowed to follow procedures that were demonstrated by the teacher either individually or as groups (Daluba, 2013). Similarly, demonstration as a teaching methodology forms an integral part of an agricultural education training because it provides for application of concepts taught in class, as well as, allowing transfer of acquired skills to real life situations. Daluba (2013) reiterated that demonstration method of teaching increases student's interest and understanding in a subject, consequently promoting high performance in a subject. According to Chikuni (2003), demonstrations take two forms, namely the whole process and step by step demonstrations. Executing the former, the instructor is expected to perform a series of steps from the onset to the end with little interference from the students to enable the learners to observe the process with maximum concentration (Chikuni, 2003). The second type of demonstration proceeds as the whole activity is explored in phases as students participate in the process. This type of demonstration accommodates students with different learning abilities.

Agricultural education plays a vital role in promoting food security in Kenya. This therefore, calls for providing the students with information that is useful in development of skills required in agriculture, to make learners productive in agricultural production (Waiganjo *et al.*, 2014). In most instances, students' performance forms part of the parameters used in gauging the degree to which the students have been equipped with requisite facts and expertise (Waiganjo *et al.*, 2014). Because many Kenyans rely on agricultural enterprises for their livelihoods, high academic accomplishment in the subject is critical to the continuation of the agricultural industry. The general performance of secondary school students in agriculture subject in the Kenya National Examinations Council (KNEC) has been satisfactory (KNEC, 2019). The report observed that the mean scores in the subject had been consistently above 50 percent for the period from 2011-2019, Table 1.

Table 1*KCSE Performance in Agriculture Subject (2011-2019)*

Year	Number of Candidates	Mean Score
2011	167,709	74.33
2012	178,424	55.69
2013	178,771	67.19
2014	191,362	83.00
2015	206,127	89.61
2016	228, 443	61.75
2017	247, 265	54.75
2018	278, 658	60.57
2019	289,315	64.82

Source: Kenya National Examinations Council (2019). *The 2019, Kenya Certificate of Secondary Education (KCSE) Examinations Essential Statistics*

Teaching methods, as well as, strategies that translate and drive learning and attainment of psychomotor skills, may be linked to students' high accomplishment in the agriculture subject in Kenya. The national examination body (KNEC, 2013) offered advisory service to agriculture teachers to make use of instructional procedures that inspire acquisition of practical skills and retention of knowledge. Kibett (2002) reiterated that effective methods should help learners to solve problems using acquired knowledge. According to KNEC (2013) report, teachers of agriculture should encourage wider student readership to understand agricultural principles and applications. This can be achieved if agriculture is taught using a variety of active teaching methods, such as, PBL.

Hands on experiences on the school farm and participation of students in club activities are essential in improving learning in agriculture subject. That is why; Ngesa (2006) noted that agricultural clubs such as Young Farmers Club (YFC) is important in improvement of quality life in Kenya, however, Ngesa (2006) observed a trend where majority of students took active roles in agricultural shows and examinations while very few students in general engaged in agricultural club activities. The importance of YFC activities in a school setting cannot be ignored. This is because the club can be used as a springboard for good academic performance. The club is important in the school set up since the clubs are crucial for students in the proficiency and achievement of skills in the learning domains. This is because skills are developed best through practicing. According to Njoroge *et al.* (2014), increased

engagement of youth in agricultural production through young farmers clubs is a good step to making the country food secure. The central purpose of YFC of Kenya is mentoring and teaching youth to be productive in their future careers as farmers. Notably, secondary school education has always been terminal to the majority of the youth in Kenya; however, if students fail to attain lifelong skills in agriculture, they may end up with poor lifestyles; as a result of which, there would be a decline in agricultural productivity (Njoroge *et al.*, 2014).

Research findings document that teachers using lectures rarely involve students during training process (Umar, 2012). In most of the times, the use of lectures allows for less meaningful academic relation, which lead to boredom of students (Seevers & Graham, 2012). In this method, the teacher dispenses knowledge to passive learners. In using the lecture method, the teacher has the leeway to cover a large content within a shorter time; however, as noted by Umar (2012), the method does not encourage mastery of concepts by students. In essence, lecture teaching method does not take into consideration the existing students individual differences, which may lead to retention of less information during lectures.

There has been a growing desire in Kenya to restructure the educational system to be more responsive to students' needs and goals by moving away from a traditional knowledge based approach and toward a competency based approach. As a result, the Kenya Institute of Curriculum Development (KICD) and the Ministry of Education (MoE) have embraced Competence Based Curriculum (CBC), which is considered as a better alternative to the 8-4-4 examination based system of education (KICD, 2017). The new 2-6-3-3-3 education system is said to be a more participatory curriculum that can assist pupils develop a variety of skills and knowledge by putting what they've learned into practice (Namwambah, 2020). Competency Based Curriculum has been aligned to various policy documents, such as, the Kenya Vision 2030, the Constitution of Kenya 2010, the Taskforce report on Re-alignment of Education Sector, the Sessional Paper No. 2 of 2015 on 'Reforming Education and Training, on 21st Century skills and Harmonised Curriculum for East Africa states (KICD, 2017).

Kenya's Vision 2030 goals are focused at strategically transforming the country into a middle-income country by 2030. This would be accomplished by providing free basic education and vocational education, both of which provide skills for the economy by connecting Kenyans via languages and social studies, as well as emphasizing mathematics and sciences (Akala, 2021). These recommendations would ensure that Vision 2030's economic, social, and political cornerstones are realized.

The United Nations (UN, 2015) announced a global initiative to ensure a systematic reduction in the gap between labour market needs and educational requirements. As a result,

the United Nations launched the Sustainable Development Goals (SDG) agenda, which aims to provide universal access to high-quality secondary education (2015). This program would be realized through competency-based instruction, which would allow students to gain the mastery skills needed in the twenty-first century (UN, 2015). Many industrialized countries in Europe, Asia, and America have introduced Competency Based Curriculum in their education systems. It's also worth noting that CBC has been adopted in various African countries, including South Africa, Rwanda, Mozambique, Tanzania, Zambia, and Zimbabwe (Kaviti, 2018; Mulenga & Kabombwe, 2019; Ondimu, 2018).

Educational achievements in agriculture subject by the students in Kenya have displayed a general improvement as reported by Kenya National Examinations Council (2019). However, the good students' performance has not been replicated in Ndhiwa Sub County (Table 2), where the students' achievement in the subject has been below average. The scenario may be caused by instructional culture. Therefore, the study sought to examine the comparative effects of teaching methods (Problem Based Learning, demonstration and lecture) on achievement of students' in agriculture in Ndhiwa Sub County.

Table 2

KCSE Performance of Agriculture Subject in Ndhiwa Sub County (2011-2016)

Year	Number of Schools	Sub County Mean Score
2011	33	46.91
2012	33	52.41
2013	36	48.67
2014	39	48.91
2015	44	45.25
2016	45	40.07

Source: Ministry of Education Science and Technology (2016) Ndhiwa Sub County Education and Prize Giving Day Manuals.

According to a research by the Kenya National Bureau of Statistics (KNBS) and the Society for International Development (SID), Ndhiwa Sub County was purposefully chosen for the study due to poor literacy levels (KNBS & SID, 2013). Ndhiwa Sub County had the lowest percentage of residents with a secondary education, at 11percent, compared to Homa Bay County, which had an average of 17 percent. In some ways, this environment may have led to pupils' poor performance because they lack mentors at home. Except for the year 2012,

when the mean was 52.41 percent, the Sub County performance in agriculture has constantly been below the average mean score of 50 percent, as shown in Table 2. Second, according to a survey conducted by the researcher on the most common agricultural teaching methods in the Sub County, the majority of the respondent agriculture teachers use the lecture teaching method first, followed by the demonstration teaching method. The survey was conducted in order to justify the inclusion of the two teaching methods in the study. Despite being an active teaching technique that has proved its superiority in boosting student achievement, Problem Based Learning was included in the study since it was not employed as a teaching method at all among agricultural teachers. The study was conducted in Ndhiwa Sub County due to the low achievement of students in agriculture subject, low literacy levels, and the frequent use of lecture teaching method in agriculture education. The goal of the study was to uncover effective teaching methods that would improve agriculture students' learning and, as a result, their achievement in the subject. In Ndhiwa Sub County, this was accomplished by comparing PBL, demonstration teaching method, and lecture teaching method.

1.2 Statement of the Problem

The student's achievement in agriculture subject in the Kenya National Examinations Council (KNEC, 2019) has been generally satisfactory. However, this observation has not been reflected in Ndhiwa Sub County, despite the availability of numerous outlets for learning agriculture. Many students have repeatedly demonstrated low achievement in agriculture subject in the KNEC examinations. Similarly, as shown in Table 2, students' achievement levels in agriculture subjects in the Sub County have consistently been below the average mean score of 50 percent for the years 2011-2016. Students' low achievement in the subject has an overall impact on their final grade, as well as, school mean grade. This scenario may jeopardize students' prospects of enrolling in agricultural-related occupations, resulting in a shortage of competent workers in agricultural-related professions, which could undermine Kenya's achievement of Vision 2030 targets. The low outcomes could be attributed to teacher centred instructional methods, as well as, other factors not examined in this study. Therefore, there was need to explore other active teaching methods like Problem Based Learning (PBL) and Demonstration Teaching Method (DTM) which have been tried in other places and found to work well in improving students' academic achievement. Several empirical studies in Kenya explored the relationship between teaching methods and learner achievement in different clusters of subjects. However, there are few, if any, research in Kenya that have looked at the relationship between PBL and agricultural achievement at the

secondary school level. As a result, the study looked at the comparative effects of PBL, DTM, and Lecture Teaching Methods on secondary school agriculture students' learning outcomes.

1.3 Purpose of the Study

The purpose of the study was to compare the effects of educating students in Ndhiwa Sub County using Problem Based Learning, Demonstration Teaching Method, and Lecture Teaching Method, and to document how these teaching methods affect students' agricultural achievement in the Sub County.

1.4 Objectives of the Study

The following objectives guided the study.

- i. To compare the effect of PBL method and lecture teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County.
- ii. To compare the effect of demonstration teaching method and lecture teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County.
- iii. To examine the effect of PBL method, demonstration teaching method and lecture teaching method on academic achievement in secondary school agriculture with regard to gender of the students in Ndhiwa Sub County.
- iv. To compare the effects of PBL method and demonstration teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County.

1.5 Hypotheses of the Study

The following null hypotheses were used in the study.

- H0₁** There is no statistically significant difference in the effects of PBL and lecture teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.
- H0₂** There is no statistically significant difference in the effects of demonstration and lecture teaching methods on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.

H03 There is no statistically significant difference in the effects of PBL, demonstration teaching method and lecture teaching method on academic achievement of secondary school students in agriculture with regards to gender of students in Ndhiwa Sub County.

H04 There is no statistically significant difference in the effects of PBL and demonstration teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.

1.6 Significance of the Study

Results from this study may improve students' achievement in agriculture subject, as well as, contribute to the knowledge base of teaching and learning as a process in education in general, and specifically in the field of agricultural education. Furthermore, the study is expected to establish a starting point for subsequent studies in the teaching-learning processes of various school subjects. The findings from this research coupled with the body of knowledge gathered during the study may provide basis for improving the teacher preparation programmes at the universities and teacher training colleges in Kenya for pre-service teachers. The findings of the study are also expected to inform practicing teachers of an alternative teaching method, as well as, provide a case for integration of PBL method into teacher education programmes. More significantly, the results are expected to entrench a method that should be used by teachers to help students develop problem solving skills.

1.7 Scope of the Study

The study compared effects of PBL, demonstration and lecture teaching methods on achievement of students who were given instruction through the aforementioned methods. The research study was limited to teaching methods used in teaching agriculture subject. The study was carried out in Term One from January through March, 2019. The independent variables in this study were PBL method, demonstration teaching method and lecture teaching method. The dependent variable was learning outcomes that were to be measured using an agriculture achievement test. The study involved 18 schools composed of Form Two students in Ndhiwa Sub County. Some six selected schools were instructed through PBL and another six schools followed demonstration teaching method. The rest of the students in six schools were exposed to lecture teaching method which acted as teaching method and control for the experimental treatments. The experiments were scheduled to last for six weeks. The topic that was used for instruction for all the groups was "Livestock Production II"

(Nutrition) as per the secondary school agriculture syllabus. In addition, agriculture achievement test was derived from the Livestock Production (II) Nutrition topic in Form Two secondary school agriculture syllabus which covered the following units of learning. Components of feeds: water, carbohydrates, fats, proteins, minerals and vitamins, Feeds and feedstuff: roughages and concentrates, concepts in rationing, ration computation, digestion in ruminants, and digestion in non-ruminants (pigs and poultry) differences and similarities between ruminants and non-ruminant digestive systems and appropriate livestock handling techniques while feeding.

1.8 Assumptions of the Study

The researcher assumed that;

- i. All the respondents involved in this study were honest in giving the required information.
- ii. The students' achievement scores in agriculture marked and presented by the agriculture teacher to the researcher were a true reflection of the achievement scores obtained in the agriculture achievement test during pretest and posttest.

1.9 Limitations of the Study

The under listed shortcomings were experienced during this study;

- i. There were few studies in Kenya on the PBL method. As a result, most of the relevant literature sources used on PBL were mainly drawn from European and the American experiences.
- ii. The schools in the study were limited to public secondary schools in the Sub County and County category. There were no national and private secondary schools included in the study because they were not represented in Ndhiwa Sub County.

It is evident that educational settings in Kenya may be considerably varied; this scenario is not different to schools in Ndhiwa. Notwithstanding, it is difficult to be prescriptive about particular results of this study. The results are limited to secondary schools in Ndhiwa Sub County and to a specific context of the research study and therefore, findings may be used to make generalizations on specific effects of PBL, demonstrations and lecture teaching methods on students' achievement in agriculture and the results should not be applied to dissimilar levels of schooling. However, the outcomes may be applicable to comparable schools having the same circumstances.

1.10 Definition of Terms

The following terms assumed meanings indicated against them in this study;

Academic Achievement: This is knowledge attaining ability in education matters mainly quantified by examination and graded depending on students' attainment (Ganai & Muhammad, 2013). In this study, it was defined as achievement in agriculture examination as measured by scores in agriculture moderated achievement test.

Lecture teaching method: This is a method of instruction where the teachers control the subject matter to be learnt and the teacher presents information orally to the learners (Paul, 2015). The term was defined as a teacher centred method where the teacher dispenses knowledge orally to passive learners.

Demonstration teaching method: This is a method where the teacher shows student's how something is done from one stage to the next (Ameh, Daniel & Akus 2007). In this study, the method involved verbal and practical explanations by the teacher during instruction.

Teaching: Explaining, persuading, demonstrating, leading, inventing, and instructing are all part of the process of teaching (Nasibi, 2003). It was defined as a method of imparting information, skills, and values to students in order to help them improve their behaviour through experiences of PBL, DTM and LTM.

Problem-Based Learning (PBL): Refers to instruction that is executed by use of problems (Dutch, 2016). In this study, it is a teaching method where students are presented with contextualized problems where they are challenged to find solutions as they work in small groups.

Secondary School Agriculture: This is the processing and adding value to the basic agriculture commodities (O'Shea *et al.*, 2012). It was defined as the content of agriculture syllabus that is taught from Form One to Form Four in secondary schools.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The teaching methods discussed in this chapter include Problem Based Learning, Demonstration, Lecture, Discussion, Field trips and Projects, respectively. In addition, the theoretical and conceptual frameworks are presented at the end of the chapter.

2.2 Teaching and Learning in Agricultural Education

In agricultural education, instructional methods are critical in advancing the required skills and technologies for agricultural production. In the United States, schooling is provided with the primary purpose of preparing students to meet the challenges of the twenty-first century, which necessitates that students be adequately trained with skills to deal with work-related challenges (Doerfert, 2011). As a result, a paradigm shift in teachers' instructional methods should occur, moving away from conventional teaching methods toward active teaching methods (Estep & Roberts, 2013). Consequently, agriculture teachers should have a solid understanding of the subject matter in order to provide instruction using student centred approaches (Whittington, 2005). Furthermore, Blythe *et al.* (2015) observed that using an inquiry-based learning approach was more beneficial to students' knowledge of agriculture than using teacher centred instructional methods. Additionally, Seemiller and Grace (2016) stated that realistic teaching experiences and internships should be included in students' curriculum for effective agriculture teaching.

The teaching of agricultural education in European countries is oriented toward the implementation of technologies that foster sustainable agricultural practices. As a result, educator's job is to prepare students to respond to today's challenges by teaching them about sustainable agriculture (Meek & Tarlau, 2016). According to Samarasekera *et al.* (2014), educational institutions bear sole responsibility for providing students with skills through effective teaching practices in order for them to establish the fundamental competencies required in the agricultural industry. Roberts (2006) suggested that agricultural education curriculum be supplemented with experiential learning opportunities that emphasize learning through doing in a separate study. As opposed to teaching methods that rely on direct instructional methods, instructional methods that are functionally dependent on experiential learning have a significant effect on students' cognitive skills, as well as, their attainment of psychomotor skills. Since its inception, agricultural education has been linked to the

development of curriculum rich in experiential learning, with a focus on learning through doing (Roberts, 2006). As opposed to education focused on direct instruction, Baker and Robinson (2016) observed that instruction based on experiential learning had a positive effect on students' creative intelligence, as well as, realistic intelligence.

A study commissioned by the World Bank (2002) found that the curricula and teaching methods used in the teaching of agricultural education in developing countries like Bangladesh are not applicable to the needs of students, as well as, the development objectives of the respective individual countries. According to Gazi *et al.* (2009), agricultural teacher preparation is insufficient in many respects. For example, the students' curriculum does not provide students with opportunities for industrial attachment and apprenticeship programmes, making teaching and learning theoretical.

Agriculture is taught in Sub-Saharan Africa using a variety of teacher centred and student centred instructional strategies. According to Vandenbosch's (2006) study, many teachers in Sub-Saharan African secondary schools and technical and vocational education and training systems use a variety of teaching and learning experiences to adequately prepare students for the industry. Field trips are one of the techniques used in teaching agriculture, and they are used to supplement other teaching methods in order to break up the monotony of the classroom and enrich the students' learning experiences. According to Davidson *et al.* (2010), well-organized field trips with reconnaissance studies conducted by the agriculture instructor and subsequent active participation of students during the field trip may have a major impact on students' learning and attitudes. Ogbulujah (2014) study found that field trips provide students with a wide variety of learning opportunities, as well as, practical learning exposure to current farming technologies and agricultural processing methods, in a study conducted in Nigerian secondary schools.

Teachers of agriculture in Kenya use a variety of instructional methods. As a result, the instructional form to be used is determined by the teaching material in question (Kisirikoi *et al.*, 2008). Interaction, collaborative, transmission, experiential, and facilitation techniques are all different types of teaching methods. Interaction approach, as described by Wanzala (2013), is the substantive exchange of ideas that occurs during group work between students and teachers, as well as, between learners themselves. Similarly, in agricultural projects, a collaborative approach involves sharing of ideas among students. The transmission method allows the instructor to use lectures to dominate classroom instruction. Students' learning is focused on past experiences, which are used as a springboard for the acquisition of new knowledge through an experiential approach. The teachers' role in the facilitation approach is

to guide students by guiding their learning as they explore new information. According to Vandebosch (2006), the most popular teaching methods used in agricultural education are lectures, discussions, demonstrations, field trips, and projects. Agriculture teachers have a big say in choosing new and creative participatory approaches in teaching agriculture (Konyango & Asienyo, 2015). As a result, it is the teacher's duty to determine the approach that best suits the material to be learned in order to bring out the best in students (Ohiwerei & Nwosu, 2009).

2.3 Students Learning and Assessment of their Performance

Different education practitioners and the general public have a firm belief in the benefits of gradually increasing science achievement (Noor & Hamidon, 2016). The National Commission on Excellence in Education in America focused on the effort to increase student success in science disciplines (Mintzes & Wandersee, 1998). The study provided a thorough examination of students' poor performance in science education in America, owing to the use of teaching methods that do not promote imagination and innovation in young students. Due to low student achievement, many students in the agricultural industry are unprepared with agricultural communication skills that are essential for the dissemination of agricultural innovations (Leal, 2016).

Notably, in the Australian context, there was persistent low achievement of students in mathematics and science disciplines. This scenario necessitated the Government of the day to set up an excellence centre responsible for mathematics and sciences with a mandate to actively support the teaching of mathematics and science in a better way that would enhance students' achievement (Fraser & McRobbie, 1995). In this regard, there were factors that were recognized as primary indicators of low achievement in sciences. These factors include; use of instructional methods that promote memorization of knowledge, inappropriate mix between boys and girls, negative thinking towards learning of science related subjects and careers, as well as, lack of enough facilities for teaching of sciences in the schools (Ejakait *et al.*, 2011; Fraser & McRobbie, 1995).

Internationally, education is considered powerful and a worthy investment to any sovereign state. Education is used in promoting every aspect of community development (Hanushek & Woessmann, 2007). Therefore, it is regarded as the centre for promotion of quality life and a bright future. According to Gachukia (1999), proper investment in education will raise economic development of a country; this eventually will substantially reduce death of infants and their mothers, thereby improving family health, and at the same

time, making education of children a priority. In addition, Bargetuny (1999) asserts that educated citizens have the capacity and ability to prudently manage the natural resources. The environmental resources, if well managed, may reduce instances of absolute poverty. The author further asserts that education increases the chances of citizens in actively getting involved in community service and domestic affairs, as well as, participation in the republic's political system. Therefore, it is believed that, education improves the living standards of her citizens.

In Kenya, secondary schooling is designed at realizing national goals of education. The first purpose of education is aimed at fostering a feeling of togetherness through unity among the different tribal orientations, genetic heritage, as well as, religious groups in Kenya (Republic of Kenya, 2008). This sense of common understanding encourages individuals with diverse backgrounds to harmoniously live in a common habitat in peace; as a result, these people are encouraged to maximally contribute to the economic growth. Secondly, education is meant to produce citizens who are well equipped with extensive knowledge base that is essential for rapid economic growth. Therefore, for a country to realize faster economic development, the citizens should be equipped with high quality education coupled with modern technical skills (Republic of Kenya, 2010). Thirdly, education is aimed at enabling the students to develop fascinating attitudes and social relations that are essential in creating the enabling values, beliefs, customs and practices for faster economic growth. Fourthly, education is aimed at enhancing equal opportunities and a sense of sustainable development. It is therefore, believed that education system should always aim at ensuring that all citizens have equal opportunities for learning. It also allows for competitive atmosphere for a person's well-being along with inspirational chances used in communal advancement of one's natural skill, their diverse interests and abilities, social, as well as, religious orientation (Orodho *et al.*, 2013).

The Kenya Institute of Education (2006) clearly outlines the content in agriculture syllabus relevant to high school learners. Teaching should concentrate on learning the basic principles necessary for agricultural production. The student should realize and be aware about the objectives of teaching secondary school agriculture by developing curiosity and consciousness of opportunities available in the agricultural sector, to generate a better comprehension and relevance of agriculture to the family, besides practically demonstrating that farming is a noble occupation. Finally, to advance and go beyond information and expertise acquired through experience in basic agricultural practices. The other goals are to adequately prepare students for higher education, develop self-sufficiency, imaginative,

analytic and a job-related viewpoint on agriculture, support good agricultural practices that are cognizant on environmental conservation and wellbeing, and taking a leading role in countryside growth through incorporating agrarian enterprises in the syllabus (Republic of Kenya, 2012a).

Academic performance has been regarded as the extent to which both students and the teachers, together with the school, have attained learning outcomes that are usually determined by national examinations or regular assessment tests, using varying grading structure (Ward *et al.*, 2011). Indeed, education in any country performs an indispensable function to spur economic growth. Education supplies required critical personnel that can effectively change other resources into outputs that are valuable. As such, education is used as the sole vehicle for provision of economic and social development of individuals in a society (Orodho, 2004). Schools as organizations in the society are started with the sole responsibility to assist the wider society to increase cognitive knowledge, positive attitudes and psychomotor skills (Okumbe, 1998). Additionally, schools are supposed to advance dual goals namely, performance objectives and organizational maintenance objectives. In essence, schools follow these performance objectives by striving to achieve higher mean scores in national examinations. On the other hand, organization maintenance goals are activities such as good academic performance in examinations, training students to obey rules and codes of behaviour, excelling in after school programmes and displaying good mannerism (Okumbe, 1998). In secondary school settings, the achievement of the two goals involves provision of quality education. Good academic preparation by the teachers is often gauged by how students perform in national examinations (Adair, 2009).

Teachers employed to teach in secondary schools have been trained on various instructional methods used in the teaching of agriculture subject. Therefore, teachers use various pedagogical methods at their disposal in various subjects. Some of the most common methods used include lecture, discussions, projects, demonstration, problem solving, and occasional field excursions. However, the use of these methods depends heavily on the availability of facilities and resources as per the status of the institution (Munyao, 2014). According to Daluba (2013), it is imperative for teachers to continuously arrest students' attention, interest and curiosity during classroom teaching, and if operationalized, it may promote students' achievements. Using teaching methods that are activity based and at the same time actively engages the students, like PBL method and demonstration teaching method, should be embraced instead of depending on the lecture method (Daluba, 2013).

Teachers in secondary schools in Kenya use different teaching methods in teaching agriculture subject. According to Miles (2015) teachers should use instructional methods that fully engage learners. If that is effectively implemented, students are expected to drastically improve on their academic performance. Teaching methods that can bring improved academic achievement in students should involve methods that promote better social interaction amongst students through group interactions. Therefore, the social engagement taking place in the classroom facilitates students teaching (Nguyen *et al.*, 2012). Additionally, the students should be accorded supportive atmosphere that may allow them to discover knowledge.

Assessment has been described as the systematic collection of useful statistics about educational programmes, which are reviewed and used to improve learning (Palomba & Banta, 1999). In addition, Spiller (2009) asserted that assessment forms an integral part in determining what is learnt in schools. A study by Caffrey (2009), observed that a good assessment method should serve four fundamental purposes: instructional, where results are used to alter instructional methods and materials to suit students' desires; predictive in which the results are used to determine whether or not a student will meet a set goal; diagnostic, where assessment is used to determine students cognitive ability and observable strength and weakness and finally, evaluative, to find out whether the learning outcomes stated in a particular curriculum are being achieved. In reality, it is impossible for one assessment to meet all the requirements of the four objectives; therefore, Caffrey (2009) further suggested a comprehensive assessment of students which combines elements of both formative and summative assessments.

There are two approaches to assessments as identified by Dikli (2003). They include traditional assessment and alternative assessment which may be performance or authentic assessment. Performance assessment is concerned with production of a permanent product through the process of vigorous production of an answer which is observed directly or indirectly. Whereas, authentic assessment occurs in situations where the task at hand and the situation in which the assessment is done, the assessment must be pertinent and should represent the actual existing problems.

According to Dikli (2003) a project is defined as a method of assessment that allows the learners to apply and display their knowledge about a particular topic. The project may be administered to individual students or in groups. Students are presumed to address emerging challenges in doing the project. Finally, the students are expected to present their findings in various forms such as role plays, presentations and written reports (Dikli, 2003). In the

teaching and learning process, the use of project teaching method has been recommended over the years because of its holistic approach. In this regard, project work is usually aligned to the curriculum content and the assessment is intended to evaluate student's natural ability regarding application of learnt materials (Asim *et al.*, 2012).

Assessment in agriculture subject in secondary schools is done using three papers namely; agriculture paper one (443/1), agriculture paper two (443/2) and agriculture paper three (443/3), respectively. In practice, agriculture paper one (443/1) and agriculture paper two (443/2) are both theory based while, agriculture paper 3 (443/3) is project based. The agriculture paper tests the candidate's competence in understanding agriculture principles, concepts and practices where skills in cognitive, psychomotor and affective domains are tested (KNEC, 2014). It tests the candidate's practical skills in growing a selected crop, from land preparation to harvesting, rearing selected livestock to maturity or construction of farm structures (KNEC, 2014). According to KNEC (2010) students usually perform better in agriculture paper one (443/1). This has been established because students are most of the time given crop production projects in the project paper, agriculture paper three (443/3).

Despite the numerous avenues available for teaching secondary school agriculture in Ndhiwa Sub County, students have continued to perform poorly in agriculture, according to the current report. As a result, the study looked into teaching methods as one of the factors causing underachievement in agriculture, especially in Ndhiwa Sub County.

2.4 Instructional Methods and Performance of Students

Agriculture is one of the undisputed sectors considered key to Kenya's economy. In fact, a country's economic stability is usually estimated by the flexibility on how a country efficiently exploits plant based resources (Diamond, 2005). There will be a major challenge in the production of feed and biofuel feedstock to sustain the fast growing global population that may be estimated to be nine billion people in the year 2050 (United Nations Department of Economic & Social Affairs (UN DESA, 2009). As a result, students should be prepared in ways that are sustainable to meet the global challenges in food production. This calls for a paradigm shift in ways teachers employ their instructional methods to adapt to the ever changing world. As a result, there is a need for teachers to change instructional methods from memorization of knowledge to active learning methods that emphasize problem solving to encounter the contemporary issues of the world (Trivedi, 2013). Indeed, education experts have noted that students' academic achievements improve when active learning methods are used. Consequently, conventional instruction methods are being replaced with active teaching

methods (Dewitte & Rogge, 2012). Notably, PBL as an active method is gaining ground in secondary school education (Maxwell & Mergendoller, 2005).

According to Rich (2010) there has been a growing skills deficit on problem solving skills within the young population which endangers United States of America (U.S.A) global economic competitiveness in comparison to its peers around the world. This is because those applying for jobs are turned away by employers because they do not have the skills required for those jobs. As a result, they remain unemployed (Rich, 2010). This scenario was attributed to a mismatch between the skills required in the industry in comparison to low level skills from those seeking employment. According to Gordon (2009), author of *Winning the Global Talent Showdown*, most young employees are addicted to social technology networks, however, most of them lack the talent qualifications and lack of interest in occupations based on designing, producing, restoring and using several 21st Century technologies (Gordon, 2009).

The realities in the industry today, demands that one must be well equipped with lifelong problem solving skills to succeed in a knowledge economy (Bray *et al.*, 2010). Therefore, the employers warn that if there are skills shortages among the students, it can endanger the economic growth and global competitiveness of a country, especially in the science, technology, engineering and mathematics (STEM) areas (Bray *et al.*, 2010). In such a scenario, there would be a mismatch between employees' competencies with the skills required in the economy. Therefore, the education system and the industry should support students in adapting to technological realities of the 21st Century (Bray *et al.*, 2010).

Considering the Netherlands and American experiences, the political aspects of educational reform first came from United States of America when they internationally compared their students' performance in specific scientific areas such as mathematics, scientific literacy, as well as, problem solving. Because of advanced development in technology, it is mandatory for the students to have both investigative and practical skills. Students should show proficiency in a variety of skills required to function well in different careers within United States (Haynes, 2012).

Instructional techniques, to a larger extent, influence the degree to which knowledge is synthesised and retained by the student (Duruji *et al.*, 2014). The instructional techniques include teacher-centred methods together with student centred methods. In the former, the teacher provides knowledge to the submissive learners, through lectures, with the conclusive goal of testing and assessment of students (Duruji *et al.*, 2014). In the latter, proper engagement is systematically achieved in the classroom. Facilitation of learning is

purposefully done to measure products of learning using formal and informal assessments. In essence, the methods teachers use has relevance on comprehension of a subject. Therefore, the performance of students in a subject mirrors on the methods used (Duruji *et al.*, 2014).

Using appropriate instructional methods often lead to good teaching, thereby, accomplishing a desired result. In this regard, appropriate utilization of teaching materials in the classroom immensely improves the classroom transaction (Akerele & Afolabi, 2012). Alongside this, Ayinde (1999) argued that proper use of video and audio stimulate interests in the subject, as well as, aid in assimilation of knowledge. In addition, Fakunle (2008) reiterated that students remember 90% of what was seen during instruction, whereas, only 10 percent is remembered through reading. In Uganda, use of substandard teaching methods; integrated with limited teaching exposure combined with teachers' weak academic orientation, as well as, lack of a regular professional growth, hinder students teaching (Opolot-Okurut *et al.*, 2008).

Several empirical studies in Kenya have investigated the link between teaching methods and students' achievements. The studies have focused on Chemistry (Wachanga & Mwangi, 2004) Biology (Muraya & Kimano, 2011) and Business Studies (Odundo & Gunga, 2013). None of these studies has examined the connection between PBL and students' academic attainments in secondary school agriculture. Academic literature on PBL remains scanty in terms of school results in agriculture subject, especially in Kenya.

2.5 Teaching Methods in Secondary Schools in Kenya

Teacher-centred methods are instructional pedagogy that allow the teacher to be at the centre of classroom activities, (Ahmad & Aziz, 2009). These methods encourage students to have a distinct and predetermined perception of their roles as submissive audience; on the contrary, the teachers are the ones dominating classroom talking. This scenario hinders students' active participation in the class. In another study, Tanner (2009) observed that teachers' frequently dominate lecture room talks while the students only contribute in class when giving responses to questions. Similarly, Adeyemi (2008) for instance, noted that lectures fail to arouse interest concerning creativity alongside research, but to some extent, the method leads to cramming. Similarly, methods that are dependent on the teacher are characterized by boring lessons that result into poor discovery of knowledge (Tella *et al.*, 2010).

Instructional methods have generated considerable debate regarding their effectiveness. In this regard, another study examined the success of a learning method which

is dependent on teacher and student-centred method on students learning outcomes (Chang, 2010). The results revealed personalized learning changed students' perceptions towards the learning of science subjects. This was because; many students valued their participation in groups, than mere classroom attendance. Therefore, learner-centred methods were found to promote teaching versatility besides encouraging cognitive discourse (Chang, 2010). Additionally, learner-centred methods influence positive and meaningful engagement of students during the study. Thus, students develop bright outlook regarding object of interest, as well as, making students have good mastery of the subject matter. In an environment where learning is learner-centred, students assume full responsibility for their learning, whereas, the teacher, acts as the facilitator in the student teaching (Ahmad & Aziz, 2009).

According to Froyd (2007), collaborative learning involving connection of new information with previous knowledge constitutes a learner-centred pedagogy. Learner centred methods encourage representative engagement during a discussion process, which in essence promotes brainstorming. In the process, students' communication ability is enhanced and this goes a long way in improving students' performance in class (Cummins, 2007). The advantages of this interactive method has been emphasized by Chika (2012), who reiterated that interactive teaching methods have been found to increase students' academic performance when compared to teacher-centred methods. Additionally, Kumar (2006) also concurred that students' centred methods have a lot of influence on the general students' academic performance as compared to teacher centred pedagogies.

2.5.1 Lecture Teaching Method

This method of imparting knowledge is a popular method of instruction that has led to supporting and opposing arguments. Therefore, users have been warned against false feeling that students have been taught well, especially when students are able to remember isolated concepts (Keshta & Harb, 2013). These misconceptions may be identified when students are examined at higher levels of learning when they are found with a lot of misunderstanding concerning the learnt material. In addition, Odundo and Gunga (2013) observed that lecture method is characterized by presentation of a lot of content, leading to learning of a few concepts.

In lecture method, facts and concepts are presented verbally to passive learners (Umoren, 2001). Lecturing is a preferred mode of instruction by teachers because; it is an easy method to transmit information to the students (Veselinovska, 2011). This method

generally leads to transmission of information in one way, leading to poor understanding, as well as, low retention of information. Evidences from many disciplines demonstrate that teaching through lecture method often brings about limited study experiences (Veselinovska, 2011). This calls for a policy change on the manner instructional methods are used to reflect the dynamic nature of today's society. If this happens, then, students trained using the active methods are likely to fit well in the society, as well as, possess the skills to make informed decisions. Therefore, selection of a good teaching method is instrumental in the learning process.

Considering that learning is a process that involves investigating, as well as, using innovative ideas to solve problems, teachers have recognized that learning is productive if the learners are tasked to implement instead of being asked to remember information (Ganyaupfu, 2013). Lecture method has never promoted active participation of learners, nor built the required level of reasoning among students. However, a better understanding of the concepts is achieved when students are collaboratively engaged in problem solving (Ganyaupfu, 2013).

Lecture method limits learners to note taking and listening as the main activity during the teaching and learning process. Measurement involving paper and pencil test is a common practice in many schools. This scenario significantly contributes to the use of lectures, as a result; it makes learning process to be based on memorization (Scott, 2005). That is why Scott (2005) referred to students taught using lecture method as brilliant students with the potential to pass with good grades. The conclusion is the non-fulfilment of learners to be in charge for their own learning (Illeris, 2007). Lecture method relegates students as information receivers with little activity on their part (Williams & McClure, 2010), leading to low knowledge retention, as well as, a decrease in students' attention.

Surprisingly, the lecture teaching method places a greater emphasis on what is learned rather than the learner, and as a result, the method has struggled to improve the learners' ability, owing to the emphasis on completing the syllabus. According to Ogide (2017), the lecture teaching method is widely used in universities, implying that the method of instruction makes learners passive and learning shallow because teaching is prioritized over learning, with teachers dispensing information to passive students. During the teaching-learning process, it is believed that teachers are the only educated individuals. Students, on the other hand, may be made useful in a variety of ways if they are made responsible for their own learning. Students, as Ramsden (2003) points out, may play an important role in setting

up experiments and developing teaching resources. As a result, Young *et al.* (2009) noted that by varying their presentations, teachers can reduce boredom during lectures.

In another study, Scott (2005) observed that students can increase the retention of what is taught when they use problem solving skills during teaching and learning process. The students can achieve this by analysing, evaluating and synthesising information used in solving problems. Active learning methods highly strengthen student's learning by improving knowledge retention instead of memorization of facts (Gleason *et al.*, 2011). Learning enables students to connect old concepts with new concepts to aid mastery (Limbach & Waugh, 2010).

The point of convergence in the lecture method was passing considerably detailed information to many students (Gehlen-Baum & Weinberger, 2014). However, evidence from research attests to the fact that when lectures are used in science based courses, there is low retention of knowledge. In such a scenario, Bok (2006) observed that an average student can only retain 42% of what is learnt at the end of the lecture and a paltry 20% one week later. That is why the method is considered, by any means, deficient in attributes of collaborative learning pathway (Berry, 2008).

The future of teaching using lecture method is still very vivid, due to its over reliance on the teacher in learning process. However, many students who are experienced in using current technology, favour participatory study culture which boosts confidence in the course of teaching and learning process (Afonso *et al.*, 2005). According to Noel *et al.* (2015) teaching using lectures does not recognize development of skills found in domains of educational activities. As a result of these limitations, many experts emphasize the use of combined instructional methods in medical training where more interactive teaching methods that involve maximum students' participation such as PBL are required (Noel *et al.*, 2015).

Considering some of the limitations of lecture teaching method, Berry (2008) reiterated that teaching using lecture method does not support active learning strategies. In this regard, Franklin *et al.* (2014), observed that any content taught to students in lecture-based model, results into rote learning compared to students taught with various methods that involve the students. Indeed, Lecture teaching method in most instances involves verbal conveyance of facts from the teacher to the students. In most cases, this happens without engagement of the learners through discussions and questioning. This scenario makes lecture method a poor teaching method (Al-Rawi, 2013). The method concentrates on information presented and ignores the learner. In addition, the teaching mainly focuses in telling students what to do instead of allowing students to discover knowledge for themselves (Miles, 2015).

Despite the shortcomings of lecture teaching method, the method have the advantage of delivering new information to a significantly large audience within a short time (Gehlen-Baum & Weinberger, 2014).

2.5.2 Demonstration Teaching Method

Demonstration is an educational approach that involves teaching students through practice, in addition to verbal and realistic examples, with the aim of acquiring practical skills. Since students participate actively in the process, this approach is thought to be very successful (Ogwo & Orangu, 2006). Teachers use demonstrations to show students how to do things and to articulate strategies. According to Daluba (2013), demonstration teaching methods usually engage and promote students' thought in class. As a result, the approach should be adopted in order to increase student achievement.

When the presentation approach is used, the course objectives are better known. Because of the simplicity of the demonstration teaching process, Furo *et al.* (2014) suggested that it is a good method for teaching because it motivates students to engage in class and can thus be used successfully in primary and secondary schools. In a separate study, Inuwa (2018) found that using the demonstration teaching method to improve students' financial accounting achievement was beneficial for secondary school students in Nigeria. According to the findings of a study by Basheer *et al.* (2017), teaching with demonstrations improved students' understanding of redox reactions and electrolysis in chemistry. As a result, the method improved students' performance in chemistry, especially in redox concepts. Furthermore, the approach aided in the growth of manipulative skills, making it more successful in the retention of information (Ogwo & Oranu, 2006). These findings are confirmed by Chikuni's (2003) study, which found that demonstration provides a forum for the instructor to demonstrate the procedure.

According to Chiappetta and Koballa (2002), a well organised demonstration has the likelihood to improve students' chemistry knowledge and comprehension. Similarly, Hofstein and Lunetta (2004), well organised demonstrations have the capacity to gradually alter student's attitudes, thus, improves motivation in students, thus enhancing learning. In a related study, Towns and Grant (1997) opined that demonstration has enabled students to process information in an active environment, in the process, they develop significant learning. It is argued that demonstration can be useful to students if components of cooperative learning are infused in the demonstration. If such elements are integrated into the

demonstration lessons, then, students retention of what is taught is improved (Eilks *et al.*, 2013).

In a study focusing on the results of teaching through demonstration approach Daluba (2013) established that demonstration teaching had notable consequences on performance in agricultural science. Remarkably, students who followed demonstration method excelled in contrast to lecture method. In addition (McKee *et al.*, 2007) study established that demonstration has the potential to improve student's understanding and retention. Furthermore, Al-Rawi (2013) observed that demonstration method is more useful during experiments, as well as, when using tools and equipment. However, in practice, it is not practically possible to conduct demonstrations because of time constraints. Because of this limitation, students have no option apart from simply making observations rather than carryout laboratory practicals (McKee *et al.*, 2007).

2.5.3 Discussion Teaching Method

Discussion is a method of teaching which allows intricate exchange of ideas in the classroom situation. This interaction stimulates the learners in critical thinking (Umar, 2012). The method helps the teacher to establish good networks with the students by appreciating students' contributions during discussions, as well as, allowing students to express themselves freely as they articulate their ideas during the discussions (SeEVERS & Graham, 2012). Discussions usually involve grouping students into small and manageable units for effective teaching of a particular topic.

Discussion method allows students to freely engage with other students through meaningful interactions. The teacher is expected to moderate the groups to prevent few students from dominating the discussions (Yusuf, 2012). Interestingly, information flow is usually from students to students or from students to teachers, as well as, from teachers to students. Discussion method helps both students and teachers in expressing what they know collectively in solving problems. That is why there is an assertion that the method functions on the basis that people may arrive at solutions to problems when they share their knowledge and ideas in an environment that encourages learning (OyedEji, 1996).

Classroom discussion facilitates proper engagement of the teachers and students in discovering answers to problems. In the process, it is contemplated that students refine social competence in addition to listening capability (Yusuf *et al.*, 2016). When discussions are not properly conducted, some academically bright students may hijack the discussions, thus discouraging academically weak students from participating in the discussions (Yusuf *et al.*,

2016). Therefore, information gained from these discussions may fail to be processed as knowledge, unless the students take active role in synthesizing the information (Akinleye, 2010).

Notably, exchange of views is bidirectional which involves speaking plus listening, as a result, the process of mutual engagement during exchange of knowledge and ideas may take place (Stephen & Stephen, 2005). The process helps the students to expand their horizons and it fosters mutual understanding among students. The study observed further that discussions allow students to get exposed to new points of view, and as a result, students' knowledge base increases through understanding and this brings motivation to learn. In a related study, Cruickshank *et al.* (2012) reported that discussion method enables free exchange of information between students and teachers. As a result, there are huge educational benefits that students get by virtue of the fact that there is reciprocal relationship among students including teaching staff during classroom discussions (Eggen & Kauchak, 2012).

According to a study by Njura *et al.* (2019), discussion teaching method was confirmed impressive in terms of raising success at school and retention of what is learnt than the conventional lecture method, therefore, they recommended its integration with other teaching methods. Similarly, a study by Falode *et al.* (2015) found that using discussions stimulate critical thinking in students; this in turn permits school children undertake in in-depth learning of the subject. Scholars such as Yusuf *et al.* (2016) noted that discussions may have some advantages like building of strong networks amongst the students, continual growth of social skills in communication, as well as, sharing and explanation of ideas by students. However, they opined that despite its numerous advantages, discussion may turn messy if not properly controlled. Consequently, confusion may rein in the class as a result of poor coordination of different activities during discussion sessions (Yusuf *et al.*, 2016).

2.5.4 Field Trips Teaching Method

Tours and field trips are outdoor teaching methods that are organized for students to engage in learning what was not possible in classroom settings. The organization may be based on a topic or a series of topics involving demonstrations and practical activities (Seevers & Graham, 2012). The reason for the outdoor learning is to allow the learners to have an opportunity to develop teamwork skills (Umar, 2012). Field trip is a vital teaching method to students because it allows transfer of knowledge between students (Goh, 2011). This occurs when students with experiences on what is being learnt share their knowledge with other students. These shared experiences serve to integrate the group members. Other

studies, for example, Goh (2011) and Wong and Wong (2009) reported that using fieldtrips as a teaching method enhances students' learning and this in turn increases student's authentic knowledge.

Organization of tours and field trips in secondary schools may pose a challenge to timetabling in schools. This is because, these trips and tours are not timetabled in the school and therefore, its planning should be done during the school mid-breaks and holidays to prevent disruption in school timetables. Planning and organizing field trips are difficult and complex activities because they involve proper planning that includes all stakeholders involved in the field trips. Therefore, field trips and tours should be well planned and blended within the curriculum in use (Orion & Hofstein, 1994). Field trips and tours are one of the methods based on experiential learning, which offers effective experiential learning activity (Roberts, 2006).

In another study conducted by Ezechi (2018) on the impact of expeditions in learning biology in Enugu East LGA of Enugu state, Nigeria found that field trip teaching method is not popular among teachers of biology. Furthermore, the study found that field trip was an effective teaching method because students were able to gain useful knowledge as they enjoy the outdoor activities during the field trip. According to Yusuf (2011), students are more inclined to learn more through personal experience when they are exposed to natural learning environments. Indeed, field trips may engage the cognitive and affective abilities of the students thereby making the students to appreciate the significance of what they learn in the classroom setting. According to Akubuilu (2010), field excursions allow students to learn outside classroom setting to enable the learners to get firsthand experience since they observe the phenomenon under study in natural settings. According to Ilori (2010) field trips are beneficial to students in interacting with new materials not available in the class. The teaching method may enable students to gain relevant scientific, technological and vocational information, through discovery and exploration of new information that is used in the organization of previous experiences. Indeed, it is without doubt that field trips may arouse interest in learners, thereby increasing retention of what is learnt during the field trip.

Using school trips for teaching purposes has been employed for a long time in preparing youths and adults alike in agricultural practices. However, its use as a method of instruction has faced some challenges, such as, lack of adequate funds, limitations of time and growing accountability issues (Myers & Linda, 2013). Most parents and educational managers are not happy at requests for field trips because of huge financial obligations inherent with expeditions. Even though there are numerous challenges, educational outings

are valuable fountains of knowledge, as well as, experiences toward equipping learners with modern agricultural production methods (Myers & Linda, 2013).

2.5.5 Projects Teaching Method

In defining project teaching method, Jansen (2012) describes project teaching method as a programme where work is done in teams or on individual basis for given period to solve problems using multifaceted methods to achieve the objective of the project. Agricultural projects are usually done in schools to improve students' practical skills, as well as, psychomotor skills. This in turn is geared towards improving food security through diversification of a household's resource. This may improve the economic status of women (Walingo, 2006). The project method is a student centred strategy where teachers use collaborative approach in facilitating students in solving problems by using extended inquiry approach as they apply their technical know-how in problem solving (Howell, 2003).

In executing the projects, the students are given specific assignments and in the process, they are expected to produce something accurate and solid from the experiment or assignment from the examination and interpretation of data. A report is finally required to summarize exactly what was done during the project and the outcome of the project (Wambugu, 2008). According to Zhaoyao (2002) project teaching follows a different procedure used in PBL. In addition, in project based learning, students are expected to use knowledge that was previously acquired and the main focus of the assignment is the final product produced. Teaching through class projects is based on the premise that learning by doing as students engage one another through discussions, helps learners to understand their learning environments better (Diise *et al.*, 2018). According to Toplis and Allen (2012) learning becomes more enjoyable to students when they are engaged in practical activities. The project method uses students' experiences, interests and abilities to permit students to influence the study (Katz & Chard, 2000).

In another study, White (1988) postulates that project method is an instructional process where students describe their master plan, required funds that may help them to arrive at a variety of solutions. Twoli (2006) observed that projects taken individually usually measure the capability and responsibility of individual students, especially when they are given projects that are done with minimum supervision from the teachers. This particular method may engage the learner to develop various skills such as cognitive skills, manipulative skills and bright outlook towards physics (Chiapetta & Koballa, 2006). The students are informed by the class teacher on the need to undertake projects. This is followed

by the process of discussing the procedure by the teacher to encourage the students to be artistic in tackling the projects through making good use of materials found within their reach.

The teaching of agriculture subject requires practical involvement of learners because the subject demands practical activity. In this regard, teachers are expected to use the school farm from time to time in conducting practical agriculture lessons and demonstrations. In addition, Kirimi *et al.* (2013) observed that a school farm is necessary to facilitate practical projects and demonstrations. However, the authors further noted that some schools do not have enough land to establish effective school farms, thereby, limiting the students' practical engagement in the school farms.

In view of shortcomings in some of the teaching methods popularly used by different teachers depending on their varied circumstances, the researcher, found it necessary to investigate on the PBL as an instructional strategy in secondary institutions in Kenya to help improve students' achievement in agriculture subject.

2.6 Problem Based Learning

Different scholars define Problem Based Learning (PBL) in different ways (Albanese & Mitchell 1993; Barrows, 1985; Norman & Schmidt, 1992). Indeed, Barrows (1996) opined that PBL has been described by separate scholars in different ways leading to numerous definitions put forward by distinct learning organizations with the sole responsibility to clarify their specific methodologies. Notwithstanding, many scholars recognize Barrows and Tamblyn (1980) definition used in the medical field. The duo described PBL as a learning strategy where trainees work in relatively small teams towards understanding and arriving at a firm decision to a problem. Problem Based Learning uses an active teaching strategy toward concrete problems to make learning easy. The students are given actual problems which evoke the application of investigative skills in looking for required details (Major, 2000).

According to Barret (2004) PBL is the training institutions' response to the ever dynamic needs of the workplaces. The intention of PBL is to generate a reliable knowledge base which allows for transfer of acquired skills to later use in the work place. Azer (2005) defines PBL as a method where students collaboratively analyse problems in small teams as they think deeply using their experiences. Therefore, it means that PBL is a teaching method where the contents to be taught to students are introduced through the process of problem solving, rather than introducing problems after teaching the content (Jervis & Jervis, 2006).

Problem based learning (PBL) is a teaching methodology where the problem is the motivation behind the learning (Overton, 2010). In other words, learning new skills occurs within the context of problems. According to Overton (2010) PBL significantly occurs differently from problem solving. In PBL settings, students are given the problems before they get any useful information from any source. The investigative approach produces an outcome based on experience. Therefore, the teaching style demands that learners should solve problems that are based on actual cases using any resources they think may be of use.

In another definition, Savery (2006) described PBL as a teaching method which gives learners authority to carryout research, combine hypothesis and application of facts and expertise in searching for a workable explanation. The method allows learners to establish what they should know, as well as, examine and transmit their discovery to members of the team (Williams, 2000). Problem Based Learning method has been modified by different scholars to fit the specific requirements of different students, specialty and backgrounds following conflicting comparisons. From that time, PBL has been applied in a whole curriculum, or in part within the established conventional course. Consequently, PBL is currently used in diverse fields of training in medical sciences, sciences fields, secondary schools and university education.

In conclusion, the various definitions of PBL concur that PBL teaching method uses day to day real-life problems where students collaborate in small groups in solving the problem. From the researcher's own perspective, Problem Based Learning is a student centred pedagogy which works on the assumption that authentic learning occurs through working collaboratively in small groups in solving a problem. Based on these definitions, it can be conclusively said that instruction that takes place under PBL begins with the presentation of an actual case to students as it is envisaged that they embrace teamwork skills under leadership of the facilitator (teacher). This variety regarding PBL execution presents difficulties in translating and executing PBL investigation.

2.6.1 Origin and Application of Problem Based Learning

Problem Based Learning has its origin dating back to 1920 (Yuruker, 2011). It is documented that a primary school teacher by the name Celestin Freinet came back injured from World War I. This situation made him to become unable to teach his students for a longer duration. As a result of his injuries, he was therefore, forced to devise a new teaching method that would enable him continue discharging his professional duties in a satisfactory way. He came up with a teaching strategy where students engaged in action, characterized by

intense participation. The leading tenets of this particular pathway were conversation, interdependent learning, taking self-obligation and own examination of their learning.

Based on the origin of PBL, Graaf and Kolmos (2003) consider modern PBL to be a teaching approach that originated in Canada at McMaster Medical University in the late 1960s as a result of low students' enrolment coupled with unhappy students with the educational experiences (Barrows, 1996). The main aim of introducing PBL was to enable students develop requisite skills in the field of medicine, as well as, develop content knowledge applicable in the practice of medicine. After the adoption of PBL in Canada, Limburgh University in Netherlands together with Newcastle University in Australia followed suit ten years later and adopted PBL in training students (Savin-Baden & Major, 2004). Indeed, many universities found PBL to be appropriate method of training medical students, therefore, more medical schools in other universities on other continents adopted the use of PBL by 1980s.

The utilization of PBL was not limited to medical field, as it was later introduced in many specialties of training. For example, in 1974, University of Limburgh at Maastricht expanded the use of PBL in other disciplines that included psychology, law, and economics (Schmidt & Moust, 2000). This university was the first in the world to fully use PBL outside the boundaries of medical education. In this regard, the implementation of PBL was infused into other disciplines throughout the world. These other disciplines were engineering, business, architecture, forestry and political science (Savin-Baden & Major, 2004). The implementation of PBL became imperative in the 1990s, where PBL was successfully used in disciplines such as natural sciences and social sciences. The classical example in this case was Samford University in Alabama that found the teaching methodology to be more learner centred pedagogy. The University infused the new teaching approach in humanities by end of 1999. As a result of this development, many universities across the world joined the band in the implementation of PBL in major disciplines.

Consequently, the use of PBL expanded from universities to secondary school education. Following this transition, it is documented that an academy for talented students called Illinois Mathematics and Science Academy (IMSA), embraced then eventually adopted this method into their curriculum in 1985 (Savery, 2006). This resulted into creation of a PBL centre in 1992 (Savin-Baden & Major, 2004), this centre was mandated to train teachers, develop PBL curricula, as well as, carryout research in PBL (IMSA, 2011). In addition, both middle and elementary schools started implementing PBL. Since then, the

implementation of PBL has spread throughout the world and is being implemented in multiple disciplines.

Problem Based Learning allows students to study a subject collaboratively in break-out sessions by means of resolving issues from the occurrence (Savery, 2006). Therefore, PBL is a guided inquiry method that has ability to integrate new knowledge as used in another context (Hmelo-Silver, 2004). Problem Based Learning follows constructivist pedagogy. In that regard, McCombs (2001) acknowledged that there should be a paradigm shift from what should be taught and the skills to be gained from an educational experience. This acknowledgement therefore, supports the theory that knowledge is constructed and not transmitted (Seatter, 2003). In addition, Phillips (1995) emphasized this concept as the main domain among constructivist views. Constructivism is a concept that represents the way people in the society solve real-life problems, as they work in small groups (Jonassen, 1997).

Educators have used PBL for over the past 30 years. Earlier PBL models originated from medical school programmes (Barrows, 2000) however, the use of PBL in other disciplines has been successful, leading to its inclusion into many professional fields of study (Fenwick & Parsons, 1998). Learning establishments have implemented PBL in different ways, such as, tailoring the teaching method based on requirements and abilities of diverse students' in terms of content delivery method (Eng, 2000). Research findings affirm that learner-centred teaching methods enhance learning effectiveness. This is because, learners take full responsibility for everyday studies, while the instructors assume the responsibility of coordinating learners, as students develop knowledge and skills used to solve life problems (Metto & Makewa, 2014). Notably, developed Countries have embraced the use of PBL method, unlike, the scenario in developing countries where use of lecture teaching method is still rampant (Metto & Makewa, 2014). However, PBL has been embraced in isolated instances like in Moi University Medical School (Owino, 2010).

Despite the overall benefits of student centred learning, Metto and Makewa (2014) observed that long established methods forms the main teaching strategy applied in Kenya primary schools. This is because teachers' preparation programmes have not embraced PBL as a teaching methodology, therefore, teachers do not have a personal experience on its application. In addition, Metto and Makewa (2014) noted that, teachers fail to implement PBL due to overcrowding, inadequate resources and more significantly, learners lack the motivation that suit learner centred methods because many learners come from poor backgrounds. In another study Shikuku and Amadalo (2015) remarked that PBL students' triumphed over students under traditional method. Moreover, the two researchers further

found that learners taught using PBL acquired the linear programming skills better over students who used lecture.

2.6.2 Problem Based Learning Pedagogy

Many scholars, for example Dunlap (2005) Hmelo-Silver (2004) and Savin-Baden (2003) have acknowledged that PBL stimulates learners to actively learn collaboratively in small groups as they solve problems. However, the end product of students learning is guided by many interacting factors. The factors may include but not limited to, students attributes, teaching context and the learning outcomes as noted by Biggs and Moore (1993). Alongside these, students' attitudes, their behaviour, as well, as their learning styles affect how they learn (Biggs & Moore, 1993).

Additionally, Lee and Krapfl (2002) observed that effective teaching promotes a hands-on acquisition of skills. However, putting emphasis on assessments and teaching to cover the syllabus weakens science education and this tendency will eventually prevent teachers from teaching higher-order thinking skills (Valli, 2008).

The students are required to develop their cognitive structures to adapt in the dynamic society (Gardner, 2006). However, students enrolled in post-secondary education and particularly, those pursuing agricultural careers are not well equipped with required skills due to frequent use of teacher centred methods. The job market requires employees with varying skills coupled with ability to make conclusions based on facts as they solve problems (National Research Council, 1996).

In a related study, Visser (2002) explained stepwise the learning process used in a PBL method as follows: an amorphous problem is presented to students by the facilitator who is the usual classroom teacher. The facilitator proceeds by grouping the students so that they can research on the problem. The students in their groups are expected to meet their teacher to establish what they must know (Visser, 2002). During the discussion, the facilitator should only give scanty information about the problem, while the group is expected to note down the nature of the problem through asking relevant questions on the problem to help them generate relevant details. In that process, students work hand in hand with the teacher to produce and clarify conjecture associated with resolution of the problem (Visser, 2002). The teacher is expected to report the theory as it is, while the learners should find out the main issues that are relevant to the problem as they seek tentative solutions.

Each member in the group is assigned tasks for further researching. Members of the group are involved in individual investigation by putting materials related to the assignment

from several sources. After individual investigation is completed, members of the group report their findings in their groups. The students reconvene to further investigate the problem by using the information gathered through research to solve the problem. The presentation of investigative approach allows teachers and learners to look back at how resolution of the problem was managed (Visser, 2002).

The teachers' play a significant role in PBL method; however, their importance in the process has been overstated in writings. The function of the facilitator differs significantly from their regular role in classroom. That is why; teachers should be flexible in adopting completely new functions for effective execution of PBL. The teachers' new role is to facilitate students in recognizing important learning issues depending on the case presented. The problem is chosen and presented to the students by the teacher who later gives proper guidance on research process (Visser, 2002).

2.6.3 Goals and Characteristics of Problem Based Learning

The main objective of PBL according to Hmelo-Silver (2004) was to assist learners to build a large knowledge foundation, develop extensive analytic skills and be equipped with permanent competence as they collaborate with other students during their study. Problem Based Learning follows a concept that there is no single solution to problems; similarly, you may not find a universal feedback (Jonassen, 2000). In addition, the problems must be domain specific, as well as, possess unknown elements. Many characteristics of PBL are based on the unstructured problem (Tat *et al.*, 2010). The first step is to identify the problem before gathering information concerning the problem. Thereafter, the students' work in small teams to gather more literature on the issue as they debate on the problem until they find a solution (Tat *et al.*, 2010).

In writing down the problem cases in PBL method, it is necessary that the problems should be authentic, multifaceted, as well as, open-ended with possible broad range settlement (Bereiter & Scardamalia, 2006). Indeed, the situation may be complicated; however, it should echo previous experience. If that is not the case, the problems may fail to elicit learners' engagement with the content. In this technological era, PBL cases are presented in different forms, such as, paper-based form and multimedia form. Derry *et al.* (2006) and Hmelo-Silver (2004) reported that the latter is more appealing to students because it is more interactive and motivating. Whichever format is used; it is advisable that the cases should represent real life situations that can be dealt with extensively in classroom situations,

thus, providing opportunities that may necessitate the use of multiple perspectives in arriving at solutions by reviewing the aftermath by deliberating the choices (Brown *et al.*, 1989).

Constructing cases that provide numerous settings within the course of study may benefit teachers in forming valid link among varying concepts from students. This may help teachers and students to focus ideas and see different patterns from different perspectives and contexts (Spiro *et al.*, 1992). If teachers fail to figure out the patterns, they may fail to establish the relationships between interrelated bodies of knowledge resulting into a distorted opinions emanating from the class with many complexities. Against this background, (Shulman, 1987; Spiro *et al.*, 1987; Zeichner, 2005) asserted that many problems like classroom management practices, assessment of student learning, taking care of individual student differences and establishing strong relations amongst teachers and parents becomes impossible particularly with regards to freshly employed instructors

Throughout the literature on PBL, it is apparent that one of the main characteristics of PBL is that PBL uses real life problems in small groups. In any natural setting, people respond to problems in life through analyzing the issue to recognize the problem. In essence, learners make enquiries through searching for relevant information to allow for formation of hypothesis and finding of solutions. According to Downing (2001), PBL method is an instructional pedagogy that promotes students' knowledge transfer through motivating students, making use of knowledge in a context, encouraging students to develop reasoning skills and lastly, improving independent study experiences. Furthermore, Mergel (2008) asserts that PBL graduates can competently handle both academic and professional problems for individuals seeking their services.

In essence, PBL is not only concerned with gaining substantial knowledge related to a problem; but it is also responsible for growth of analytic skills in the learner (Barrows & Tamblyn, 1980). The problem is usually not well defined because there are several ways to arriving at the solution to the problem (Jonassen, 2000). Furthermore, the issues must be specific to genuine circumstances, as well as, have undisclosed components.

The process of dealing with a difficult situation is not certain nor concurrent. In most of the times, several disciplines are incorporated to help in resolving the problem (Jonassen, 2000). It is expected that both judgment and personal opinions are required during inquiry process. According to Newman *et al.* (2003), the implementation of lecture teaching method and PBL vary in more fields. Furthermore, the curriculum is arranged around study surrounding and end result of PBL varies from the common traditional teaching method

(Newman *et al.*, 2003). Instead of focusing on subject method, the syllabus is centred on problems that are multidisciplinary.

The prominence highlighted in PBL has always been the development of skills anchored on logical analysis over the knowledge of facts, concepts, theories and principles. PBL learning environment favours learning in small groups that allows collaborative learning facilitated by the teacher instead of teaching individual student (Newman *et al.*, 2003). The method allows for development of varied competencies, for instance, research skills, making decisions and teamwork. Therefore, the ultimate purpose about PBL is permanent learning that is geared towards problem solving.

2.6.4 Steps in the Problem Based Learning

There are four recognised steps in a PBL lesson according to Stepien *et al.* (1993). The first step involves the presentation of a problem by the facilitator to a cluster of students, who are supposed to research about the problem and present their findings before they are taught. The problem is presented in a loose manner because more information is required than is available for students to make conclusions (Barrows, 1985). The students are allowed to draw their own action plan during problem solving process. In addition, the problems must be drawn from real life experiences aimed at motivating students during their research process (Stephien & Gallagher, 1993).

The next step is based on cooperative study where there is collective students' participation. The students discuss in their teams as they share knowledge concerning the problem. Uniquely, each student is assigned a task during this process. In this regard, White and Frederiksen (1998) assert that knowledge is retained by students when they work closely together. Gleason *et al.* (2008) and Wong and Day (2008) noted that students are able to piece information together in order to relate learnt material and foreign ideas. To achieve this, teachers can only give guidance and desist from dispensing knowledge related to the problem.

The third step of the PBL lesson gives students enough time to conduct research on the problem. The ample time enables the students to use a variety of published literature in finding answers to the questions they asked, at the same time, evaluate the information they receive, as well as, discuss the answers to questions. This leads to building a new image and demonstrate the results as achieved.

The fourth step involves presentation of students' results to their colleagues. The stage allows the facilitator together with students from other groups to give effective and timely feedback and recommendations for the presenting group to motivate the students (Brookhart, 2008). Collectively, the PBL steps improve knowledge retention in students by strengthening superior abilities (Stepien *et al.*, 1993).

Therefore, PBL is organized into classroom discussion groups where they are given a problem. The students are given opportunity to deliberate and refine the type of problem. They have to identify important key issues to enable them assign roles amongst themselves and share known information. The teachers' obligation is monitoring. When students are not in class, they take part in autonomous investigation to fill up any loose ends in subject command (Overton, 2010). Finally, they reconvene to examine resources and information collected. The knowledge acquired serves in problem solving. The sequence of directed study, group synergy and critical review, may appear repeatedly as demanded by the problem.

Regarding the assessment methods, students may be assessed using traditional methods, as well as, other valid methods recommended by PBL experts (Overton, 2010). The testing and assessment methods should correspond to learning objectives. The assessment may fundamentally focus on skills acquired, as well as, problem solving process. Marks are awarded based on group efforts or to individual students. In certain circumstances, students may evaluate their colleagues based on their contributions in their groups. The assessment tools that may be used include oral presentations, detailed reports, records of activities, as well as, self-examination.

2.6.5 Problem Based Learning models

There are various PBL models normally used in the implementation of the method. These models are discussed into details and they include: The foundation model approach, Barrows 'seven jump tutorial model, the funnel approach, single model approach, the two strand model and the shoestring problem based learning model.

a) The foundation model approach

In this particular model, lectures are initially used to allow the learners adapt well before they are introduced to PBL method (Nguyen, 2009). The approach permits students to apply the acquired knowledge obtained through lectures in building a firm foundation for solving real life problems taught through PBL. Indeed, the teacher takes the centre stage as

the facilitator of the learning process by focusing and directing learners throughout the learning process.

b) Barrows' seven jump tutorial model

This model gives students impetus for self-directed learning as they follow well-organized and laid down procedures. The seven jump approach encourages students to develop critical thinking skills useful in investigative process as students work in groups in constructing new knowledge (Zieber, 2006). The seven jump PBL model has seven steps as proposed by Savin-Baden and Major (2004). The steps include:-

(i) *Clarifying terms*: In this step, learners are required to make clarifications of the terms found within the problem presented. This step enables students to have a common understanding of the terms used in the problem. (ii) *Defining the problem*: The step allows group members to extensively discuss the definition of the problem. (iii) *Brainstorming*: This stage allows for collation of existing knowledge related to the issue under investigation. The group members may share their ideas freely during this stage, in the process; they gather a lot of information that may be useful or irrelevant to the problem. (iv) *Structuring and hypothesis*: The step allows group members to clearly combine steps (ii) and (iii) into explanations to pave way for tentative solutions. (v) *Learning objectives*: This particular step allows students to formulate learning objectives together with the facilitator. The step ensures that the formulated objectives are specific, measurable, achievable and realistic, as well as, time bound. (vi) *Searching for information (independent study)*: The stage allows students to independently search for the solutions to the problem. The self-directed learning is expected to yield solutions to the questions raised during problem analysis phase. At the end of independent study, students collate information gathered and agree on how they will present their findings in the next lesson. (vii) *Synthesis*: This is the final step in the model where the group members share results with all groups. The coordinator is expected to check learning progress and make an assessment of the group. Therefore, the new knowledge obtained from independent study is then tested against the problem being investigated. The facilitator is always expected to give adequate guidance to the group. The facilitator may ask certain questions that may draw attention to inconsistencies. This may stimulate and widen incorporation of learnt material. In the end, the secretary to each group is supposed to write a summary of the investigation and conclusions of the group. The whole process allows for students feedback on their findings, as well as, evaluate the course on quality concerns and procedures (Schmidt & Norman, 2003).

c) The funnel approach

The model allows students to be first taught using the familiar conventional teaching methods like the lecture at lower years for tertiary students. As students' progress to higher levels, a more comprehensive and collaborative teaching approach is used to help students to understand a particular concept (Savin-Baden & Major, 2004). To allow for better student understanding and improvement in a subject, the funnel approach combines the use of PBL and other conventional methods in its application and use (Dejan *et al.*, 2013).

d) Single module model

This is the model that was widely applicable at McMaster University Medical School. The students are given problems to work on in groups. The facilitator may be available for consultations from time to time (Savin-Baden & Major, 2004). Few lectures are given to students by the facilitator. The students have the advantage of working on problems on their own with little support from the facilitator.

e) The two strand model

The model is more suitable in situations where students share modules across disciplines. The model allows complementation of PBL and other teaching methods that are used concurrently (Nguyen, 2009). According to Savin-Baden and Major (2004), the modules are planned systematically by linking topics to enable students to utilize the information attained from the mixed approach which anchors students learning in the PBL process.

f) The Shoestring Problem Based Learning model

The model is used across all the academic year levels of a university student's entire academic programme duration. Both PBL and the lecture method are used simultaneously during the course of study of a particular student (Savin-Baden & Major, 2004). The model allows designing of problems which are based on a particular course unit being taught. The teacher takes a pivotal role in supporting students during PBL implementation process. The teaching and learning process using PBL method combines the use of lectures to keep students focused throughout the course of their study. That is why Savin-Baden and Major (2004), stated that learners in this model may end up confused and fail to understand the rationale behind the dual implementation of PBL and the lecture method if they are not well supported by their facilitator. This study adopted **Barrows' seven jump tutorial model** because the model looks more applicable in teaching secondary school agriculture syllabus.

This is because the model can be used for teaching various topics at different grades or class levels (Lambros, 2004).

2.6.6 Limitations of Problem Based Learning

Executing PBL method in classroom environment contains certain limitations as identified by Akinoglu and Ozkardes-Tandogan (2007). Some of the identified disadvantages include the difficulty for tutors to change their instruction methods, which make learners take long during resolving issues. For that reason, groups can accomplish work at varying rates. The method calls for proper development of school infrastructure, such as, well-equipped laboratories, libraries and school farms for deeper investigation. As a result, it may be difficult to implement PBL model in many classroom environments. This method is not suitable for students who are unable to follow the value of the problems with social content, making assessment of learning difficult. In the foregoing discussion, PBL has many advantages to students, however, there are certain shortcomings associated with it.

One of the notable shortcomings of PBL is that it may compromise the extent of content coverage since it relies heavily on problems (Kain, 2003). Additionally, Kain (2003) opines that it may be difficult for students to build up knowledge from known to unknown concepts when they are taught using traditional teaching methods, however, in PBL classrooms, students are interested in gathering relevant knowledge to solve problems. According to Albanese and Mitchell (2004), students engage in learning activities alone as the teacher acts as the facilitator of students learning. Some teachers used to traditional teaching methods may find implementing PBL method foreign, and they may have difficulties in breaking with their past (Delafuente *et al.*, 2004).

Application and subsequent implementation of PBL consumes a lot of time, especially when setting group activities, as well as, planning and preparing relevant problems that should be used as starting points by the teacher, indeed, the method may jeopardize completion of the syllabus as compared to traditional lecture method (Dolmans *et al.*, 2005). Fundamentally, teachers implementing the method require careful planning to avoid lagging behind in syllabus coverage. In another study on students' objectives and application of PBL, it was observed that most students did not focus on the task and they somehow omitted most of the important objectives (Dolman *et al.*, 2005). In a related study, Conoldi (2008) noted with nostalgia that students may completely miss anticipated directions during problem solving process if they are not redirected by their teacher on the main content.

Problem Based Learning has some shortcomings with regard to criteria of assessments. Indeed, Schmidt and Norman (2003) have extensively advised teachers using PBL method to use alternative forms of assessments, such as, written examinations, practical examinations, concept maps, peer assessment, self-assessment, tutor assessment, oral examination and written reports, when assessing student knowledge and achievement in a particular subject. Assessment practices often mismatch innovative methods and favours pen and paper tests. Despite the numerous advantages accrued as a result of using PBL method, its use has been limited to some extent in K-16 grades in American classrooms. The implementation of PBL places intensive demands on teaching and learning process. Additionally, Marsteller (2008) argued that teachers require considerable amount of time in generating good problems. Similarly, Chapman (2013) argued that in designing a problem, you need to choose an authentic real-world problem that can elicit students' critical thinking. A good problem must have the ability to demand a final product(s). Likewise, the use of PBL method must be designed to support multiple hypotheses, as well as, present itself without too much "given" information, be open-ended, and "messy" (Grady, 2010).

Problem Based Learning method has experienced criticism, as well as, praise in equal measure. Indeed, it has been found that its weakest link is that it is not suitable for everyone. Studies have confirmed that PBL benefit students with high cognitive skills better than weak students. According to Wong and Tang (2011) students prefer inductive teaching methods to deductive teaching methods. In reference to this finding, PBL was found to be one of the inductive teaching methods. Furthermore, Wong and Tang (2011) observed that inductive teaching method did not support weaker students learning. The finding was supported by Lim and Lew (2012) study who observed that weaker students, who had problems studying English language, had similar difficulties in presenting information. They also found interesting challenges such as students' inability to work in teams, analyze, and synthesize information towards a solution, because they were deficient in literary skills.

In a related study, Prince and Felder (2006) study revealed that the experiences with PBL method favoured academically brighter students than the weaker ones, making the latter to be less likely to make progress in class atmosphere. As a teaching method, PBL lack sufficient research that can support its effectiveness as a teaching method. That is why Hung (2011) argues that available proof supporting PBL success remains unsatisfactory due to the fluctuating nature of factors influencing the student's outcomes. It is understood that these methods most of the time, focus on students' outcomes and the methods fundamentally

ignore the impact of teaching methods on student outcomes, thus ignoring the impact of PBL teaching method (Gijsselaers & Schmidt, 1990).

In his study, Hung (2011) pointed out that the assertion that PBL use in medical schools and engineering programmes improved problem solving skills in students is a questionable concept. His argument was supported by 13 different studies that examined the competence of graduates from medical schools with medical practice experience ranging several years. The survey found inadequate proof to support the assertion that PBL helped practitioners to solve problems. Additionally, the study observed that routine procedures undermine scholarly study and defeat the intention of gaining skills in problem-solving and independent learning skills. Therefore, the assertion that PBL motivates students in active learning is far-fetched (Hung, 2011).

Problem Based Learning ought to be applied solely, or it should augment other teaching methods. In another study, Sweller (1988) argues that if PBL is used alone, it may obstruct students learning outcome. Therefore, students may develop a reasoning strategy that allows grouping of encountered problems according to their schemas. Although there is proof that the method is beneficial, especially in engineering disciplines, PBL practitioners should design the method to meet particular demands of a programme. That is why, Perrenet *et al.* (2000) suggested that engineering programmes require successive knowledge that cannot be obtained through direct approach.

In conclusion, Gurses *et al.* (2007), in their study, maintained that changing from conventional to PBL curriculum requires adequate adjustment by the students. This is because the students are more concerned with covering the content (Dods, 1997). The students, in most cases, have problems in separating extra information from important information concerning the test. Furthermore, students have the challenge in bridging the gap between their inquiry and what is required in the class. In short, students' main concerns are doubts about their grades (Woods, 1996). Therefore, students become worried if they are examined using a variety of methods. This is because of their new roles in PBL classroom setting (Woods, 1996). Problem Based Learning is successful in the environment when students are aware of the importance attached to the learning issues (Mitchel *et al.*, 2009). If students do not see the connection, then, they will definitely question why they are doing it. To make PBL more relevant, teachers should use problems which relate to student's everyday lives.

In adapting to 21st Century Pedagogy, students sometimes resist learner-centred method of learning because it is such a departure from their previous experiences for “they

have never been asked to learn this way before,” (Sumrall, 2008, p.12). Transitioning to 21st Century pedagogy requires teachers to adapt as well (Sumrall, 2008). The teachers must develop new ways of curriculum planning, classroom teaching, and student management. “We are used to answering our students’ questions. We have to learn not to answer, but instead to act as facilitators so that students can answer their own questions,” (Sumrall, 2008, p.12).

2.7 Gender and Students’ Academic Achievement

Gender plays a significant role on students’ academic achievement, especially in science subjects. The importance of studying students’ performance as linked to gender differences is particularly related to community behavioural differences between boys and girls (Adigun *et al.*, 2015). Moreover, Adigun *et al.* (2015) established that boys are given more difficult chores compared to girls. Therefore, the public see girls as a weaker gender (Adigun *et al.*, 2015). Gender differences were not established in connection to performance in several subjects, that was according to Adeyemi and Ajibade (2011), Agbaje and Alake (2014), Awofala and Nneji (2011), and Dania (2014) study. Furthermore, Adigun *et al.* (2015) study did not find gender differences in students' achievement in computer studies.

Schools play a significant role in socializing students because the latter frequent school settings (Byoung-Suk & Christopher, 2012). In a related study, Mudassir *et al.* (2015) found that school environment significantly influences students’ academic performance. They confirmed that students from well-established schools with adequate infrastructure, excellent relationships between teachers and students, as well as, favourable learning environment, perform well. That is why scientists and educational policy makers alike are keen in finding out how schools can provide a suitable learning environment that can fully exploit students’ full potential. Creemers and Kyriakides (2008) and Crul and Schneider (2009) studies examined the extent to which schools equally affect students from various economic and family background. The scholars observed that the effect of schools on students differs significantly; however, it is worth noting that differential educational performances seen in boys and girls should be investigated, in view of strong female performance in education (Eurostat, 2013; Stoet & Geary, 2013; Van Hek *et al.*, 2016).

The focus in educational research nowadays has put tremendous emphasis as to why girls perform better than boys in academic accomplishments (Van Hek *et al.*, 2016). In a related study, gender disparities in students’ academic achievement were established to vary

between schools (Machin & McNally, 2005; Ma, 2008). However, the studies abstained from examining reasons for the gender inequality in students' performance. Furthermore, Legewie and DiPrete (2012) study found that the schools socioeconomic composition had adverse effects on boys than girls. This affected boy's performance more than girls. In a related study, Martin and Mullis (2013) found that literacy skills play a powerful role to determine students' performance in mathematics and science subjects. Furthermore, Martin and Mullis (2013) study concluded that gender disparities in literacy skills have far reaching results in the provision of education. In addition, Ma (2008) established that gender differences in literacy skills were not the same among the schools. In addition, Ma (2008) observed that significant gender variations exist between schools compared to gender differences in science and mathematics skills. This implies that training institutions exert a statistically significant effect on gender difference in literacy outcomes.

There has been other studies on gender discrepancies (for example, Chang 2008; Abubakar & Bada, 2012) that have exclusively focused on the differences attributed to performance in different science subjects. Indeed, some studies found notable gender test scores, where boys outperform girls in science related subjects, whereas girls achieve so much better in spoken and written English and Kiswahili (Else-Quest *et al.*, 2010; Penner, 2008). However, a study by Ajai and Imoko (2015) did not confirm notable gender differences on achievement and retention outcomes. In a statistical procedure combining data from multiple studies, Voyer and Voyer (2014) analysed data from 1914 through 2011 and established a slight but significant strong performance of girls in languages, but interestingly, dismal performance in mathematics and sciences. The scenario led Voyer and Voyer (2014) to equivocally state that differences between boys and girls proceed in a common design on tests scores, regardless; girls have the edge on test scores irrespective of the subject matter. The implication is that society should not regard boys as better achievers than girls in matters involving a lot of logical reasoning. Furthermore, Voyer and Voyer (2014) educators have observed a trend where girls perform better than boys in science that need logical thinking.

In another study, Pillow (2008) while investigating the relationship between academic achievement and gender differences established that individual's environment to a larger extent affect students cognitive and non-cognitive behaviours in test scores. Similarly, Nori's (2002) study did not confirm notable connection between creativity and sense of self-worth on performance. In classroom environment, teachers may promote gender bias when a learning platform is created that favours the success of either boys or girls. Male gender perform excellently well in structural assignments, while female gender excel in languages.

These recognised differences may be due to known hormonal differences exhibited by male and female teachers who have slowly and continuously developed the habit to treat boys and girls differently (Renold, 2006).

The findings of a study by Amao and Gbadamosi (2015) noted that society has placed a huge expectation that boys are naturally gifted to be rational, whereas, girls are expected in most of the times to be quite, polite and spend a lot of time studying. Girls are expected to have superior social skills to boys, and girls are also expected to succeed in language skills (Amao *et al.*, 2016). In most cases, gender bias arises in courses such as mathematics and sciences, where girls and boys participate in distinct ways, thus, perpetuates the belief that males are born with an edge in areas believed to be difficult.

2.8 Theoretical Framework

The theoretical framework for this study was based on Constructivist Learning Theory. This theory combines Cognitive Development Theory put forward by Piaget (1972) and Sociocultural Theory proposed by Vygotsky (1978). The theory and related variables are consolidated in Figure 1.

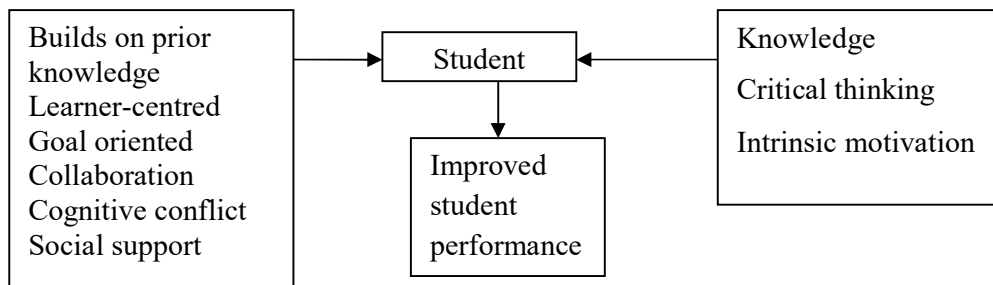


Figure 1. *Constructivist Learning Theory*

Source: Adapted from Hmelo-Silver and Eberbach (2012)

In a nutshell, constructivism is a theory that argues that useful knowledge and skills are built by individual learners through a process of construction as they learn (Hein, 1991). In this case, the learner receives the majority of the focus. Learners can only create meaningful knowledge if the knowledge is related to the learners' previous experiences. Scholars such as Bransford *et al.* (2000) and Myers and Dyer (2006) emphasized that good teaching environments should be focused on the student's interests, with both expertise and evaluation requirements centred solely on the learner. The Cognitive Development Theory of Piaget and the Sociocultural Theory of Vygotsky are the foundations of constructivism (Fosnot, 1996; Schunk, 2004). Simpson (2002) stated in another study that constructivism is not a philosophy in the strict sense, but rather a collection of statements or a theory of

knowledge focusing on the essence of learning. Constructivism is concerned with how information is formed rather than how it is acquired (Schunk, 2004).

Cognitive psychology is at the heart of constructivism. As a result, it has split into distinct styles such as post-modern constructivism, individual constructivism, and social constructivism (Steffe & Gale, 1995). Learning in the constructivist model, according to Ben-Ari (1998), is regarded as a vigorous exercise of continuous development and incorporation of skills. Intercommunication between the brain and the social world leads to better success (Biggs & Moore, 1993). Students build their own perspectives on the basis of a positive approach (Le Cornu & Peters, 2007). The advocates, on the other hand, believe in a fusion of social and cognitive systems, in which information is shaped internally and then arbitrated communally. Classrooms, according to constructivists, are areas where serious study and continuous learning take place (Holt-Reynolds, 2000).

Vygotsky's theory looks at practical understanding of a subject and the state of being true as concepts that are generated through instruction (Fosnot, 2013). Normally, ideas are formulated as the learners are subjected to everyday events. The learners are engaged fundamentally in defining the reality so constructed. The constructivist approach, therefore, creates interesting circumstances where students are consumed in cognitive discourse. The instructor is tasked with the responsibility of guiding learners in organized groups in solving the problems. Vygotsky theory postulated four basic principles; that learning culture is initiated by collective social responsibility; that what students can't do on their own but, can confidently do with the help of teachers can inform curriculum development and preparation for teaching; that schooling should take place in a relevant background that is inseparable from what children learn in a natural world. In fact, experiences gathered outside school should augment school experiences (Daniels, 2016).

According to Savery and Duffy (2001) implementation platform of PBL is compatible with the Constructivist Learning Theory (Figure 1). The theory indicates that learning requires direct involvement of the learner as they interact with the natural world, to create cognitive stimulus that will enhance social interaction of the learner. Therefore, knowledge is built through the explanation of previous experiences (Hmelo-Silver & Eberbach, 2012; Savery & Duffy, 2001). According to Biggs and Moore (1993), the best learning outcomes result from both cognitive and social interactions. Notably, the Theory of Cognitive Development (Piaget, 1972) influence biological maturity, experiences with physical and social environment, as well as, equilibration. Learners mature with age as a result of biological maturation. They experience the physical environment through testing and

controlling physical objects as they interact and experience a given learning situation, while social interactions allow for introduction of new ways to approach a task. Equilibration promotes moving towards a complex situation as students adapt their cognitive structures to their habitat (Duncan, 1995).

The suggestion that learners organise their knowledge and change their experiences into schema through assimilation (Piaget, 1972) was supported by Phipps *et al.* (2008). Therefore, the social and physical environment has a significant impact on learners' previous experiences (Fosnot, 2005). Piaget's phases of cognitive growth comprise of sensorimotor, preoperational, concrete operations and formal operations stages. Throughout sensorimotor period, the child deploys actions to understand the world. In the preoperational stage, the child focuses on their present situation as they imagine the future, as well as, reflect on their past (Schunk, 2000). During the third stage, concrete operations stage, individuals are able to think logically and interpret many characteristics using observable objects and situations. Therefore, learners are able to solve problems, describe relationships and understand time and space. The formal operations stage enables the learners to reason abstractly and develop hypotheses (Phipps *et al.*, 2008).

Stressing on the importance of sociocultural theory, Schunk (2004) argued that social environment facilitates learning, that can make a man to change his environment to suit his needs through social communication (Tudge & Scrimsher, 2003). Emphasizing on Vygotsky's theory, Meece (2002) stressed that social interactions are central to knowledge development. Finally, the zone of proximal development distinguishes what students are able to do and assistance that they may require (Meece, 2002; & Schunk, 2004). In the context of the study, students are assisted in cognitive growth by the agriculture instructor. The theory has helped this study by allowing learners to think logically in situations that require different interpretations in solving problems. Therefore, the results of the study were interpreted as per the Constructivist Theory.

2.9 Conceptual Framework

The conceptual framework was directed along the Constructivist Learning Theory. Constructivist Learning Theory held a strong view that learning occurred when students interacted well with their environment, in the process knowledge and truth was created during teaching (Fosnot, 2013). The underlining principle of constructivist theory was that students learnt something when they have gained experience from what they learn. Students were expected to create their own meaning through experience. Damico and Roth (1994) study

observed that good quality education were explicitly defined in terms of output, such as, the number of students passing a standardised national examination. Therefore, a school having students with low achievement scores in a national examination was said to be non-performing.

The interaction of different factors or variables usually affect learning outcomes. These variables could be classified into independent, dependent and extraneous variables. These variables and their interactions constituted the conceptual model of the study. Teachers applied broad range of instructional mechanisms while teaching agriculture which somehow could, have had effects on student's academic achievement. Figure 2 displayed the connection among different variables used for establishing the effects of teaching using Problem Based Learning (PBL), Demonstration Teaching Method (DTM) and Lecture Teaching Method (LTM) on students' achievement in agriculture.

The independent variables in this study are Problem Based Learning, Demonstration and Lecture Teaching methods. Teaching using PBL and DTM are treatments, while LTM is used as a control. The dependent variable is achievement in agriculture as measured by scores on agriculture achievement test which is to indicate the effectiveness of teaching methods. Extraneous variables are variables that are not manipulated by the researcher but may have important impact on the dependent variable. They must be controlled; otherwise, they would distort and invalidate conclusions resulting from the findings. Therefore, it is generally recognisable that learning outcomes may be affected by extraneous variables, such as, students' age, type of school and teacher qualifications and gender of students, as reflected in Figure 2.

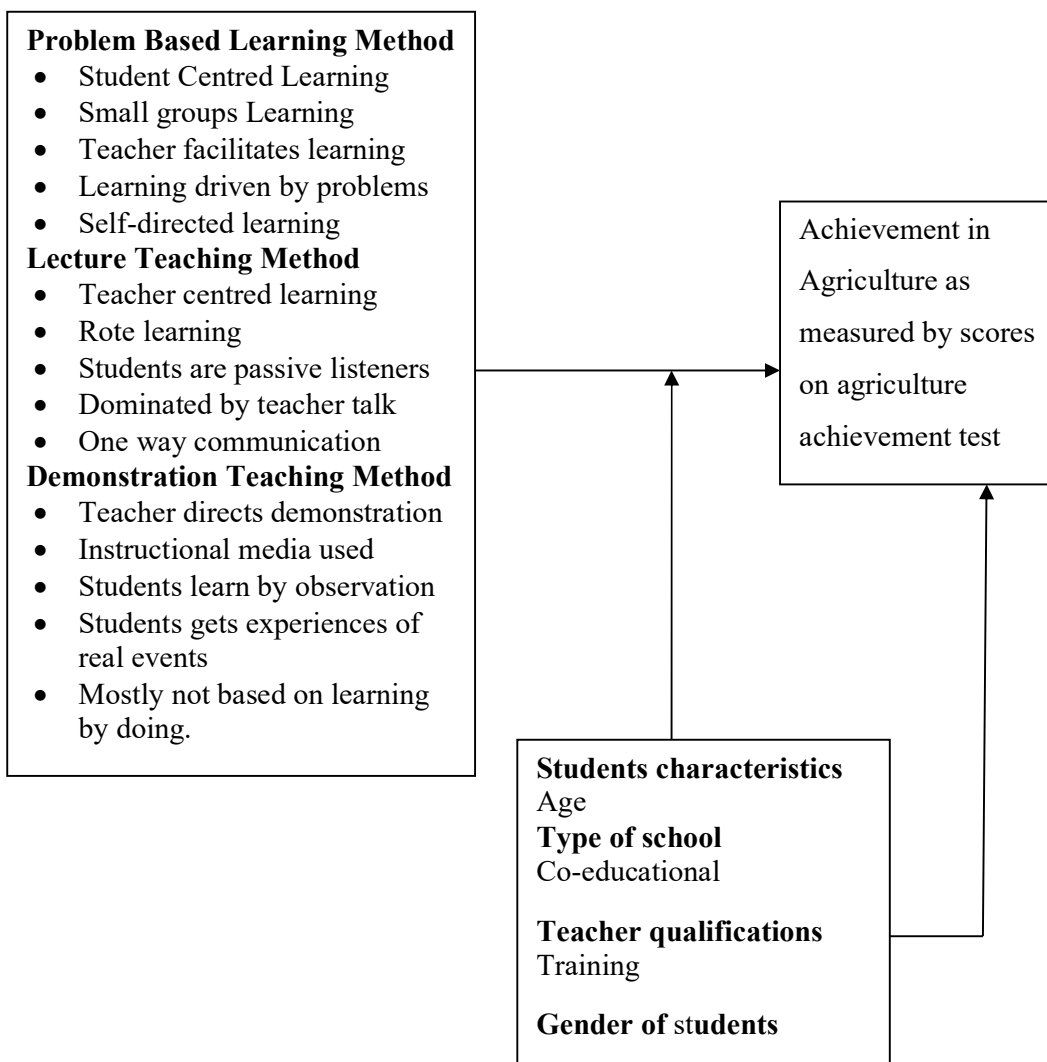
Independent Variables**Intervening Variables Dependent Variable**

Figure 2. A Conceptual Framework showing Relationships among Variables.

The school type and students' age were controlled by evaluating learners in intact groups and in their normal school setting, and the learners' age dictated what they were taught, which is why Form Two students in the same age bracket took part in the study. The instructional method chosen by the teacher and the effectiveness of which the teacher would use the method were determined by the teacher's qualifications as a teacher of agriculture. Training meant the qualification teachers received to qualify as teachers of agriculture, for example, Diploma in Science Education, Diploma in Agricultural Education and Extension, Bachelor's degree in Education Science, Bachelor's Degree in Agricultural Education and Extension and Master's Degree in Agricultural Education. As a result, only qualified teachers by training took part in the study to account for any differences in teacher qualifications. The

research was performed in school groups containing boys only, girls only, and schools containing both boys and girls to regulate the form of school variables (mixed schools). However, as an uncontrollable variable, gender of students cannot be directly regulated, and its consequences cannot be ignored.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section gives details of research design, location of the study, target population, sampling procedures, instrumentation, data collection, data analysis techniques, as well as, ethical considerations observed during the study.

3.2 Research Design

A quasi-experimental design is one in which the researcher has little control over the study participants' selection; as a result, the researcher is unable to delegate participants randomly or ensure that the sample selected is as homogeneous as desired (Leedy & Ormrod, 2010). The study utilised quasi experimental design, constituting three sets of six schools. Two sets of schools were subjected to Problem Based Learning and Demonstration treatments respectively, while the remaining set acted as a control. Non-equivalent Control Group Pretest-Posttest Design (Campbell & Stanley, 1963) were considered robust and extensively utilized quasi experimental design in pedagogical studies (Ary *et al.*, 2010). Further, the design was suitable for testing and validating the effects of treatments between PBL and Demonstration teaching methods. Quasi experimental design was applied because classes already existed in the school and remained that way throughout the study period. Form Two classes were randomly allocated to treatment groups (PBL and DTM) while Lecture teaching method served as a control. All classes in secondary schools occur as intact groups. Therefore, school management could not accept dismantling and reassembling classes in favour of scientific investigation (Franken & Wallen, 2000).

According to Sekeran and Bougie (2011), Non-equivalent Control Group Pretest-Posttest Design permits manipulation of the independent variable in order to establish the degree of its creative consequences. The design was regarded detailed because it provided greatest assurance to internal and external validity. The design was a good choice for the study because random allocation of students to groups was not feasible (Ary *et al.*, 2010). This gave the design the advantage of controlling reactive effects of experimentation, especially when intact classes were used, and students were probably less aware of an experiment being conducted than when students are drawn from classes and put into experimental sessions (Ary *et al.*, 2010). This contributed to the general applicability and generalizability of the findings. Furthermore, it was satisfactory for managing all the threats to internal validity. The three groups took a Pretest and a Posttest, hence a total of six

observations were made. The observations were used to generate estimations of the effect of the experimental treatments and that of the control variable. The students were pretested in the three groups before they were taught Livestock Production II (Nutrition) topic. Problem Based Learning was applied within first category, whereas demonstration method was operationalized in the second group and finally, lecture teaching method was used on the last group that was used to verify the results. All students were taught for six weeks, thereafter, posttest was given to the groups. The research plan is presented in Table 3.

Table 3

Non-Equivalent Control- Group Pretest-Posttest Design

Group	Pretest	Treatment	Posttest
1 st Experimental group	O _{1P}	X _P	O _{2P}
2 nd Experimental group	O _{1D}	X _D	O _{2D}
Control group	O _{1C}		O _{2C}

Where:

O_{1P} represents Pretest scores for problem based learning method (1st Experimental group)

O_{2P} represents Posttest scores for problem based learning method (1st Experimental group)

X_P Represents treatment for problem based learning method (1st Experimental group)

O_{1D} represents Pretest scores for demonstration teaching method (2nd Experimental group)

O_{2D} represents Posttest scores for demonstration teaching method (2nd Experimental group)

X_D Represents treatment for demonstration teaching method (2nd Experimental group)

O_{1C} Represents Pretest scores for Lecture teaching method (Control group)

O_{2C} Represents Posttest scores for Lecture teaching method (Control group)

3.3 Location of the Study

The investigation was undertaken in Ndhiwa Sub County in Homa Bay County which is located in the western part of Kenya. The Sub County is approximately 420 kilometres from Nairobi City. The Sub County lies on a geographical co-ordinates of 34° 22'0"E and 0° 44'0 "S. It occupies a total area of 711.4 km² of which (638 km² is arable land), (Figure 3) and a population of 218,136 (Kenya National Bureau of Statistics (KNBS), 2019). It is situated at an altitude of between 1200-1400 metres above sea level with an average annual rainfall of 1300mm which is distributed in a bimodal pattern.

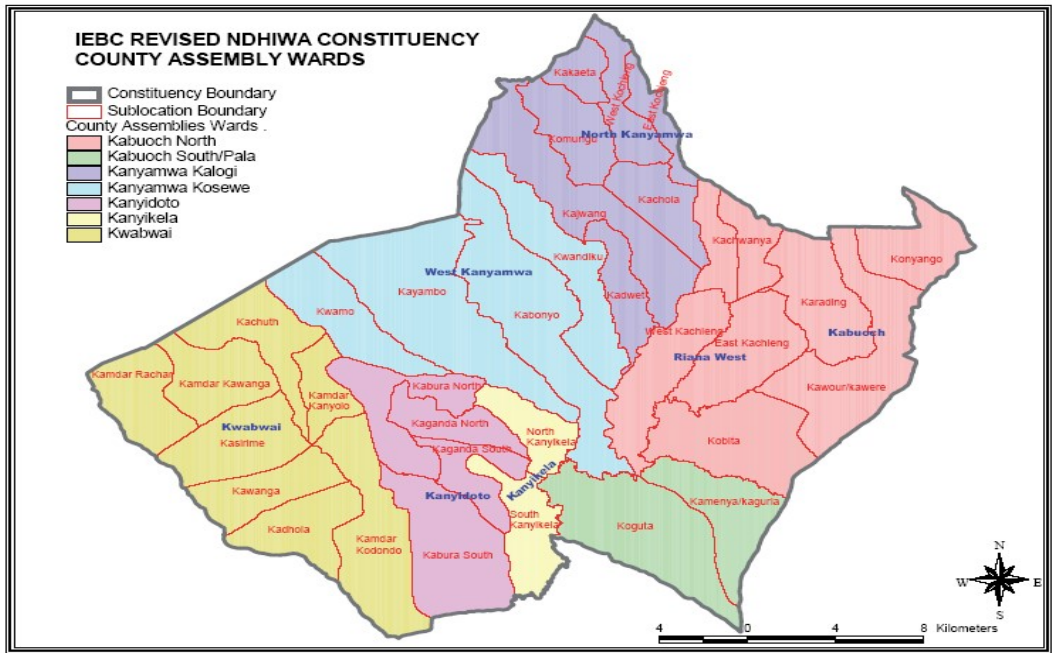


Figure 3. Map of Ndhiwa Sub County/Constituency

Source: Independent Electoral Boundary Commission (2012)

Ndhiwa Sub County has one Constituency which has six administrative divisions consisting of 29 locations and 50 sub locations. There are seven wards within the Sub County (KNBS, 2019). There are 45 secondary schools with a population of 11,728 students (Ndhiwa Sub County Director of Education office records, 2017).

3.4 Target Population

Target population is defined as the population where the sample of the study is taken and the findings of the study is finally generalized (Kothari, 2004). The primary group in the present research was all secondary school agriculture learners registered within Ndhiwa Sub County in year 2019, as well as, all teachers of agriculture in Ndhiwa Sub County. The accessible population was Form Two students taking agriculture subject, as well as, trained teachers of agriculture. Form Two students were selected for study because almost all students in secondary schools take agriculture up to Form Two before they select preferred subjects in Form Three. There were 45 secondary schools with 7,124 students taking agriculture in Ndhiwa Sub County. The schools are classified into Extra County, County and Sub County schools. The registered schools according to school clusters are shown in

Table 4.

Table 4*Number of Secondary Schools in Ndhiwa Sub County*

School Type	Boys only	Girls only	Co-educational	Total
Extra County	2	1	0	3
County	2	1	0	3
Sub County	5	7	27	39
Total	9	9	27	45

Source: SCDE office records, Ndhiwa Sub County (2017)

3.5 Sampling Procedure and Sample Size

A sample is a group or subject that is obtained from the target population (Mugenda & Mugenda, 2003). Sampling is defined as the selection of sub-sets from entire set which is used to make conclusions (Orodho, 2009). A survey conducted by the Kenya National Bureau of Statistics (KNBS) and the Society for International Development (SID) (KNBS & SID, 2013), reported that 20 percent of Homa Bay County residents do not have formal education, with only 17 percent of residents having an ordinary level of education or higher. Lanterns are used by another 21 percent, while tin lamps are used by 73 percent. Just 24 percent of residents have cement floors in their homes, compared to 75 percent who have earthen floors. Less than 1 percent of households have tile floors. According to the statistics, low literacy rates and a lack of access to opportunities for a decent life are prevalent. Because of these factors, Homa Bay County was chosen. Similarly, Ndhiwa Sub County was chosen for research because it has the lowest literacy rate in the County, at 11 percent, compared to the County average of 17 percent (KNBS & SID, 2013).

Secondary schools were used as the unit of sampling instead of individual students because schools function as intact groups (Gall *et al.*, 1996). As a result, every school was regarded as a cluster. School registers in Ndhiwa Sub County were used as the sampling frame. The researcher used SCDE records to find out the number of trained teachers in the schools. The schools were selected using stratified sampling method and purposive sampling methods. The selection of the schools was organized on the basis of students' gender. Form Two students and trained teachers were purposively selected. Eighteen out of 45 schools participated in the study. Sampling involving ex post facto and experimental designs require a sample size that is not less than 15 cases (Gall *et al.*, 1996).

Three schools were chosen from each of the six wards using stratified sampling based on the administrative divisions in Ndhiwa Sub County, forming a total of 18 schools. Where

the population from which the sample is to be taken does not consist of a homogeneous group, stratified sampling is used (Etikan & Bala, 2017). Purposive sampling is often used when the researcher is able to collect information from the subjects or entities that can best provide the necessary information (Sekaran & Bougie, 2010). To ensure that all school categories were included in the sample, a purposive sampling approach was used to pick at least one school in each of the Extra and County school categories that contained both boys and girls only schools, due to the smaller number of schools. Simple random sampling was used to pick the schools in the Sub County category since there were so many. This was accomplished by randomly selecting numbered pieces of paper and folding them to give schools in this group an equal and independent chance of being chosen for inclusion in the study. In each category of teaching methods, the 18 institutions were further divided into three equal groups of six schools. Two boy schools, two girl schools, and two coeducational schools made up the PBL group, demonstration group, and lecture group. The number of schools per group defined in Table 5 was used to sample the schools. Mugenda and Mugenda (2003) reaffirmed that data from simple random sampling can be used to generalize. As a result, schools with multiple Form Two streams were sampled using simple random sampling to select a single stream for participation.

Each of the eighteen participating schools had one teacher chosen from among them. Purposive sampling was used to pick the teacher with the most teaching experience in cases where there were multiple agriculture teachers. Six of these schools were boys' schools, while the other six were girls' schools, as gender was a factor to be examined. This was based on school category and school type within the Sub County. Since an appropriate sample size should be representative of the target population, large sample sizes have been preferred because they are more representative of the target population (Tromp & Kombo, 2006). The sample size was determined based on the number of students enrolled in the schools. The school's location in terms of divisions within the Sub County, syllabus coverage, ability to collaborate, and gender diversity were all factors considered in the decision to choose participating schools. The sample size was 779 students with 401 boys and 378 girls (Table 9). There were 280 students in the PBL, 295 in the DTM, and 204 in the LTM (Table 33). National and private schools in the Sub County were not included in the research. This is due to the closure of private schools in the Sub County, and the national schools in Homa Bay County are located outside of Ndhiwa Sub County.

Table 5*Sample of Schools, Students and Teachers According to School Category*

School Type	Boys only	Girls only	Co-educational	Total	Teachers	Students
Extra County	2	1	0	3	3	182
County	2	1	0	3	3	169
Sub County	2	4	6	12	3	428
Total	6	6	6	18	18	779

Source: SCDE office records, Ndhiwa Sub County (2017)

3.6 Instrumentation

A researcher constructed Agriculture Achievement Test (AAT) (Appendix E) was utilized as the research tool. The instrument was administered twice in form of pretest and posttest. The first administration was for the pretest and the second administration was for the posttest. The term test was defined as the deliberate use of test scores as the research data (McMillan & Schumacher, 1997). A table of test specification was used to standardize the agriculture achievement test. This was done to ensure that the test was balanced and that the achievement domains that were being assessed were identified, as well as, to ensure that a fair and representative sample of questions were included on the test. As a result, the scoring, administration, and analysis of the test results were all consistent. The instrument was designed to allow the researcher to determine the level of achievement of the students. Furthermore, the agriculture achievement test was derived from the Livestock Production (II) Nutrition topic in the secondary agriculture syllabus in Form Two. The following learning units were covered in the agriculture achievement examination.

- a) Components of feeds
- b) Feeds and feedstuff: Roughages and Concentrates
- c) Ration computation
- d) Digestion in ruminants and non-ruminants

Students' learning outcomes were measured using the agriculture achievement test. Written tests were preferred because they helped to regulate research conditions in a standardized way, making it easier to compare outcomes through students. The agriculture achievement test contained 26 structured questions with a score of 120. For the purposes of the analysis, the AAT scores were converted to 100 percent. The study's instructional plans were drawn from the Kenya Institute of Education's Secondary Agriculture Form Two

Syllabus (KIE, 2002). The researcher was well aware that good planning in terms of preparation of schemes of work and lesson plans by teachers is a feature of quality teaching (Otunga *et al.*, 2011). To ensure standardization in teaching, the researcher prepared schemes of works for the treatments and control groups, respectively. A total of 18 lessons were used for each method of teaching.

Based on the research literature, the researcher developed a self-report survey tool (Appendix S). The survey's goal was to determine the most common agricultural teaching methods. Teachers were given a range of teaching methods to choose from, including problem based learning, demonstration, lecture, discussion, field trip, and project teaching methods. They were then asked to choose their favourite teaching methods from a variety of options. The two subheadings used to group questions were preferred teaching methods and teaching experience. The aim of grouping questions under each of these subheadings was to arrange the questionnaire into a structure informed by the literature and make it easier for teachers to complete (Beaudry & Miller, 2016). The survey was administered in the form of a questionnaire. In certain cases, questionnaires are used because they are simple to use in data collection (Fraenkel & Wallen, 2000). The aim of this survey was to justify the choice of the three teaching methods (LTM, DTM, and PBL) in the study.

3.6.1 Validity

Validity is defined as the extent to which an instrument measures exactly the variables it claims to measure (Kathuri & Pals, 1993). Likewise, according to Burton and Mazerolle (2011) it pertains to the degree that a tool can evaluate whatever it planned to assess. Face validity is an evaluation of an instrument's appearance with the aim of establishing the instruments ease of use and clarity, while content validity is assessment of how much a device samples representative content to be studied (Burton & Mazerolle, 2011). The two types of validity were used to establish the credibility, accuracy and relevance of knowledge regarding the domain.

To enhance content validity, the research instruments were validated by the researcher's supervisors and trained teachers of agriculture from the sampled schools. According to Best and Kahn (1993), expert judgment can be used to check content validity of a research instrument. In addition, the instrument was validated by expert lecturers in the Department of Agricultural Education and Extension in Egerton University. The specialists and trained teachers of agriculture in Ndhiwa Sub County examined the items to validate instruments general test appearance and how the instrument samples the content studied

(Netemeyer *et al.*, 2003). The information obtained from the experts was used to modify the content of the items.

3.6.2 Reliability

In conformity with Mugenda and Mugenda (2003) definition, reliability measures the extent a particular measuring device provides coherent outcomes following frequent repetition. Similarly, it is defined as the ability of a good instrument to produce similar results when conducted repeatedly (Burton & Mazerolle, 2011). A pilot test was conducted to ensure instrument reliability. Piloting was done primarily to determine the efficacy of test products that would be included in the study's final stages. Twenty-five to fifty respondents, according to Kathuri and Pals (1993), are ideal for pilot testing. Piloting is a procedure for pretesting the measuring instruments. It was done to make sure the instruments were measuring what they were supposed to be measuring. As a result, 50 Form Two students from a school in Rongo Sub County in Migori County, were subjected to a pilot test. The items in the test were fine-tuned by piloting. Respondents were able to provide input based on the test complexity, comprehension, and ability to follow instructions using this method. In addition, the researcher was provided with useful information about some parts that appeared to be easy, difficult, or ambiguous. These were rewritten to make them clearer. Finally, these items were modified or omitted from the test items. To ensure the instrument's accuracy, the test-retest method was used. Students were given a pretest and posttest to determine the instrument's reliability. This was done to check whether the testing conditions could be repeated at the proposed study location with fewer students for a set period of time (Supino & Borer, 2012). A similar test was given to the same subjects a second time, and the results from both testing periods were then compared. The two administrations yielded reliability coefficients of 0.76 and 0.78, indicating that the instruments were highly reliable. As a result, the reliability coefficient was sufficient in reaching accurate conclusions (Fraenkel & Wallen, 2000).

3.7 Data Collection Procedure

A clearance letter from Graduate School of Egerton University was obtained in advance to allow for acquisition of research permit from the National Commission for Science, Technology and Innovation (NACOSTI) granting authority to conduct the study in Ndhwa Sub County. The research permit was used to request for local authorization from the County Commissioner and the County Director of Education. These authorizations permitted

researcher to sample secondary institutions. The researcher undertook a visit to schools to talk to principals concurrently with agriculture teachers on need to be part of the research. A PBL training manual developed by the researcher was used to train six teachers in the experimental schools for three days on how to teach classes using PBL method. The other 12 teachers were trained for one day because they were to teach using demonstration and lecture teaching method which they already knew from their previous training. The selected teachers used similar schemes of work for the period of study to ensure uniformity in teaching the selected topic.

3.7.1 Preparatory Workshops for Agriculture Teachers

There were two workshops organized for teachers participating in the study. The workshop for PBL teachers lasted for three days and the topics covered during the workshop were: i) Objectives of the study ii) Planning for teaching iii) Theories and practices of PBL method iv) Use of teachers guide v) Administration of AAT and marking of scripts.

The second workshop for teachers using demonstration method and lecture teaching method lasted for one day and covered the following topics. i) Objectives of the study ii) Planning for teaching iii) Teaching using lecture teaching method iv) Teaching using demonstration method v) Use of teachers guide vi) Administration of AAT and marking of scripts.

3.7.2 Administration and Marking of Agriculture Achievement Tests

The source of data for the study was the AAT. Teaching objectives were used as the basis for constructing the instruments. Question papers and marking schemes were distributed to schools one week before the start of teaching. Both treatment and control school students sat the pretest at the beginning of the six weeks study. Agriculture teachers marked the pretest. The researcher collected the marked scripts from the agriculture teachers. Posttest was administratively given to experimental together with control school students at the end of six weeks study. The instrument was administered at the same time in all the schools under the same conditions, as well as, scored by the classroom teachers in a predetermined, standard manner to ensure standardization. As a result, the findings were compared around the sampled schools and related to student achievements rather than disparities in administration. To obtain test scores, study participants were asked to respond to written questions by presenting answers to the questions in order to assess their performance traits. The agriculture teachers marked and graded the posttest. The standardized test eventually

yielded a numerical value at the end of administration, and the students' scores (results) were submitted to the researcher by the teachers of agriculture.

Mark sheets for each school had the following information.

- i) Name of the school
- ii) Category of the school (Extra county, County and Sub County)
- iii) Learning Programme followed
- iv) Individual scores for learners
- v) Gender of the student.

In addition, teachers of agriculture were given questionnaires to fill out in order to decide the most preferred teaching methods used in teaching of agriculture in Ndhiwa Sub County. This was done in order to explain the inclusion of the three teaching methods that were chosen in the study.

3.8 Data Analysis

Quantitative data were accurately scrutinised and analysed using the Statistical Package for Social Sciences (SPSS) version 25 software. Scoring and organizing the scores into their categories formed part of the analysis. Each respondent's final score was converted to 100%, entered and given a distinct code identity as per the teaching method followed. Notably, data coding and transcribing process were followed by data cleaning process to eliminate errors. The analysis included descriptive statistics, for instance, median, mode, standard deviation and mean. The software processed the frequencies, percentages, mean and standard deviation which were adequately used to discuss the findings. Inferential statistics used included: chi-square, t-test, analysis of covariance, as well as, analysis of variance. Tables and in certain instances, bar graphs, were used in presentation of the results. The four hypotheses were tested at set *a priori*, of .05 level of significance. According to Best and Khan (2006), the alpha level of .05 is most cases applicable in educational and psychological studies as a standard applied in the rejection of the null hypothesis. Quantitative data were obtained from test results on agriculture test scores. Analysis of Covariance was used to test hypotheses one to four. Pretest scores were analysed using descriptive statistics such as, mean, median, mode and standard deviation. Chi-square was also used. The results were presented in form of percentages and frequency tables. Objective one to four were analysed using descriptive statistics and chi-square. The results were presented in tables.

Analysis of variance includes a group of tests that are specific to linear regression where a linear model is interpreted with reference to mean of groups. The effect of an independent variable on a dependent variable was determined using ANCOVA. In the process, the effect of the covariate factor was removed. Analysis of Covariance is done using linear regression, where there is an assumption that a linear relationship exists between the independent variable and the dependent variable. The residuals obtained which included the unexplained variance in the regression model were then subjected to an ANOVA. Therefore, the ANCOVA test was used to establish whether the independent variable had an effect on the dependent variable after removing the effect of the influence of the covariate(s). The generated F test form the final test was used to determine whether or not group means vary throughout levels of predictor variables. Analysis of variance was applied in situations with many variables. In this regard, the parameters were PBL, DTM and LTM. The stated procedures allowed for control of overall alpha level and also lower the risk of committing a Type I error. Table 6 outlines how the hypotheses were analysed.

Table 6*Summary of Data Analysis*

Hypotheses	Independent variables	Dependent variable	Statistics
H0₁ There is no statistically significant difference in the effects of PBL and lecture teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.	PBL and LTM	AAT scores	Chi square ANCOVA Mean T-test
H0₂ There is no statistically significant difference in the effects of demonstration and lecture teaching methods on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.	DTM and LTM	AAT scores	Chi square ANCOVA Mean T-test
H0₃ There is no statistically significant difference in the effects of PBL, demonstration teaching method and lecture teaching method on academic achievement of secondary school students in agriculture with regards to gender of students in Ndhiwa Sub County.	PBL, LTM and DTM	AAT scores	ANCOVA Mean T-test
H0₄ There is no statistically significant difference in the effects of PBL and demonstration teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.	PBL and DTM	AAT scores	ANCOVA Mean Standard deviation

3.9 Ethical Considerations

Ethical guidelines must be followed by every researcher. According to Resnik (2015), ethics encompasses, but is not limited to, secrecy, justice, dignity, human subject safety, objectivity, and the protection of intellectual property rights. The researcher further describe ethics as the set of rules that researchers employ to determine what is and what is not an appropriate behaviour. To ensure that research ethics was followed, the researcher received a letter of introduction from Egerton University's Graduate School, which aided in the application for a research license from NACOSTI. Following that, the researcher obtained permission from the Homa Bay County Ministry of Education and the Homa Bay County Commissioner to conduct research in the County. The researcher made a formal request in writing to the selected school Principals and teachers of agriculture to administer research instruments and collect data. The participants were guaranteed anonymity, and their right to choose whether or not to participate in the study was stressed. Before beginning the research process, Hammersley and Traianou (2012) state that the researcher must obtain the respondents' consent. Through doing so, the researcher guarantees the respondent's anonymity, autonomy, and protection. As a result, the study's voluntary participation was ensured by informing the teachers that their participation was not mandatory.

The researcher briefed the teachers on the study's purpose and significance during the teachers' workshops. Furthermore, by not writing students' names on question papers, the students' privacy was ensured. Students were informed that the information they provided would be used only for research purposes. This method fostered a positive relationship between the researcher and the students, as well as, improving their self-esteem. For easy follow up, the researcher included a space on the question paper where the teaching method used was written. The researcher ensured that this study did not contain any plagiarized content. Every piece of secondary data was acknowledged. The schools that took part in the study did so willingly. The results were stated exactly as they were collected, with no changes or falsifications. The researcher advised teachers of agriculture who did not use the PBL method in the study to re-teach the topic using PBL so that all students could learn from it.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The chapter provides information pertaining to results along with discussions on the effects of Problem Based Learning (PBL) and Demonstration Teaching Method (DTM) on the performance of secondary school students in agriculture subject. Detailed analyses are presented in Tables and Figures in this Chapter.

The chapter has been precisely ordered in various parts: (i) characteristics of respondents, (ii) academic achievement of students in agriculture subject (iii) effects PBL on students achievement in agriculture, (iv) effects of DTM and achievement of students in secondary school agriculture, (v) comparison of gender differences in academic achievements in secondary school agriculture among learners instructed through PBL and DTM (vi) comparing students' performances under PBL and DTM in secondary agriculture subject.

4.2 Characteristics of the Respondents

4.2.1 Background Information for Teachers in Ndhiwa Sub County

Teachers' teaching methods and teaching experience were among the factors assessed in the background information for teachers section. All of the teachers (100%) said they prefer to teach using the lecture technique, with 84 percent saying they prefer to teach using the demonstration technique (Figure 4). Problem Based Learning has never been used as a teaching method by the teachers surveyed since they did not understand how it works. The bulk of the teachers had 5 to 10 years of experience in the classroom (Figure 5). Agriculture teachers in Ndhiwa Sub County were profiled based on their preferred teaching techniques and past teaching experience. As a result, the researcher's decision to include the PBL method as a variable in this study was justified. Similarly, because the majority of agriculture teachers employ LTM and DTM as teaching methods, the two teaching methods were included as variables in the study.

4.2.2 Background Information for Students who Participated in the Study

According to the findings, there were 428 students in the Sub County School category compared to 169 students in the County category and 182 students in the Extra County category. Similarly, students in co-educational schools (316) outnumbered students in girls' only schools (253) and boys' only schools (210). Similarly, the number of boys who took part in the study (401) was higher than the number of girls who took part in the study (378). The

students came from boarding and day secondary schools that were either all girls, all boys, or all mixed.

4.2.3 Findings on Teachers Experience and Preferred Teaching Experience

The findings on the most favoured teaching methods (Figure 4) were crucial in identifying which teaching methods are most commonly employed by agriculture teachers in the Sub County.

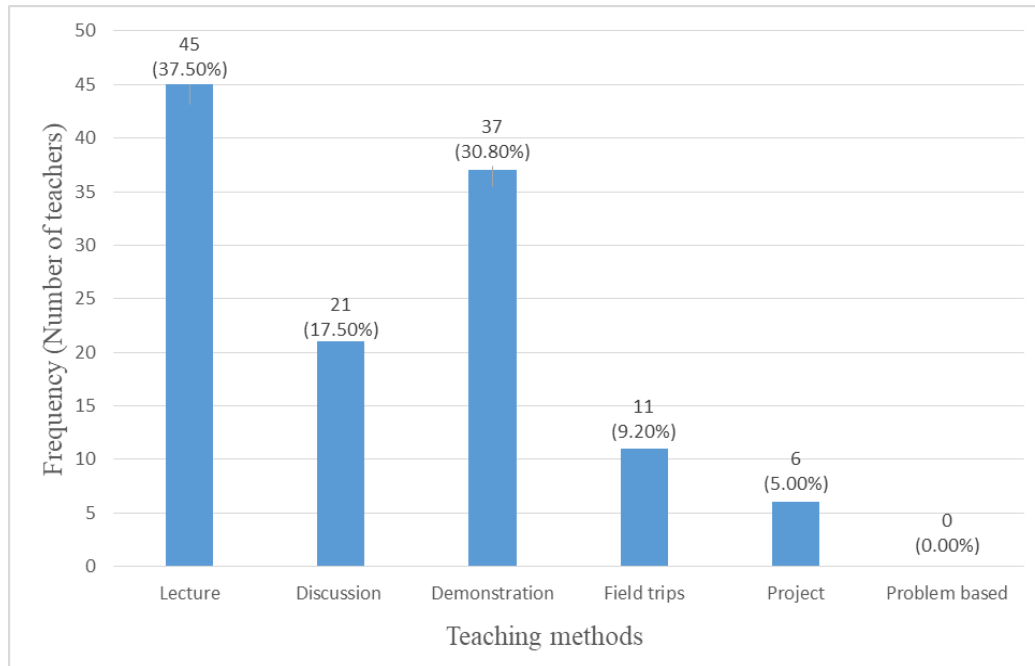


Figure 1. Teaching Methods used by Teachers in Ndhiwa Sub County

Figure 4 shows that among the respondent teachers in the Sub County, the lecture teaching method (37.5%) was the most prevalent and preferred teaching method. The second most favoured teaching method was demonstration at 30.8 percent of the respondents. Notably, 17.5 percent of teachers reported they normally teach their students through discussions. Field trip method (9.2%) and project teaching method (5%) were only used by a small percentage of agriculture teachers. It's worth mentioning that none of the teachers in the Sub County chose Problem Based Learning as their teaching method (0%). The results in Figure 5 shows the teaching experience for the respondent teachers in the Sub County. Teaching experience was considered as one of the teachers characteristics. This was an important consideration taken since proper implementation of teaching methods requires considerable experience.

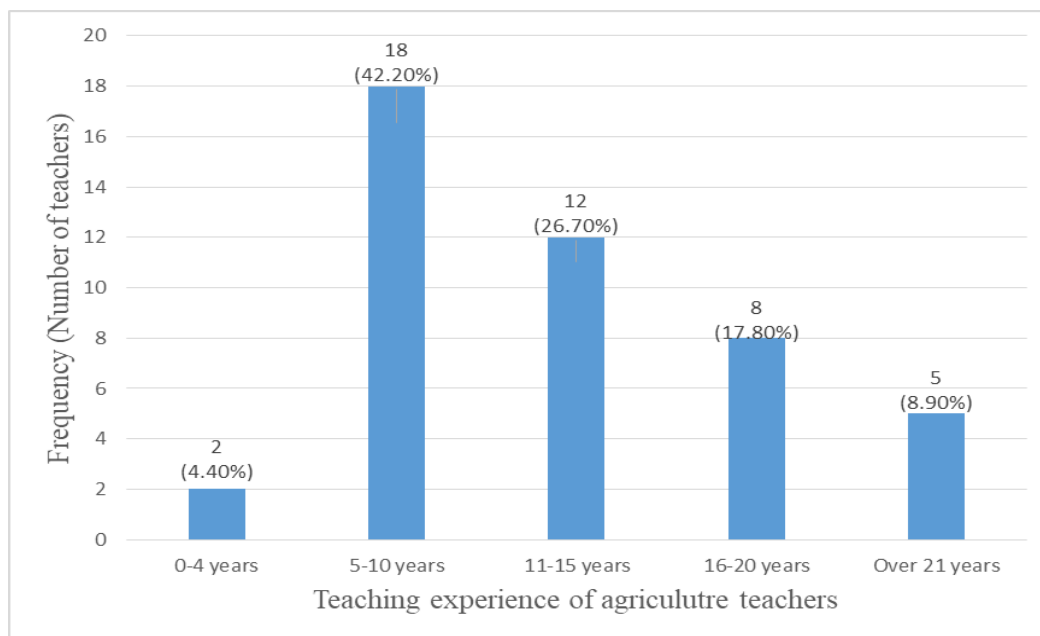


Figure 2. Teaching Experience for Teachers of Agriculture in Ndhiwa Sub County

Results in Figure 5 summarizes the findings about teachers' teaching experience. The bulk of the teachers (42.2%) had 5-10 years of experience, while 26.7 percent had 11-15 years of teaching experience. The survey established that 17.8 percent of the teachers had 16-20 years of experience with only 8.9 percent of the teachers having more than 21 years of teaching experience. About 4.4 percent of the teachers had less than four years of experience in the classroom. Therefore, the majority of respondent teachers in the Sub County were experienced, according to the survey findings.

4.2.4 Distribution of Respondents According to School Category

The categories of schools included Extra County schools, County schools and Sub County schools as depicted in Table 7.

Table 7*Types of Schools*

School Type	Numbers of schools	Percent	Number of students	Percent
Extra County	3	16.7	182	23.4
County	3	16.7	169	21.7
Sub-County	12	66.6	428	54.9
Total	18	100.0	779	100.0

Based on this study, three school categories were used; Extra County schools accounted for 16.7 percent of schools with 23.4 percent of students, County schools accounted for 16.7 percent of sampled schools with 21.7 percent of students, while Sub County schools were the majority of schools constituting 66.6 percent with 54.9 percent of students. In Kenya, secondary schools are divided into four categories. The government uses this classification to determine how much money to spend on schools and how well they are equipped. According to the Institute of Policy and Research, this requirement for admitting students based on their school category entrenches educational achievement inequalities (IPAR, 2008).

The inequalities in resource availability and staffing levels may explain why most schools in the National and Extra County categories performed better in examinations than schools in the County and Sub County categories. The majority of schools in the Sub County category are understaffed and underequipped. The situation is exemplified in Ndhiwa Sub County, where students' agricultural achievement has remained consistently poor for many years. Ogweno (2015) asserted in a related study that providing schools with teaching and learning resources by using the lecture method did not mean that the resources were not required. Furthermore, according to Ogweno (2015), students may continue to perform poorly despite the availability of resources if those resources are not used effectively. It is possible that the poor performance observed in Ndhiwa Sub County is not due to a lack of resources, but rather to the repeated use of the lecture teaching method.

4.2.5 Gender Composition of Schools in Ndhiwa Sub-County

Gender was a key factor that needed to be studied in the analysis. Data on gender characteristics of the sampled schools are presented in Table 8. It is undeniable that enrolment levels in co-educational schools are higher than those in other categories of schools. Surprisingly, the schools are classified under the Sub County category, which is

typically understaffed and underequipped, resulting in poor student achievement Institute of Policy and Research (2008).

Table 8

Composition of Schools According to Gender in Ndhiwa Sub-County

Gender of schools	Number of schools	Percent	Number of students	Percent
Boys Only	4	22.2	210	27.0
Girls Only	6	33.3	253	32.5
Co-educational	8	44.5	316	40.6
Total	18	100.0	779	100.0

4.2.6 Students Respondents' Gender

The gender of the respondents was determined using school records, and the results are shown in Table 9.

Table 9

Gender Composition of the Respondents

Gender	Frequency	Percent
Boys	401	51.5
Girls	378	48.5
Total	779	100.0

According to the statistics, all genders are equally represented. The gender balance in Ndhiwa Sub County is reflected in this composition. In this study, the number of boys was higher than the number of girls. This suggests that the number of boys enrolled in school could be marginally higher than the number of girls enrolled.

4.3 Academic Achievement of Students in Agriculture Subject

Students who took part in the study were given a pretest (Appendix E). The examination was marked and graded out of one hundred percent. The pretest scores were used as a covariate in the subsequent analysis. The results are shown in Figure 6.

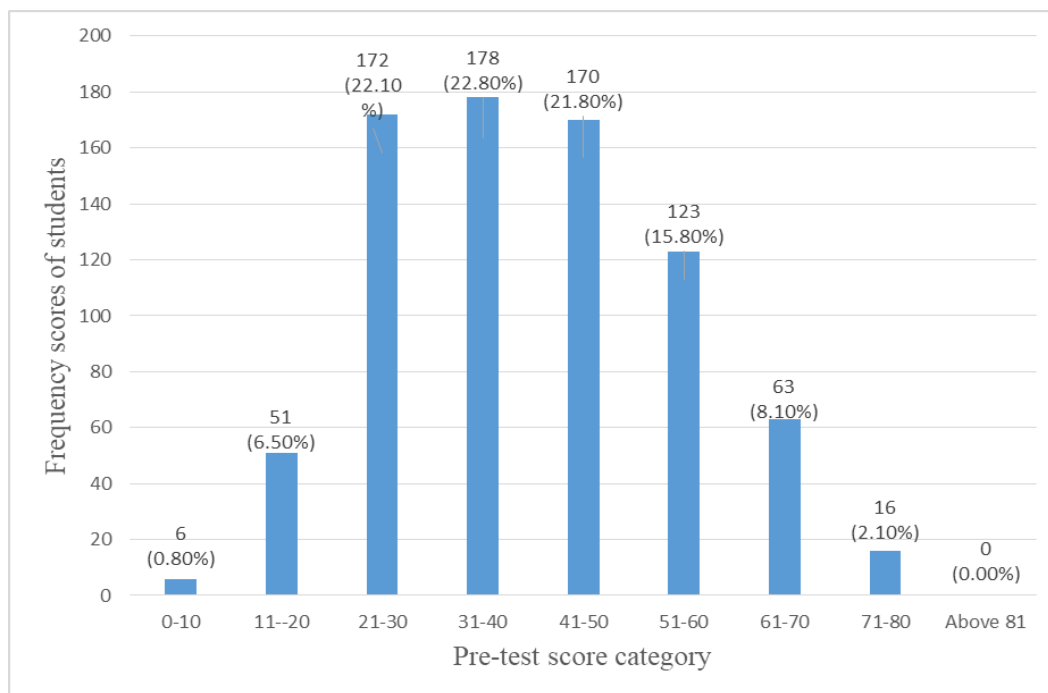


Figure 3. Pretest Scores of Students Achievement in Categories

Figure 6 indicates that the pretest score category (31-40) were higher than the other categories, with 178 students scoring in the 31-40 range. The students who scored between 21 and 30 were the second best, with 172 students (22.1%). The average student performance in secondary school agriculture was 31.8, with a standard deviation of 12.01. The lowest score was 7 and the highest was 73 percent. Because the students had not been taught the topic (nutrition) prior to the pretest, their performance on the pretest was dismal. This is due to the fact that the students were not entirely prepared for the pretest. The pupils' dismal performance was unsurprising because they had not been taught the topic or introduced to sections of the entire topic by their teachers, resulting in very little effort on their side to study the topic independently. As a result, the low student outcomes in the pretest were expected.

The Chi-square (χ^2) test was performed to compare observed pretest frequencies with the expected frequencies to find out the actual divergence of the observed and expected frequencies. The similarity in expected frequencies were so because there was need to establish whether or not the observed frequencies of student's scores in pretest occur equally for the different scores categories so that the expected frequency distribution should contain the same score in each of the score categories (Table 10).

Table 10*Chi-Square Test on the Frequency Distribution of Students Pretest Scores*

Score	Observed f_o	Expected f_e	Residual	Statistics
1-10	6	97.4	-91.4	$X^2=372.82$
11-20	51	97.4	-46.4	df= 7
21-30	172	97.4	74.6	$p= .001$
31-40	178	97.4	80.6	
41-50	170	97.4	72.6	
51-60	123	97.4	25.6	
61-70	63	97.4	-34.4	
71-80	16	97.4	-81.4	
Above 81	0	-	-	
Total	779			

The findings further showed students scoring marks between 21 and 50 which was quite low were statistically and significantly ($X^2=372.82$, df 7, $p.001$) higher than the other categories. The calculated value of chi-square ($X^2=372.82$) was very high as compared to its table value ($X^2=4.322$). This indicated that the divergence between expected and observed frequencies was very great and consequently, the overall divergence was significant. Overall, the candidates' performance in the subject therefore, was rated as poor. It can be concluded that, being a pretest, the poor results were expected because the test was taken before instruction.

4.4 The Effect of Problem Based Learning in the Academic Achievement of Students in Secondary School Agriculture

The first objective of this study was to compare the effect of PBL method and lecture teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County.

Section 4.4 addresses analysis of the data pertaining to the objective. The results, their interpretations and discussions are presented under subsections 4.4.1 to 4.4.4.

4.4.1 Academic Achievement of Students Instructed through PBL

As shown in Figure 7 and Table 12, descriptive statistics were used to analyse the achievement of learners who were taught using PBL. Figure 7 shows that the majority of students who were taught agriculture using the PBL method scored 51-60 on the Agriculture Achievement Test posttest. Similarly, the second-best students were located in the 61-71 scores range. In general, students' performance increased as a result of the PBL intervention. The results in Figure 7 displays posttest results for students who received instruction through PBL.

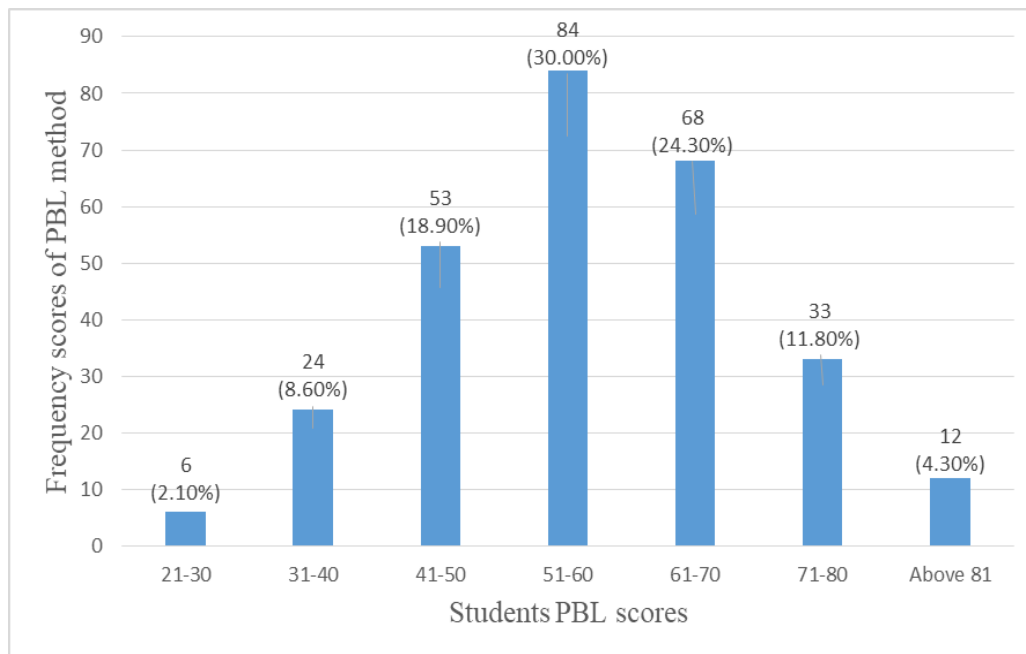


Figure 4. Posttest Scores Distribution for Students Taught using PBL Method

In comparison to their pretest scores (Figure 6), students' achievement in posttest scores under the PBL teaching technique was quite good (Figure 7). Many students scored between 51 and 60 marks category, accounting for 30% of all students who were taught through PBL method. This excellent achievement was followed by 24.3 percent of students who scored between 61-70 marks category. This result confirms that PBL instruction enhances students' agricultural achievement. Students who were taught agriculture using the PBL approach had a mean score of 57.47 and a standard deviation of 13.19. The lowest score obtained was 22 percent, while the highest score obtained was 89 percent. The results can be classified as satisfactory. In the pretest, students had a mean of 31.8 and a standard deviation of 12.01, respectively. PBL posttest findings showed a mean and standard deviation of 57.47

and 13.19, respectively. When compared to the pretest mean, the posttest results show that the PBL teaching method has a higher mean score (57.47) to pretest mean score (31.8).

As a result of the treatment procedure, the mean difference is 25.67. Problem Based Learning had a major impact on learner achievement in agriculture, according to the findings. To establish the associations among frequencies of students' scores in PBL method, a Chi-square (χ^2) test was done to compare observed frequencies with the expected frequencies to find out the actual differences in the observed and expected frequencies. The expected frequencies in the score categories were identical because the researcher wanted to see whether the observed frequencies in students' PBL scores occurred similarly for the various score categories, so the expected frequency distribution should have the same score in each score category. Table 11 summarizes the presentation.

Table 11

Chi-Square Test on the Associations among Frequencies of Students' PBL Scores

Score	Observed f _o	Expected f _e	Residual	Statistics
21-30	6	40.0	-34.0	$X^2 = 128.35$
31-40	24	40.0	-16.0	df = 6
41-50	53	40.0	13.0	$p = .001$
51-60	84	40.0	44.0	
61-70	68	40.0	28.0	
71-80	33	40.0	-7.0	
Above 81	12	40.0	-28.0	
Total	280			

The students with the scores between 51 and 60 which was high (or good) were statistically and significantly ($X^2= 128.35$, df 6, $p.001$) higher than the other categories. The results are significant because the calculated value of chi square ($X^2= 128.35$) was greater than the tabulated value ($X^2=22.458$). In essence, the discrepancy between the observed and expected frequencies are not attributed to chance. The performance in the subject was therefore, rated as good. The good performance in agriculture subject in the Sub County could be attributed partly to the method of teaching utilised by agriculture teachers in present study. In other words, students had been taught the topic that was tested. As a result of this exposure to the contents of the topic, many students were found to be generally performing better in the subject as a result of the teaching method used.

4.4.2 Hypothesis Testing

The first hypothesis of this study was stated as: *There is no statistically significant difference in the effects of PBL and lecture teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.*

To test this hypothesis an Analysis of Covariance was aimed at finding out the effect of lecture teaching method (control) and the Problem Based Learning (as an intervention) on post-intervention secondary students' agriculture score after controlling for pre-intervention (the students score before the intervention). The one-way ANCOVA was performed with two main objectives (i) to ascertain whether the independent variable was statistically significant in terms of the dependent variable; and (ii) if so, determine where any differences in groups of independent variable was. The means for the control (lecture) and PBL based on the covariate (pre-intervention score) are given in Table 12.

Table 12

Independent Samples T-Test for Lecture and PBL Teaching Methods

	N	Mean	Std. dev.	Df	t-value	p-value
Lecture	204	43.76	10.40	203	-12.77609	0.001
Problem Based Learning	280	57.47	13.19			

n= number of students, Std. dev. = standard deviation, Intervention = Problem Based Learning, Control = Lecture

Independent samples t-test analysis shows that there is a significant difference in mean scores achievement between students which were taught agriculture using lecture teaching method and PBL, $t(df = 203) = -12.77609, p = 0.001, p < 0.05$. Accordingly, the posttest means for LTM (43.76) and PBL (57.47) displays the mean differences as shown in Table 12. This finding shows that teaching using PBL has positive effects on students' academic achievement.

Mean scores obtained showed a remarkable difference among achievements of students under PBL and lecture teaching method, respectively. This in essence implies that the PBL method of teaching results in better achievement by students than lecture method of teaching livestock production II (nutrition).

Students who learned the topic through the PBL method used skills such as imagination and interpretation, application of experience in real-world environments, and independent research, resulting in higher achievement in livestock nutrition than students who learned the topic through lecture teaching. The students' best results in livestock nutrition were obtained using the PBL approach, which agrees with Shikuku and Amadalo's (2015) research, which found that students performed better when PBL was used instead of lectures.

There were no outliers in the test results, as demonstrated by the lack of standardized residuals exceeding ± 3 standard deviations. The Levene's test for equality of variances was used to check if the learning intervention and control variable (PBL and Lecture), had the same variances. Therefore, as measured by Levene's test of homogeneity of variance ($p = .220$), there was no homogeneity and homoscedasticity of variances, as shown in Table 13.

Table 13

Levene's Test of Equality of Error Variances between PBL and LTM

F	df1	df2	P
77.279	2	776	.220

Testing the null hypothesis whether the error variance of the dependent variable is equal across groups

a. Design: Intercept + control Pretest + intervention

Dependent Variable: Post Test Score

As determined by Levene's test of homogeneity of variance ($p = .220$), the test results suggest that there was homogeneity of variances. Since Levene's test result was not statistically significant ($p > .05$), the homogeneity of variances assumption was not violated, it can be assumed that the variances are equal and hence the homogeneity of variances assumption was met.

Following covariate adjustments, a one-way Analysis of Covariance was used to confirm whether there were any statistically significant group variations in relation to the dependent variable. Table 14 shows a similar finding, as well as, significant ANCOVA findings for tests of between-subjects effects.

Table 14*Tests of Between-Subjects Effects*

Source	Type III Sum	Df	Mean		P	Partial Eta Squared
	of Squares		Square	F		
Corrected Model	20019.978 ^a	1	20019.978	194.778	.001	.412
Intercept	6552.320	1	6552.320	63.749	.001	.187
Control (Pretest)	20019.9780	1	20019.978	194.778	.001	.412
Intervention	.000	0	-	-	-	.001
Error	28573.847	278	102.784			
Total	973539.000	280				
Corrected Total	48593.825	279				

Dependent Variable: Post Test Score

a. R Squared = .412 (Adjusted R Squared = .410)

Following adjustment for pre-intervention agriculture score, a statistically significant difference in post-intervention score between the interventions was found, $F(1, 278) = 194.778$, $p < .001$, partial $\eta^2 = .412$. As a result of this outcome, the null hypothesis was rejected. Therefore, the findings of the study established sufficient evidence showing statistically significant differences on students' achievement in secondary school agriculture between students who received instructions through PBL and those exposed to lecture teaching.

This result is in line with a study by Abanikannda (2016) which found that using PBL improved student's chemistry achievement when compared to traditional methods. Similarly, Shikuku and Amadalo (2015) found that students exposed to the PBL approach performed better than students exposed to strictly traditional teaching methods in a study on linear programming skills in Kenya. Furthermore, Aidoo *et al.* (2016) found a substantial difference in student achievement in chemistry between students who were taught through PBL and students who were taught through lecture teaching method in a study conducted in South Africa on the impact of Problem Based Learning on students' achievement in chemistry. Students who were taught using the PBL method performed better than those who were taught using the LTM method. In this regard, the result is in line with the results of this study.

Furthermore, the findings of this study show that PBL is a superior teaching method, as students who used it performed substantially better than those who used the lecture

method. This is most likely due to the fact that PBL focuses on small group discussions about real-world problems. Consequently, students exchange ideas in groups, allowing them to benefit from whatever topic is being investigated. This method helps students to create their own interpretations for the concepts they have learned, resulting in a high degree of recall. As a result, students acquire a wide range of skills, as well as, independent learning as they learn amongst themselves with minimal guidance from the facilitator.

4.4.3 Post Hoc Mean Comparisons

Post hoc analysis was performed through Bonferroni post hoc tests. The comparison of the mean pairs for Problem Based Learning and Lecture methods, the 95% confidence interval for the difference between group I and J, statistical significance value (p value) and standard error are shown in Table 15.

Table 15

Pairwise Comparisons of the Mean Using the Bonferroni Post Hoc Test between PBL and LTM

Comparison between	Mean	Mean	Std.	P	95% Confidence	
					Lower	Upper
Lecture (I) and Problem Based Learning (J) method		Difference	Error		Bound	Bound
(I-J)	44.36	-12.45	.723	.001	-14.189	-10.721
(J-I)	56.81	12.45	.723	.001	10.721	14.189

Dependent Variable: Posttest score for PBL

To determine whether means of PBL and lecture method was statistically significant from each other, post hoc mean comparisons using Bonferroni test was conducted. The mean comparison results for the mean pairs in Table 15, indicate that post-intervention score for the Problem Based Learning method was statistically and significantly greater than the control with a calculated mean difference of 12.45 (95% CI, 10.72 to 14.18) %, $p < .001$.

4.4.4 Univariate Analysis using the F and Eta Squared Tests

Two univariate tests were performed, that included the F test and partial eta squared. F test was particularly employed to test the effect of learning method on results of posttest in

agriculture subject. The foundation of the test rests on the linearly independent pairwise comparisons among the estimated marginal means. The eta squared (η^2) or partial eta squared (η^2_p) are indices that give the measures of effect size for use in ANOVA. They show the proportion of total variance in a dependent variable that is associated with the membership of different groups defined by an independent variable. The variance explained ranges between 0 and 1, where .01 is small, .06 medium, and above $> .14$ is large (Cohen *et al.*, 2003). Table 16 displays result of the univariate analysis.

Table 16

Univariate Analysis for PBL and Lecture Teaching Method

	Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Contrast	20019.973	1	5265.755	194.778	.001	.412
Error	28573.847	278	102.784			

R Squared = .412 (Adjusted R Squared = .410)

The effect size for analysis was found to be large as the partial eta squared was (η^2_p) = .412. This confirms that the analysis and the comparisons were authentic. The p value (.001) in Table 16 indicate that there are significant effects between PBL and lecture teaching method because the p value is below the stated alpha of .05. Notably, there is a sufficient power to detect the effects. The partial eta squared was .412 which was above .14. In conclusion, the study had sufficient power to detect significant effects between PBL and lecture teaching method.

4.5 The Effect of Demonstration Teaching Method on Students' Academic Achievement in Secondary School Agriculture

The second objective was to compare the effect of demonstration teaching method and lecture teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County. The results of the analysis are given and discussed under subsections 4.5.1 to 4.5.4.

4.5.1 Academic Achievement of Students in Secondary Agriculture Taught using the Demonstration Teaching Method

The performance of students taught using Demonstration teaching method (DTM) was methodically examined using descriptive statistics. The results are outlined in Figure 8. Students in the 41-50 marks range scored higher than students in other groups on the posttest for the Demonstration teaching method. The students who scored 51-60 marks came in second out of all the groups. For the group of students who were taught using DTM, this was an average score on the Agriculture Achievement Test.

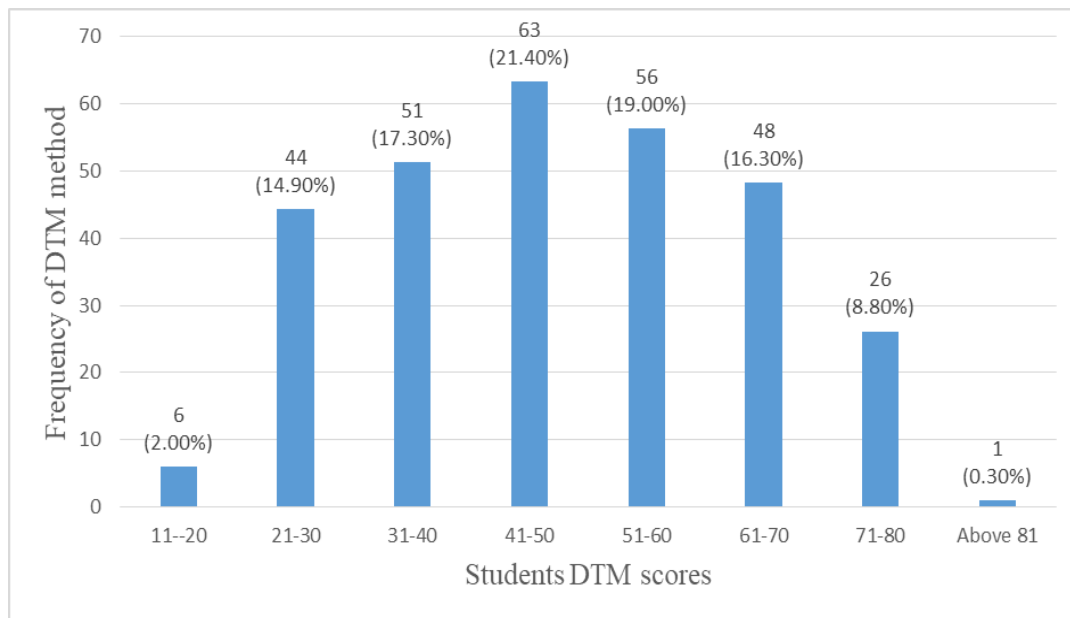


Figure 5. Posttest Scores Distribution for Students Taught Using DTM

The results show that students in Ndhiwa Sub County who were taught agriculture using the DTM scored a mean of 48.40 with a standard deviation of 16.14. The lowest score received was 15 percent, while the highest score received was 82 percent. Students who scored between 41 and 50 marks in the DTM posttest had the greatest percentage (21.4%), followed by students who scored between 51 and 60 marks (19%). The performance was rated good. The pretest mean and standard deviation were found to be 31.8 and 12.01, respectively. Similarly, for students taught using the demonstration teaching method, the posttest mean and standard deviation were 48.40 and 16.14, respectively. When compared to the pretest mean of 31.8, the students' posttest results in DTM showed a higher mean score of 48.40. This results in a 16.6 mean difference between the two teaching methods. This

confirms that there is a positive effect of treatment on students' achievement under demonstration teaching method.

Table 17 shows the results of the Chi-square test used to assess the relationship between the student's scores. The real variations between the observed and predicted frequencies were determined by comparing the experimentally obtained frequencies to the theoretically expected frequencies.

Table 17

Chi-Square Test on the Associations among Frequencies of Students' Scores

Score	Observed f_o	Expected f_e	Residual	Statistics
11-20	6	36.9	-30.9	
21-30	44	36.9	7.1	$X^2=102.53$
31-40	51	36.9	14.1	df = 7
41-50	63	36.9	26.1	$p = .001$
51-60	56	36.9	19.1	
61-70	48	36.9	11.1	
71-80	26	36.9	-10.9	
Above 81	1	36.9	-35.9	
Total	295			

The students with the score between 41 and 50 which was in the level of medium (or Fair) were statistically and significantly ($X^2= 102.53$, df 7, $p.001$) higher than the other categories. The calculated Chi-Square value ($X^2= 102.53$) is bigger than the tabulated value ($(X^2=24.322)$), therefore, the obtained Chi-Square value is too large to have arisen by chance, therefore, there were real differences between the observed and expected frequencies. Therefore, the categories did not occur with similar frequencies. The performance in the subject was therefore, rated as fair. The fair performance in agriculture subject in the Sub County could be attributed partly to the teaching techniques implemented by teachers of agriculture during the study.

4.5.2 Hypothesis Testing

The second hypothesis of this study was stated as: *There is no statistically significant difference in the effects of demonstration and lecture teaching methods on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.*

To test this hypothesis, Analysis of Covariance was carried out to determine the implications of lecture method (control) and the demonstration teaching (as an intervention) on post-intervention secondary students' agriculture score after controlling for pre-intervention (the students score before the intervention). The one-way ANCOVA was performed with two main objectives: (i) to establish whether the independent variable was statistically significant in relation to the dependent variable; and (ii) if so, determine where any differences in the groups of the independent variable lie. The unadjusted and adjusted means for the control (LTM) and DTM based on covariate (pre-intervention score) are presented in Table 18.

Table 18

Independent Samples T-Test for Lecture and Demonstration Teaching Methods

	N	Mean	Std. dev.	df	t-value	p-value
Lecture	204	43.76	10.40	203	-3.903095	0.001
Demonstration	295	48.40	16.14			

n = number of students, Std. dev. = standard deviation, Intervention = DTM, Control = LTM

T-test result indicates that there is a significant difference in mean scores achievement between students who were taught agriculture using lecture teaching method and Demonstration teaching method, $t(df=203) = -3.776095$, $p = 0.001$, $p < 0.05$. The difference is also seen in posttest mean for LTM (43.76) and posttest mean of DTM (48.40), Table 18. These findings demonstrate that teaching through Demonstration teaching method positively affected students' academic achievement.

In essence, as seen in Table 18, there was a significant difference between the two means. The assumption is that the observed mean differences were significant. As a result, when compared to students who were taught through lecture, students who were taught through demonstration performed extremely well. In a nutshell, in livestock production II, the demonstration teaching method produces better outcomes for students than the lecture teaching method.

There were no outliers in the test results, as demonstrated by the fact that there were no standardized residuals greater than ± 3 standard deviations. To confirm whether the learning intervention and control (DTM and Lecture) had comparable variances, the Levene's test for equality of variances was used (homogeneity of variances or homoscedasticity). The results showed that there was no homoscedasticity and homogeneity of variances, as evaluated by Levene's test of homogeneity of variance ($p = .540$) is shown in Table 19.

Table 19*Levene's Test of Equality of Error Variances between DTM and LTM*

F	df1	df2	P
77.279	2	776	.540

Testing the null hypothesis whether the error variance associated with dependent variable is similar among the groups

a. Design: Intercept + control Pretest + intervention

Dependent Variable: Post Test Score

The test results indicated that there was homogeneity of variances, as assessed by Levene's test of homogeneity of variance ($p = .540$). Results of Levene's test was not statistically significant ($p > .05$) meaning that the assumption of homogeneity of variances had not been violated. Therefore, it is justified to conclude that the variances are equal and so the homogeneity of variances assumption was fulfilled.

The reason for conducting the one-way ANCOVA was to find out whether group differences were statistically significant on the dependent variable upon making adjustments for the covariate. As stated in Table 19, the findings were in harmony with the results of the one-way ANCOVA that are explicitly shown in Table 20.

Table 20*Tests of Between-Subjects Effects for Demonstration and Lecture Teaching Methods*

Source	Type III Sum	Df	Mean	F	Sig.	Partial Eta Squared
	of Squares		Square			
Corrected Model	61310.598 ^a	1	61310.598	1170.431	.001	.800
Intercept	22108.570	1	22108.570	422.057	.001	.590
Control (Pretest)	61310.598	1	61310.598	1170.431	.001	.800
Intervention	.000	0	-	-	-	.001
Error	15348.202	293	52.383			
Total	767714.000	295				
Corrected Total	76658.800	294				

Dependent Variable: Post Test Score

a. R Squared = .800 (Adjusted R Squared = .799)

Following adjustment for pre-intervention agriculture score, the results obtained indicate statistically significant difference in post-intervention score between the interventions, $F(1, 293) = 1170.43, p < .001$, partial $\eta^2 = .800$. Therefore, null hypothesis was rejected, implying that confirmed statistically significant differences exist among students that were taught agriculture using demonstration method and the ones who were taught through lectures.

The results are consistent with the findings of a study by Basheer *et al.* (2017), which found a statistically significant increase in students' achievement in redox and electrolysis reactions for students who were taught using the demonstration method. Furthermore, Ekeyi (2013) found a major effect on students' achievement in agricultural science for students who were taught through demonstration and lecture teaching methods in secondary schools in the East Kogi Education Zone, Nigeria. In other words, students' achievement was higher in the demonstration teaching method than in the lecture teaching method. Similarly, the findings of this study agree with those of Inuwa (2018), who observed a substantial difference in financial accounting achievement between students taught through demonstration and those taught through lecture teaching method. In essence, the DTM was found to be an efficient method for enhancing secondary school students' financial accounting achievement. Similarly, Ogwo and Orangu (2006) observed that using DTM to improve student performance was successful because students participate actively in the process.

According to Ogweno (2014), students who were taught using DTM outperformed their peers who were taught using lecture, project, field trips, and discussion techniques. As a result, how students are taught has an impact on their performance. Similarly, there have been situations when students' learning styles coincided with teachers' teaching approaches, resulting in increased student achievement (Harb & El-Shaarawi, 2006). Learning predisposition, according to Reid (1995), can refer to a person's natural ability to synthesize new information. That is, many people vary in a variety of ways when it comes to the teaching methods that better fit their learning styles. Instructors who endorse the learning preference approach agree that good teaching can be accomplished if students' study preferences are known and teaching is tailored accordingly (Pashler *et al.*, 2008). Omrod (2008) stated that certain learners are generally predisposed to learn more when content is presented orally, while visual learners understand information much more quickly when presented in pictures. In this regard, using only one method of instruction reduces students' optimal participation in class and can have an effect on their academic success.

4.5.3 Post Hoc Mean Comparisons

In order to perform a post hoc test, a Bonferroni post hoc test was used. Table 21 shows the mean pair comparisons for demonstration and lecture teaching methods, as well as, the 95 percent confidence interval for the discrepancy between groups I and J, statistical significance value (p value), and standard error.

Table 21

Pairwise Comparisons of the Mean Using the Bonferroni Post Hoc Test

Comparison between Lecture (I) and Demonstration Based Teaching (J) method	Mean	Mean Difference	Std. Error	P	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
(I-J)	44.36	-4.248	.714	.001	-5.962	-2.535
(J-I)	48.608	4.248	.714	.001	2.535	5.962

Dependent Variable: Posttest score for DTM

Post hoc mean comparisons using the Bonferroni test were used to confirm whether the mean score derived from the lecture method was statistically significant from the mean score derived from the demonstration teaching method and vice versa. The post-intervention score for the demonstration teaching method was substantially higher than the control (Lecture teaching method) with a mean difference of 4.248 (95 % CI, 2.535 to 5.962) %, $p < .001$), according to the details of mean comparison results for mean pairs shown in Table 21.

4.5.4 Univariate Analysis using the F and Eta Squared Tests

The F test and partial eta squared were two univariate experiments that were used. In the agriculture subject, the F test was used to check how the learning method affected the posttest results. Eta squared aids in the interpretation of the findings by showing the degree to which the variance observed in the ANOVA is linked to each of the key effects and their interactions. The eta squared (η^2) or partial eta squared (η^2_p) are effect size indices that can be used in ANOVA. They show the percentage of total variance in a projected variable that is linked to membership in various groups identified by the manipulated variable. The variance explained varies from 0 to 1, with .01 denoting a small variance, .06 denoting a medium variance, and $>.14$ denoting a significant variance (Cohen *et al.*, 2003). Table 22 shows the results of univariate regression.

Table 22*Univariate Analysis for Demonstration and Lecture Teaching Methods*

	Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Contrast	61310.598	1	61310.598	1170.431	.001	.800
Error	15348.202	293	52.383			

R Squared = .800 (Adjusted R Squared = .799)

The effect size were found to be large as the partial eta squared was $(\eta^2p) = .800$. This confirms that the analysis and the comparisons were authentic. The calculated p value (0.001) in Table 22 confirmed significant effects between Demonstration teaching method and lecture teaching method. This is because the p value is below the alpha level of .05 for the two teaching methods. The partial eta squared was .800 which is above .14. Therefore, the study had sufficient power to detect significant effects between PBL and lecture teaching method. In this regard, scores on the dependent variable also contain the amount and source of variance caused by treatment effects (Thompson, 2006).

4.6 Comparison of Gender Differences in Academic Achievement in Secondary School Agriculture among Students Taught Using PBL and DTM Teaching Methods

The third objective examined the effect of PBL method, demonstration teaching method and lecture teaching method on academic achievement in secondary school agriculture with regard to gender of the students in Ndhiwa Sub County. This objective is addressed in section 4.6, and the findings are summarized and discussed in subsections 4.6.1 to 4.6.4.

4.6.1 Boys and Girls Academic Achievement in Secondary Agriculture

The overall achievement between the boys and girls among the three teaching methods (or the grand mean) were compared for the boys and girls. The results (grand mean, standard error and the 95 percent confidence intervals for the means) for both boys and girls students are presented in Table 23.

Table 23*Independent Samples T-Test for Boys and Girls Compared Using Grand Mean*

	N	Mean	Std. dev.	df	t-value	p-value
Boys	401	48.852 ^a	8.45	377	-4.26666	0.001
Girls	378	51.356 ^b	7.93			

a. Covariates appearing in the model are evaluated at: Pretest score = 30.8903.

b. Covariates appearing in the model are evaluated at: Pretest score =32.8095.

The T-test analysis established a significant difference in achievement between boys and girls performance in agriculture achievement test, $t (df=377) = -4.26666, p = 0.001, p < 0.05$. From Table 23, girls have a higher mean score (51.356) compared to boys mean score (48.852). Irrespective of teaching method used, there is statistical significant difference between girl's achievement and boy's achievement.

These findings corroborated a study that found female gender achievement in class to be slightly higher than male gender achievement (Voyer & Voyer, 2014). This is due to cultural and lifestyle influences, which lead some parents to believe that boys are more intellectually gifted than girls and, as a result, are expected to perform better. As a result, parents are more likely to provide guidance to their daughters so that they can work hard in school. In a similar vein, this study contradicted Wangu's (2014) findings, which found that boys performed better than girls in science subjects and languages among Kenyan secondary school students. However, in a study involving Nigerian college students, Goni *et al.* (2015) found no major gender differences in academic achievement.

Table 24 shows the descriptive statistics for the three teaching methods for boys and girls, as well as the interpretation of students' results in the three teaching methods (lecture, PBL, and demonstration) for both genders.

Table 24*Posttest Mean Scores for Boys and Girls for the Three Teaching Methods*

Gender of Student	Learning Methods	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Boys	Lecture	43.979 ^a	.833	42.342	45.616
	Demonstration	47.699 ^a	.719	46.286	49.112
	Problem Based Learning	54.879 ^a	.545	53.808	55.950
Girls	Lecture	45.636 ^b	.714	44.232	47.040
	Demonstration	48.785 ^b	.611	47.584	49.987
	Problem Based Learning	59.648 ^b	.840	57.996	61.300

The mean score for the girls were generally higher (45.636, 48.785, 59.648) than the boys (43.979, 47.699, 54.879) for all the three learning methods (LTM, DTM and PBL), respectively. The results (Table 24) show that girls had a higher mean score of 59.648 in PBL method compared with the mean score of girls in the control group (lecture method) 45.636. The mean difference of 14.012 was much greater. The results indicate a notable difference in terms of mean scores attained in PBL and lecture method, respectively. Similarly, the mean for boys in PBL (54.879) was higher than the mean for boys in lecture method (43.979). The mean score difference between PBL and lecture method for boys was 10.9. Similarly, girls had a mean score of 48.785 in demonstration method compared with a mean score of 45.636 in the lecture method. This gives a mean score difference of 3.149 between demonstration teaching method and lecture teaching method for girls. The boys achieved a mean of 47.699 in demonstration method in comparison to 43.979 mean obtained in lecture teaching method. Mean score differences between demonstration teaching method and lecture teaching method for boys was 3.72. The results showed that PBL teaching method for girls had the highest mean score difference of 14.012 than the boys mean score difference of 10.9 in PBL teaching method. This implies that girls performed better than the boys in PBL in the administered test. This is an indication that girls' achievement in agriculture subject under PBL platform is better than boys' achievement in the same subject using the same teaching method. This is probably due to the fact that girls could be more diligent in school matters and thus are unlikely to be absent from class.

In addition, girls' registered slightly higher mean score in the posttest in all the three teaching methods compared with boys participants. Therefore, going by the results, girls

easily got acquainted to the three teaching methods and this gave them the head start to perform better than boys. This research supports Hartley and Sutton's (2013) findings that girls outperform boys in school academic achievement, motivation, and self-regulation. In a research conducted by Miheso-O'Connor (2002), it was discovered that girls were positive and decisive in their use of interactive teaching methods. In the three teaching methods used, girls performed better than boys in the posttest findings. The research by Hannover and Kessels (2011), on the other hand, found no gender gaps in student achievement.

According to the findings of the study, gender has a significant effect on student achievement, especially in agriculture subject in Ndhiwa Sub County. Another research, backed up the findings, confirming that females do much better than boys in subjects like languages and the arts (Chambers & Schreiber, 2004). This is because female students are more focused on their studies and are less likely to skip classes or be distracted by other activities. In the demonstration teaching method, the mean differences for girls and boys were 3.149 and 3.72, respectively. As a result, the measured mean difference in demonstration teaching method between males and females was not greater. In support of this finding, Voyer and Voyer (2014) provided conclusive evidence that females performed on average better than males in many school subjects, and that this trend had been observed in many countries since the early twentieth century.

In addition, there were no outliers in the test results, as demonstrated by the fact that no standardized residuals exceeded ± 3 standard deviations in any case. To see whether the control variable and learning intervention (LTM and DTM) had similar variances, the Levene's test was used (homogeneity of variances or homoscedasticity).

As shown in Table 25, there was no homoscedasticity or homogeneity of variances, as determined by Levene's test of homogeneity of variance ($p = .090$ for boys and $.100$ for girls).

Table 25

Levene's Test of Equality of Error Variances for the Three Teaching Methods

Gender of Students	F	df 1	df 2	P
Boys	32.244	2	398	.090
Girls	62.623	2	375	.100

The test results show that there was homogeneity of variances ($p = .090$ and $.100$), as determined by Levene's test of homogeneity of variance. Since the Levene's test results were

not statistically significant ($p > .05$), the homogeneity of variances assumption was not violated, and the variances were equal, the homogeneity of variances assumption was met.

4.6.2 Hypothesis Testing

The third hypothesis was stated as: *There is no statistically significant difference in the effects of PBL, demonstration teaching method and lecture teaching method on academic achievement of secondary school students in agriculture with regards to gender of students in Ndhiwa Sub County.*

An Analysis of Covariance was eventually conducted to test this hypothesis in order to determine the effect of lecture (control) with PBL and demonstration teaching methods (as interventions) on post-intervention secondary school students' agriculture score for both boys and girls after controlling for pre-intervention (the students score before the intervention). The reason for conducting the one-way ANCOVA was to confirm whether there were existing statistically significant gender differences on the dependent variable after adjusting for the covariate. The analysed results are presented in Table 26.

Table 26*Tests of Between-Subjects Effects for Boys and Girls*

Gender of Student	Source	Type III			F	p.	Partial Eta Squared
		Sum of Squares	Df	Mean Square			
Boys	Corrected Model	63329.50 ^a	3	21109.836	343.687	.001	.722
	Intercept	16125.24	1	16125.245	262.533	.001	.398
	VAR00008	38490.610	1	38490.610	626.661	.001	.612
	VAR00007	10531.510	2	5265.755	85.731	.001	.302
	Error	24384.423	397	61.422			
	Total	1113447.00	401				
	Corrected Total	87713.930	400				
Girls	Corrected Model	60684.01 ^b	3	20228.006	328.960	.001	.725
	Intercept	14010.398	1	14010.398	227.846	.001	.379
	VAR00008	46375.266	1	46375.266	754.184	.001	.668
	VAR00007	8754.633	2	4377.317	71.187	.001	.276
	Error	22997.519	374	61.491			
	Total	1040619.00	378				
	Corrected Total	83681.537	377				

a. R Squared = .722 (Adjusted R Squared = .720)

b. R Squared = .725 (Adjusted R Squared = .723)

Dependent Variable: Post Test Score

The variables (PBL and DTM) dealing with the intercept (VAR 00008 and VAR 00007) are control for boys and girls. The results show that after adjustment for pre-intervention agriculture score, there was a statistically significant difference in post-intervention score between the interventions for boys, $F(3, 397) = 21109.83$, $p < .001$, partial $\eta^2 = .722$ and $F(3, 374) = 20228.32$, $p < .001$, partial $\eta^2 = .725$ for girls. In this regard, the null hypothesis is rejected. Conclusively, there were statistically significant differences due to PBL and demonstration teaching method with respect to gender in students' agriculture achievement at secondary school level.

PBL is a superior teaching method, according to the findings, because students who were exposed to it outperformed students who received instruction by demonstration and

lecture methods, respectively. The findings corroborated a research by Kehinde (2005), which revealed that students taught using the PBL fared much better than those taught using the lecture technique. Shehu (2015) found that students who were instructed using the PBL method performed substantially better than those who were taught using the lecture method. Similarly, Daluba (2013) observed that demonstration teaching method was more effective in improving students' performance and recalling learned material than the lecture teaching method. According to the author, using the demonstration teaching method typically increased students' interest and comprehension of the subject, resulting in a high achievement rate among the students.

On the contrary, the students who received instruction through lectures posted lower means scores in comparison to their counterparts who got instruction using PBL and demonstrations method platforms. In a study by Fatoke and Olaoluwa (2014) it was established that lecture method of teaching chemistry proved less effective than the PBL method. The findings indicate that Problem Based Learning method outperforms Demonstration and Lecture teaching methods in terms of student outcomes. This may be due to judicious and clear instructional dispensation that allows students to improve analytic and practical skills. It was likely that low achievement level witnessed in the use of lecture method in teaching agriculture subject was because teachers come to teach and students usually memorize what is taught with little retention and understanding of what is being taught.

In a PBL environment, students apply what they have learned, use investigative techniques, and develop individual learning skills, resulting in higher achievement in posttest than students who were taught using DTM and LTM. These findings are consistent with those of Hung (2008), who stated that PBL is the most creative teaching method ever used and applied in education because it aims to improve individual research skills while increasing awareness application to real-world problems. Post hoc mean comparisons using the Bonferroni test were used to identify the statistically significant means, as defined in section 4.6.3.

4.6.3 Post hoc Mean Comparisons

The results of experimental data were analysed using Bonferroni procedure. The comparison of the mean pairs for Demonstration Teaching Method (J) and Lecture Teaching Method (I) and Problem Based Learning (J) and Lecture Teaching Methods (I) for both boys

and girls, at 95 % confidence interval for the difference between group I and J, and the statistical significance value (*p* value) and standard error are given in Table 27.

Table 27

Pairwise Comparisons for Girls and Boys

Gender of Student	Mean Comparisons: Lecture (I) minus- Learning method (J) (I-J)	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Boys	Demonstration	-3.720	1.098	.002	-6.360	-1.079
	Problem Based Learning	-10.899	.949	.001	-13.182	-8.617
Girls	Demonstration	-3.149	.963	.004	-5.465	-.833
	Problem Based Learning	-14.012	1.098	.001	-16.652	-11.372

The mean comparison results for the mean pairs presented in Table 30 indicate that Post-intervention score for the Demonstration teaching method and PBL were greater than the control (lecture) method for boys and girls. Comparing the differences in mean scores for the boys and girls for the demonstration teaching method, the boys had significantly higher mean differences -3.720 (95% CI, 6.360 to -1.079) %, $p < .002$ than the girls -3.149 (95% CI, -5.465 to -.833) %, $p < .004$. In comparing the mean differences for the boys and girls in PBL, the girls exhibited highest mean differences -14.012 (95% CI, 16.652 to -11.372) %, $p < .001$ than the boys -10.899 (95% CI, -13.182 to - 8.617) %, $p < .001$.

4.6.4 Univariate Analysis using the F and Eta Squared Tests

The researcher conducted two univariate test. The F and partial eta squared tests were among them. In the agriculture subject, the F test evaluates the effect of teaching method on posttest results. The eta squared (η^2) or partial eta squared (η^2p) are indices that give the measures of effect size for use in ANOVA with variance ranging between 0 and 1, where .01 is small, .06 medium, and above $> .14$ is large. The F test and the partial eta squared are presented in Table 28

Table 28*Univariate Analysis for Girls and Boys*

Gender of Student		Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Boys	Contrast	10531.510	2	5265.755	85.731	.001	.302
	Error	24384.423	397	61.422			
Girls	Contrast	8754.633	2	4377.317	71.187	.001	.276
	Error	22997.519	374	61.491			

The study established that the effect size for both the boys and the girls were large as the partial eta squared (n^2p) = .302 for boys and .276 for girls. As a consequence of these findings, the study and comparisons were genuine. The p values for boys and girls was .001, which is lower than the alpha value of .05, suggesting that there were substantial gender effects between posttest outcomes in the PBL and DTM agriculture achievement test. There is sufficient power to detect the effects because (n^2p) = .302 for boys and .276 for girls are above .14 in each case.

4.7 Comparison between the PBL and DTM on Student Academic Achievement in Secondary School Agriculture Subject

The fourth objective compared the effects of PBL method and demonstration teaching method on academic achievement of students in secondary school agriculture in Ndhiwa Sub County. This section is focussed on addressing this objective. The relevant statistical data, analysis and discussion of the results are addressed in subsections 4.7.1 to 4.7.5.

4.7.1 Descriptive Statistics for the Teaching Methods

The statistical techniques used for the learning methods are expressed in Table 29. The result shows that PBL had the highest mean followed by the demonstration teaching method and finally the lecture method.

Table 29*Descriptive Statistics for the Teaching Methods*

Learning method	Mean	Std. Deviation	N
Lecture (Control)	43.7696	10.40892	204
Demonstration Teaching	48.4000	16.14758	295
Problem Based Learning	57.4750	13.19740	280
Total			779

4.7.2 Tests for Assumptions made for the ANOVA Analysis

To verify equality of variances, through testing to ensure that PBL and DTM had equal variances, the Levene's tests for equality of variances are discussed in sections 4.4 to 4.6.

4.7.3 Hypothesis Testing

The fourth hypothesis was stated as: *There is no statistically significant difference in the effects of PBL and demonstration teaching method on academic achievement of secondary school students in agriculture in Ndhiwa Sub County.*

To determine the effect of lecture (control method) PBL and Demonstration (interventions) methods on post-intervention secondary school students' agriculture scores after controlling for pre-intervention scores before the intervention, ANCOVA was performed on the data to yields results. The unadjusted and adjusted means for the control, PBL and DTM are presented in Table 30.

Table 30*Adjusted and Unadjusted Mean and Variability for Post-intervention Scores with Pre-intervention Scores as a Covariate*

Teaching methods	N	Unadjusted		Adjusted	
		Mean	Std. Dev.	Mean	Std. Error
Lecture	204	43.76	10.40	44.36	.549
Demonstration	295	48.40	16.14	48.61	.469
Problem Based Learning	280	57.47	13.19	56.81	.469
Total	779				

n= number of participants, Std. dev = standard deviation, Std. Error +Standard Error

Intervention = Problem Based Learning + DTM, Control = Lecture

The results presented in Table 30, show that PBL teaching method registered the highest posttest mean of 57.47 with a standard deviation of 13.19. Demonstration teaching method followed at an average of 48.40 and 16.14 standard deviation. Lecture teaching method recorded 43.76 as mean and 10.40 as standard deviation. The calculated mean differences for the three teaching methods were quite noticeable. The implication of the results is that PBL method is a dominant teaching method compared to both demonstration and lecture teaching methods, thus suggesting that PBL is impressive in promoting improved achievement in agriculture subject compared to demonstration and lecture teaching methods.

The findings show that the Problem Based Learning approach generated higher achievement scores for students. This is most likely due to the social interactions that occur between students when they work together to solve problems. The improved performance may be attributed to the fact that students who adopted the PBL teaching method were inspired to learn together because they believed that comprehension and mastery of a subject is not exclusive to a person, and as a result, they had to value the views of group members during discussions. The results of the study agree with those of Gehlen-Baum and Weinberger (2014), who observed that lecture teaching is a unidirectional form of instruction that makes students passive in their learning, compromising information retention and resulting in low student achievement. In a similar vein, Miles (2015) claims that the lecture teaching method does not encourage students to explore knowledge; rather, the teacher's function is to advise students about what they should do. As a result, students become overly reliant on the teacher.

Students typically profit from demonstrations if they are focused on what is related to real-life experience, according to Moskovsky *et al.* (2013). As a result, what is being taught is remembered longer, resulting in increased student performance. Priyono *et al.* (2018) found that students who were taught using the demonstration method had significantly higher achievement outcomes. Students are motivated to learn and develop their learning outcomes when they are taught using the demonstration method (Priyono *et al.*, 2018). This claim is supported by the findings of this study. Furthermore, the findings of this study are consistent with those of Zejnilagi-Hajri *et al.* (2015), who found that PBL teaching provided better results in primary school chemistry than lecture teaching. In another study, Ganyaupfu (2013) discovered that using student centred teaching approaches has a significant effect on students' academic achievement. This is because, as opposed to teacher centred methods, student centred methods are more efficient in content delivery.

After correcting for the covariate, one-way ANCOVA was used to check whether there were statistically meaningful group variations between groups and the dependent variable. As shown in Table 31, these findings were presented alongside the ANCOVA primary outcomes.

Table 31

Tests of Between-Subjects Effects between Pretest and Posttest Results

Source	Type III Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Corrected Model	123727.880 ^a	3	41242.627	670.353	.001	.722
Intercept	38551.110	1	38551.110	626.606	.001	.447
Control (Pretest)	99565.930	1	99565.930	1618.335	.001	.676
Intervention	19870.018	2	9935.009	161.483	.001	.294
Error	47680.867	775	61.524			
Total	2154066.000	779				
Corrected Total	171408.747	778				

a. R Squared = .722 (Adjusted R Squared = .721)

As a consequence of making adjustments in Pretest scores, statistically significant difference were noted in Posttest scores between the interventions, $F(3, 775) = 670.353, p < .001$, partial $\eta^2 = .722$. After adjusting for pre-intervention (Pretest scores), a statistically significant difference in post-intervention (Posttest scores) between the interventions were observed, $F(2, 779) = 161.483, p < .001$, partial $\eta^2 = .294$. The null hypothesis was rejected, resulting in the finding that PBL and demonstration teaching methods had statistically significant variations in students' agricultural achievements. These results support Mabrouk's (2007) findings that using the PBL method significantly improved students' academic achievement in biochemistry and bioanalytical chemistry topics. In Nigeria, Abanikannda (2016) discovered that, in contrast to traditional methods, using Problem Based Learning helps students improve their chemistry achievement. Similarly, Shikuku and Amadalo's (2015) findings from a study in Kenya focused on linear programming skills found that PBL teaching produces better student outcomes than traditional lecturing.

The use of lecture method had the lowest improvement index in agriculture achievement test in the livestock nutrition as results indicated that students had low achievement as compared to the other teaching methods. The method allows the teacher to dominate classroom presentations, thereby forcing learners to memorize concepts with little

understanding of those concepts. Further, post hoc test was then conducted to establish the means that were statistically significant from the others.

4.7.4 Post hoc Mean Comparisons

Bonferroni test became essentially important in performing post hoc analysis. To this end, the comparison of the mean pairs for Demonstration Teaching Method (J) and Lecture Method (I) and Problem Based Learning (J) and Lecture Method (I), the test was performed at 95 % confidence interval for the difference separating I and J group, with statistical significance value (p value) and standard error (Table 32).

Table 32

Pairwise Comparisons between PBL and Demonstration Teaching Methods

Lecture (I) Learning method (J) (I-J)	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Demonstration	-4.248	.714	.001	-5.962	-2.535
Problem Based Learning	-12.455	.723	.001	-14.189	-10.721

The results of the mean comparison for the mean pairs in Table 32 indicate that post-intervention score for the demonstration teaching method and PBL were to a larger extent better off in terms of performance by comparison to control (Lecture).

Comparing the mean differences for Demonstration and Problem Based Learning methods, the PBL had significantly higher mean differences -12.455 (95% CI, -14.189 to -10.721) %, $p < .001$, than the demonstration learning methods -4.248 (95% CI, -5.962 to -2.535) %, $p < .001$.

4.7.5 Univariate Analysis using the F and Eta Squared Tests

The F test was performed to assess the effect of the learning method on the post test results in agriculture subject. The eta squared (η^2) or partial eta squared (η^2p) are used to measure the effect size for use in ANOVA. The variance is between 0 and 1. Where .01 is small, .06 medium, and above $> .14$ is large. The results for the F test and the partial eta squared are presented in Table 33.

Table 33*Univariate Analysis*

	Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Contrast	19870.018	2	9935.009	161.483	.001	.294
Error	47680.867	775	61.524			

The results showed that the effect size for the compared learning interventions was found to be large as the partial eta squared was $(\eta^2p) = .294$. With reference to the results, the study therefore, concludes that analysis and comparisons were authentic. The p value of .001 is below the alpha value of .05 confirm that there was a significant effect between the learning method and posttest results in agriculture achievement test. Likewise, the partial eta squared $(\eta^2p) = .294$ obtained was found to above .14, meaning there was adequate capacity to detect the effects.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The first section of this chapter summarises key findings of the study, followed by conclusions and recommendations.

5.2 Summary of the Study

The study was undertaken to establish how different teaching methods affect the students' achievements in secondary school agriculture subject using Ndhiwa Sub County as a test case. The study addressed the objectives which included comparison of specific effects of various methods of teaching in secondary school agriculture consisting of PBL, demonstration teaching, PBL and demonstration teaching in relation to gender, and finally, making comparisons between PBL and DTM in relation to students' performance. The study was conducted using non-equivalent control group and pretest-posttest design to establish students' achievement. Stratified random sampling procedure helped in selection of 18 schools and a sample size of 779 students. Analysis was achieved by use of inferential and descriptive statistics.

As per the findings, the first objective results in Table 14 compared mean scores for PBL (57.47) with Lecture teaching method (43.76). PBL had a higher mean score compared to LTM. Additionally, mean scores for the post-intervention score for the PBL was significantly higher with reference to lecture teaching method with a difference in mean of 12.45 (95% CI, 10.72 to 14.18) %, $p < .001$). Teaching students using PBL increased students' performance index in agriculture subject. Therefore, PBL was found to be a better teaching method compared to Lecture teaching method.

Results on the second objective established that the mean score for Demonstration teaching method (48.40) was higher than Lecture teaching method (43.76). The mean score comparison results for post-intervention score for the Demonstration teaching method was significantly higher than the Lecture teaching method with a mean difference of 4.248 (95% CI, 2.535 to 5.962) %, $p < .001$). This performance improved students' performance in agriculture subject relative to using the lecture teaching method. Teaching through Demonstration teaching method improved students' performance in relation to the use of lecture teaching method.

Taking into consideration the results of third objective, it was observed that the general overall performance difference between girls and boys was minimal. Nevertheless,

female learners (51.356) posted a higher mean score in contrast to male students (48.852). The results for the three teaching methods (Lecture, Demonstration and Problem Based Learning methods) showed that the mean scores for girls were higher (45.636, 48.785, 59.648) than the boys (43.979, 47.699, 54.879) for all the three teaching methods. While comparing means for the mean pairs, the post-intervention score for the Demonstration teaching method and Problem Based Learning were remarkably greater than the control (lecture teaching method) for both gender. Girl's performance was better than boy's performance in agriculture in all the three teaching methods (LTM, DTM and PBL).

Comparing the disparities in mean scored by male and female students in the demonstration teaching method, the boys had significantly higher mean differences, -3.720 (95% CI, 6.360 to -1.079) %, $p < .002$ than the girls -3.149 (95% CI, -5.465 to -.833) %, $p < .004$. While comparing the differences in means scores for the boys and girls in Problem Based Learning method, the girls had significantly higher mean differences; -14.012 (95% CI, 16.652 to -11.372) %, $p < .001$ than the boys; -10.899 (95% CI, -13.182 to - 8.617) %, $p < .001$. Therefore, the study established that gender proved significant altogether in affecting students' general performance with respect to the teaching methods used. The results for the fourth objective revealed that PBL had the highest mean followed by the demonstration teaching method and finally the lecture method (57.4750, 48.4000, 43.7696) respectively.

The mean comparison results for the mean pairs indicated that post-intervention score for the demonstration and PBL teaching methods by and large had substantially higher mean outcomes in comparison to control (lecture teaching method). Comparing mean differences for the demonstration and problem based learning methods, the PBL had significantly higher mean differences, -12.455 (95% CI, -14.189 to -10.721) %, $p < .001$, than the demonstration teaching method, - 4.248 (95% CI, -5.962 to -2.535) %, $p < .001$. The results showed that PBL increased students' performance in agriculture subject better than demonstration teaching method.

5.3 Conclusions

Based on the objectives of this study, the study concludes that:

- i) Teaching through PBL is more effective in producing improved academic results when compared to the lecture teaching method for secondary students taking agriculture subject. Therefore, the use of PBL in Ndhiwa Sub County has resulted into higher achievement in agriculture subject by the students.

- ii) Teaching through demonstration method produces better students' achievement outcomes in secondary school agriculture subject in comparison to lecture teaching method in Ndhwa Sub County.
- iii) The female students' achievement in agriculture is better in all the three teaching methods (Problem Based Learning, Demonstration Teaching Method and Lecture Teaching Method) when compared with the achievement of male students.
- iv) Teaching through PBL compared to DTM and LTM, produced the highest student's achievement in agriculture.

5.4 Recommendations

The following recommendations are made:-

- i) Kenya Institute of Curriculum Development, in conjunction with the Ministry of Education, Science and Technology, should emphasize the use of PBL teaching method in the syllabus, because PBL use has demonstrated to produce better results in agriculture than lecture method. This will enable teachers to adopt the method in the teaching of agriculture subject.
- ii) Universities and Teacher Training Colleges in Kenya should put more emphasis in the use of PBL teaching method in teacher preparation programmes. This is because PBL use is robust in producing better student's academic achievement than lecture method which is a popular method of training in Universities and Colleges.
- iii) Directorate of Quality Assurance and Standards office should re-emphasize to practicing teachers to utilise demonstration teaching method in the teaching of agriculture subject. This is because teaching through demonstration method is effective in producing better students learning outcomes than using lectures.
- iv) Ministry of Education, Science and Technology should organise for workshops for re-training (retooling) teachers in PBL and Demonstration teaching method for effective teaching in agriculture for improved students' achievement in agriculture.
- v) The supervisory arm of Ministry of Education, Science and Technology, should discourage secondary school teachers, as much as possible, from over reliance on lecture teaching method. The method yields comparatively lowest achievement in students learning outcomes in agriculture subject. The method also limits exchange of ideas amongst teachers and students.

5.5 Suggestions for Further Research

While this investigation has established that there may be fundamental challenges in the manner agriculture subject is taught in secondary schools and recommended remedies to address the problem, there still remains a significant gap in knowledge and practice which should be explored in future as suggested.

- i) Factors that influence success of PBL and demonstration teaching method (physical, as well as, financial requirements).
- ii) The sample used in the study incorporated secondary school students in Ndiwa Sub-County. To consolidate knowledge about effects of PBL and DTM on students' performance in agriculture subject in Kenya, future samples may be taken across the secondary schools in Kenya, as well as, colleges and universities to establish differences associated with localized economies, culture and farming systems, among other factors.
- iii) Universities and teacher training colleges should integrate PBL teaching method in their pedagogy teaching methods to pre service students.
- iv) More research should be done on the applicability of PBL in teaching other subjects.

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APPENDICES

Appendix A: Administrator Consent Form

To

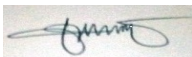
The Principal,

I am Peter Oyier Ogweno, a Ph.D. student at Egerton University undertaking a study entitled *“Effects of Problem-Based Learning and Demonstration Teaching Method on Students’ Academic Achievement in Secondary School Agriculture in Ndhiwa Sub County, Kenya”*. Your agriculture teacher has been randomly selected to participate in a study on the effectiveness of teaching methods.

The topic of instruction will be Livestock Production II (Nutrition) in Form Two secondary school agriculture syllabus. Data will be collected on your students in three forms; a unit test on Livestock Production II (Nutrition), using Lecture teaching method, PBL and Demonstration methods. In all cases, the information will be collected by the agriculture teacher. Student identification will be kept anonymous. Data collected from your school will be kept confidential and individual school data will not be reported. The data from this study will be used for my thesis preparation. The study period will be six weeks. The results from this study will help teacher educators plan a more effective programme of study for prospective teachers.

Participation in this study is completely voluntary. Consent or refusal to participate in this study will in no way affect your school’s relationship with the researcher or Egerton University.

Yours Sincerely,



Peter Oyier Ogweno
Ph.D. Candidate
ED11/04073/14

Please sign below to indicate your consent for the participation of your school and agriculture teacher in this study. _____

Appendix B: Agriculture Teacher Consent Form

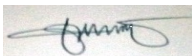
To Agriculture Teacher

I am Peter Oyier Ogweno, a Ph.D. student at Egerton University undertaking a study entitled *“Effects of Problem-Based Learning and Demonstration Teaching Method on Students’ Academic Achievement in Secondary School Agriculture in Ndhiwa Sub County, Kenya”*. I have randomly selected you as a participant in this inquiry. Hopefully, more information may be generated about teaching methods and in addition, allow me to share valuable information with education stakeholders institutions involved in teacher preparation programmes and fellow agricultural education teachers. I hope the lessons are something you will find useful along with the data and results I gather. I hope your classes will work through this study and find the topic interesting.

It is anticipated that you will read over all the contents and instruct the students as described in the schemes of work. In order for this study to have validity, it is important that each person teach the lessons in the same manner. Please look over the lessons as there may be items you have to order.

Participation in this study is completely voluntary. Consent or refusal to participate in this study will in no way affect your school’s relationship with the researcher or Egerton University.

Yours Sincerely,



Peter Oyier Ogweno

Ph.D. Candidate

ED11/04073/14

Please sign below to indicate your consent to participate in this study.

Appendix C: Design of the Study

Lessons in the Study

Step No	Problem Based Learning Method (Treatment Group), Demonstration Teaching Method and Lecture teaching Method (Control Group)
1	Students write School ID number, admission numbers Students take pretest
2	Teach lesson 1 (Components of feed)
3	Teach lesson 2 & 3 (Feed nutrients- water, carbohydrates and fats)
4	Teach lesson 4 (Feed nutrients- proteins and minerals)
5	Teach lesson 5 & 6 (Feed nutrients- vitamins)
6	Teach lesson 7 (Feed and feed stuffs- roughages)
7	Teach lesson 8 & 9 (Concept of rationing and expression of feed values)
8	Teach lesson 10 (Ration computation)
9	Teach lesson 11 & 12 (Digestion in ruminant animals)
10	Teach lesson 13 (Digestion in non-ruminants e.g. pigs)
11	Teach lesson 14 & 15 (Digestion in poultry)
12	Teach lesson 16 (Differences between ruminant and non-ruminant digestion systems)
13	Teach lesson 17 & 18 (Appropriate livestock handling techniques while feeding.)
14	Students take posttest

Basically, there are 18 lessons you will be teaching.

Appendix E: Agriculture Achievement Test

Name of school.....School category.....

Gender of student..... Student score.....

Learning programme followed.....Admission number.....

Instructions

- Attempt all questions
- This paper contains 26 questions with a total of 120 marks
- Score for each question are shown in the parenthesis

Time: 2 Hours

1. State **four** functions of water in an animal. [4 marks]
2. Explain any **four** factors that determine the amount of water required by an animal. [8 marks]
3. Differentiate between Disaccharides and Polysaccharides, giving an example in each case. [6 marks]
4. State **four** functions of proteins in livestock. [4 marks]
5. State **four** deficiency symptoms of vitamin B complex in livestock. [4 marks]
6. Differentiate between essential amino acids and non-essential amino acids. [4 marks]
7. Deficiency of Zinc results in Parakeratosis. State **four** characteristics of Parakeratosis. [4 marks]
8. Name **four** sources of calcium and phosphorous in livestock. [4 marks]
9. Give **two** examples of water soluble vitamins. [3 marks]
10. Distinguish between a feedstuff and a feed. [3 marks]
11. State **four** characteristics of roughages. [4 marks]
12. Differentiate between roughages and concentrates. [4 marks]
13. Explain four factors affecting maintenance requirement of a livestock. [8 marks]
14. What is the function of oesophageal groove? [2 marks]
15. State the functions of the **three** pancreatic enzymes in small intestines. [6 marks]
16. What are the functions of hydrochloric acid in the stomach during digestion? [4 marks]
17. Rabbits, horses, donkeys and camels have monogastric stomach, though they can handle large amounts of roughage which form the bulk of their diet. Explain this phenomenon. [3 marks]
18. State the function of the following in poultry digestion. [6 marks]

- a) Crop
- b) Gizzard
- c) Proventriculus

19. Differentiate between the function of omasum and abomasum in ruminant digestion. [4 marks]
20. Explain **two** functions of reticulum in ruminant digestion. [4 marks]
21. Name **two** examples of a ruminant animal. [1 mark]
22. Explain **five** differences between digestion in ruminants and non-ruminants. [10 marks]
23. Differentiate between maintenance ration and production ration. [4 marks]
24. Explain **four** factors affecting digestibility of animal feeds. [8 marks]
25. Using Pearson's Square Method, compute a 100kg ration with 20% DCP from oats which contains 10% DCP and simsim seed cake containing 60% DCP [6 marks]
26. Differentiate between Crude protein and Digestible Crude Protein. [2 marks]

Appendix F: Agriculture Achievement Test Marking Scheme

1. State **four** functions of water in an animal. [4 marks]
- Component of body cells and many body fluids such as blood.
 - Used for transportation of nutrients in the body.
 - Makes cells turgid, maintaining the shape of the body cells.
 - Used in biochemical reactions in the body, for example, in the digestion of feed.
 - Helps to regulate body temperature through sweating and evaporation.
 - Helps in excretion of waste products from the body.
 - It forms part of animal products, for example, milk contains 83% water and egg contains 55% water. *Any 1x4=4 marks*
2. Explain any **four** factors that determine the amount of water required by an animal. [8 marks]
- Ambient temperature; animals need more water when it is hot due to high rate of sweating.
 - Type of feed eaten by an animal; animals drink a lot of water when they eat dry feeds than when they eat succulent feeds. For example, cattle drink a lot of water if they eat straw or hay.
 - Level of production or amount of work; animals producing milk; animals producing milk or eggs require more water. This is because water is a constituent of those products. Draught animals lose a lot of water in form of sweat and hence need to drink more.
 - Weight of the animal or body size; a fat heavy animal requires more water than a lean and light animal. This is because the body physiological process and metabolic rate is higher in a fat animal to produce more energy for maintenance that is, the basal metabolism is higher in heavy animals.
 - Species of animal; under the same environmental conditions, cattle need more water than camels. The camels' physiological make-up makes it able to resist drought better than cattle. *2 marks for stating plus explanation. Any 4x2= 8 marks*
3. Differentiate between Disaccharides and Polysaccharides, giving an example in each case. [6 marks]
- Disaccharides are carbohydrates formed by the combination of two simple sugars. Examples are sucrose and lactose.

- Polysaccharides are carbohydrates consisting of very many simple sugar molecules which form a complex molecular structure. Examples are glycogen, starch, cellulose and lignin. *4 marks for differences and 2 marks for two correct examples.*
4. State **four** functions of proteins in livestock. [4 marks]
- Growth, repair and replacement of worn out body tissues.
 - Production of antibodies which protect the animal from diseases.
 - Production of digestive enzymes to break feed particles.
 - Production of certain hormones in the body.
 - Production of such products like meat, eggs and wool. *Any 4x1= 4 marks*
5. State **four** deficiency symptoms of vitamin B complex in livestock. [4 marks]
- Retarded growth.
 - Slow heartbeat.
 - Reduced resistance to disease attack.
 - Poor reproduction. *Any 4x1= 4 marks*
6. Differentiate between essential amino acids and non-essential amino acids. [4 marks]
- Amino acids that cannot be manufactured or synthesized in the body and so must be supplied in the animal's diet are called Essential amino acids. *1x2= 2marks*
 - Amino acids that can be manufactured or synthesized in the body and therefore, need not to be supplied in the animal's diet are called non -essential amino acids. *1x2= 2marks*
7. Deficiency of Zinc results in Parakeratosis. State **four** characteristics of Parakeratosis. [4 marks]
- Unhealthy appearance.
 - Rough coat.
 - Stiffness of joints.
 - Dry scaly skins on the ears.
 - Cracking of the skin around nostrils. *Any 4x1= 4 marks*
8. Name **four** sources of calcium and phosphorous in livestock. [4 marks]
- Milk.
 - Meat and Bone-meal.
 - Ground limestone.
 - Oyster shells. *Any 4x1= 4 marks*
9. Give **two** examples of water soluble vitamins. [3 marks]

- Vitamin C.
 - Vitamin B complex. Accept B1, B2, B6 and B12 for full marks. *Any 2x1.5=3marks*
10. Distinguish between a feedstuff and a feed. [2 marks]
- Feedstuff is a feed material containing one or more nutrients; while a feed is a mixture of several feedstuffs which supply the required nutrients to animals. *2x1=2marks*
11. State **four** characteristics of Succulent Roughages. [4 marks]
- High fibre content.
 - High moisture content.
 - Low protein content.
 - High carbohydrate content. *Any 4x1= 4marks*
12. Differentiate between Roughages and Concentrates. [4 marks]
- Roughages are feedstuff with a high fibre and carbohydrate content and low in protein; while Concentrates are feedstuff with a high amount of proteins or energy (carbohydrates) and low in crude fibre. *2x2=4marks*
13. Explain four factors affecting maintenance requirement of a livestock. [4 marks]
- Body size or weight of the animal; a large animal uses more energy to sustain essential body processes.
 - Age of the animal; the minimum energy required for maintenance by a young animal is more than for an older animal.
 - Animal's activities; active animals need more energy for maintenance since their body mechanisms are always in action.
 - Level of production; higher producers need more for maintenance requirement. This is because, for them to produce, their body activities such as blood circulation, respiration and secretory rate are increased. *4x1= 4marks*
14. What is the function of oesophageal groove? [2 marks]
- To allow feed enter into the reticulum from the rumen through its opening and closure. *2x1=2marks*
15. State the functions of the **three** pancreatic enzymes in small intestines. [6 marks]
- Pancreatic amylase; converts starch to maltose;
 - Lipase; converts fats to fatty acids and glycerol;
 - Trypsin; converts proteins to peptones and peptides; *2x3=6marks*
16. What are the functions of hydrochloric acid in the stomach during digestion [4 marks]

- Hydrochloric acid creates a suitable acidic medium for the action of enzyme pepsin;
 - Hydrochloric acid kills harmful micro-organisms which might have been eaten with feed; *2x2=4 marks*
17. Rabbits, horses, donkeys and camels have monogastric stomach, though they can handle large amounts of roughage which form the bulk of their diet. Explain this phenomenon. [3 marks]
- Their digestive system is equipped with a large caecum; which contains micro-organisms; that break down cellulose in the roughage; *3x1=3 marks*
18. State the function of the following in poultry digestion. [6 marks]
- a) Crop: stores feed temporarily and moisten it with water;
 - b) Gizzard: crush and grind feed into paste;
 - c) Proventriculus: produces pepsin enzyme; *3x2=6 marks*
19. Differentiate between the function of omasum and abomasum in ruminant digestion. [4 marks]
- The function of omasum is to absorb water and to grind and sieve feed particles by means of its folds;
 - The function of abomasum is the true stomach where enzymatic digestion takes place; *2x2=4 marks*
20. Explain **two** functions of reticulum in ruminant digestion. [4 marks]
- Sieving and separating fine from coarse feed materials;
 - Retaining foreign and indigestible materials such as polythene papers, wires, and pieces of strings which might have been eaten accidentally; *2x2=4 marks*
21. Name **two** examples of a ruminant animal. [1 mark]
- Cattle;
 - Sheep;
 - Goats; *Any 2x1/2=1 mark*

22. Explain **five** differences between digestion in ruminants and non-ruminants. [10 marks]

Ruminants	Non- Ruminants
<ul style="list-style-type: none"> ▪ They normally chews cud ▪ They are polygastric, i.e. possess four chambered stomach ▪ The animals are actively involved in regurgitation of feed ▪ Possess the ability to digest cellulose. This is because of presence of micro-organism in rumen that have the potential to digest cellulose ▪ Ptyalin enzyme is not present in the saliva, eliminating possibility of enzymatic digestion in the mouth ▪ Almost all digestion and absorption occurs in the rumen ▪ Ammonia in saliva makes it alkaline. 	<ul style="list-style-type: none"> ▪ Usually do not chew up cud ▪ These animals are monogastric, i.e. have one chambered stomach ▪ Cannot regurgitate feed once swallowed ▪ The stomach lacks essential micro-organisms, therefore, are not able to digest cellulose except animals having these micro-organisms in the caecum ▪ Enzyme ptyalin is found in the saliva hence digestion involving enzymes starts in the mouth ▪ Digestion and absorption mostly occurs in the small intestines ▪ The pH of saliva is neutral.

Any 5x2=10 marks

23. Differentiate between maintenance ration and production ration. [4 marks]

- Maintenance ration is the everyday feed allowance given to each animal which contains all required nutrients in the right proportions to sustain all the body functions without losing or increasing weight; while production ration is the daily amount of feed given to an animal over and above the maintenance requirements and contains all the nutrients in proper proportions for production purposes. *2x2=4 marks*

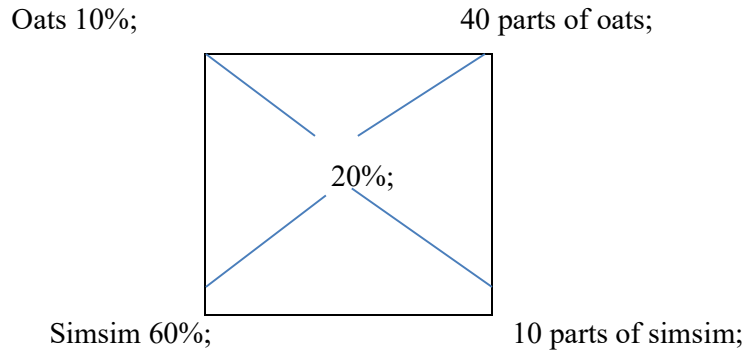
24. Explain **four** factors affecting digestibility of animal feeds. [8 marks]

- Chemical composition of feed; for example, the %age of lignin or cellulose will effects digestibility.
- The form in which the feed is offered to the animal; for example, crushed maize is more digestible than whole maize.
- The species of the animal; for example, the digestibility of grass is higher in sheep than in pigs.

- The ratio of energy to protein will affect digestibility; the higher the ration, the lower the digestibility.
- The quantity of feed already present in the digestive system of an animal.

Any 4x2= 8marks

25. Using Pearson's Square Method, compute a 100kg ration with 20% DCP from oats which contains 10% DCP and simsim seed cake containing 60% DCP. [6 marks]



Total parts= 40 parts of oats + 10 parts of simsim=50 parts;

Therefore; $40/50 \times 100 = 80$ kg of oats;

$10/50 \times 100 = 20$ kg of simsim;

6x1=6 marks

26. Differentiate between Crude protein and Digestible Crude. [2 marks]

27. Crude protein refers to the sum total of all nitrogenous compounds in a feed; while Digestible Crude Protein is used to express the %age of the protein absorbed from a feed by an animal's body. *2x1=2marks*

Appendix G: Training Manual for Problem Based Learning Method

Introduction

This is a student centred method which entails providing learners with a problem which they must work on as they are facilitated by their teacher.

Origins of Problem Based Learning

The teaching methodology was initially implemented at School of Medicine in McMaster University, Canada in 1960. Its introduction was occasioned due to low enrolment and dissatisfaction of students with the educational experience (Barrows, 1996). Problem Based Learning contains elements of constructivist pedagogy which are applicable to classroom situations. In another review, McCombs (2001) recognized the need for a paradigm change from what should be taught to what students should learn in terms of content and skills. As a result, this acknowledgment is compatible with constructivist beliefs that information is most often built (Seatter, 2003). Constructivism is a way of thinking about how people address real-world problems in society. This is accomplished by collaborating with others to make sound decisions and taking charge of the problem-solving process (Jonassen, 1997).

PBL Characteristics

- The problems are correctly described to guide teaching and curriculum.
- The questions are based on real-world concerns, with students acting as experts.
- Exact solutions do not necessitate accurate problems. As they try to find the solution, the students can develop problem-solving skills.
- The problems are set up in such a way that multiple appropriate answers can be produced.
- Teachers are urged to refrain from offering solutions because it is up to students to solve problems.
- Teachers provide guidance on the skills needed to solve problems.
- The assessment is focused on the fact that the presentations do not have correct answers.

Reasons for Implementing Problem Based Learning

Many colleges and universities around the world have accepted the use of PBL in their curricula. In comparison to graduates from traditional classroom teaching approaches, research studies show that graduates from universities that adopt PBL gain successful skills and progress rapidly in their careers. PBL has been used to teach medical students in the

United States. When subjected to similar examinations, PBL students and students graduating from traditional systems have shown similar success in examinations 10 years after graduation; however, PBL graduates have a more illustrious career.

Scholars argue that at least half of the subject matter taught to students will be outdated by the time they graduate, and that it is almost impossible to predict what will be obsolete by then. In this regard, rather than obtaining what is currently the case, students must develop a culture of analysis and problem-solving skills. These, in effect, prepare students for genuine and valid situations. Students also begin to develop important teamwork and networking skills.

How to identify Problems when using PBL

- Using PBL necessitates a full shift in mind set. Teachers and students who are used to traditional teaching methods may struggle with the PBL model and eventually revolt. Educators who are used to teacher centred pedagogy can find it difficult to adjust to this teaching method. Similarly, students who are accustomed to receiving factual information and evaluations based on memorization may complain if they are not given what they are accustomed to.
- When PBL is used in the classroom in the form of lectures, the advantages associated with it fade away. As a result, PBL is only effective in circumstances where the entire subject matter is presented in a student centred manner and does not rely on rote learning.

How to give responses to Problems:

It is common to see students who are accustomed to traditional methods of instruction resisting PBL's adoption and value. They might believe they are not being taught at times. As a result, teachers must expect and address such behaviours as soon as possible. The instructor should pay close attention, ensuring that the courses are student centred and refraining from overemphasizing accurate facts, in order to maintain his position as a facilitator and maintain a smooth transition even while students are being assessed.

Advantages of Problem Based Learning

- Assists students in developing high levels of ability and knowledge
- Meets or exceeds traditional learning outcomes or targets
- Allows students to focus on known facts rather than just knowing anything
- Encourages a socially responsible and lifelong learning community.
- Combines and encourages a multifaceted and innovative problem-solving approach.

- Facilitates the formation of teams and networks through student interaction.
- Real problem scenarios are used to model assessments.
- Has the ability to inspire students who are uninterested in learning. As a result, synergy between students of different abilities is possible.

Method for Teachers in Implementing PBL

(1) Formation of Small working groups

The instructor has the option of incorporating PBL into all or part of what they are teaching. Students are expected to create small groups of 3-5 students on their own initiative. Students may be divided into classes by the instructor.

(2) Presenting problems to students

The issue is stated in a presentation, which is usually written on paper. The following is an example of a problem; Peter's cow appears to have osteomalacia and rickets. You might add a video clip or realia to the problem statement to help you think about it. The instructor should emphasize that the cases being discussed are real. Students may be stimulated by very strange troublesome situations. It's a good idea to go over the case history before giving a presentation in class so that all of the necessary information are covered.

(3) Set the groups in motion

The groups are activated by asking them to ponder on the causes of osteomalacia and rickets. Every group has to discuss and find out more about the bone, this should include the role of calcium and phosphorus in the diet, characteristics of calcium and phosphorus deficiency, their use during pregnancy and milk production. This stage gives the students impetus to learn a lot of things together as they get to know importance and uses of minerals in livestock diet. PBL students must reflect upon functions of minerals and vitamins and refrain from rote learning. The teacher should visit each group to help the students but should resist the temptation of providing answers. At times, the groups may follow a direction that is not expected. This is a necessary course of action which should not be suppressed. It is not advisable for the teacher to influence the agenda of the groups. Every group may prioritise their hypothesis as they look for more literature on the subject.

(4) Giving feedback to students

The teacher should always task group representatives to write their data request on the chalkboard (if a group's choice is already presented by another group, tell them to give their next choice). If you find this impracticable, request verbal proposal among the groups once you temporarily stop collective effort and the class is reconvened. These suggestions may include:-

- Little amounts of calcium and phosphorous in cow's diet
- Inability to walk with cow lying down with the neck bent sideways
- Softness of bones that are weak and brittle
- Pica or depraved appetite
- Loss of weight, pain and muscular weakness

The suggestions are discussed by the whole class. Every contribution is valued by the instructor. This motivates students in analysing the issues involved. The students may be requested to provide more data, for example, what will be the results if you request for test results of this cow? It is advisable to continue the group work as feedback is given from time to time to maintain student's interest while lengthening the resolution to the problem to allow for actual learning to take place

(5) Ask the students for a solution

Following the example given earlier, the groups are likely to focus on the minerals required for formation of strong bones and production of milk. They may ask you for phosphorous and calcium levels in the cows body. After group work is completed, a written report detailing the case under study is presented. The teacher may ask groups to include key words in their reports.

Method for Students in Solving PBL Cases

Successful solution to problems demands an organised pattern of approach. Skills used in solving problems fails to miraculously occur following teachers giving students the problems.

It has been discovered that majority of students use a practical approach. This involves:

(1) Precisely define the problem

Determine what is to be discovered. Do you think the problem have various elements? You may state them separately if you discover there are many parts. Do all group members concur with problem statement? Members of the group should verify whether the problem is well stated and look for mistakes in comprehension.

(2) Scrutinise remedies

Exchange ideas leading to finding a solution. Provide a rationale for your ideas to your teammates. Expound relevant nutrition included. Allow group members to rephrase your ideas. Pay close attention to ideas from the groups and give positive feedback. Write the learning issues by analysing what is known and what is not known. You may ask if the problem is comparable to any past problem. Identify key concepts in agriculture that may be applied to the problem and give each group to research on the problem.

(3) **Narrow** your choices

You are expected to sort and rank the hypotheses developed. Write down the required data for testing each hypothesis. Start with the simplest and less costly tests. Finding information on diet is much easier as compared to carrying out biochemical tests.

(4) Test the tentative solution

You may ask your teacher for data required for testing your ideas. You may start all over again if all your ideas to the solutions are eliminated. Receiving relevant data against conjecture helps in documenting information about the issue under investigation.

Three Stages of Problem Based Learning Method

1. Define the problem

Students should clearly understand the extent of the problem. To enable them develop a tentative hypothesis for the question. For example, students may see array of symptoms of a particular disease affecting a certain individual and is told the person is suffering from diabetes. The student may write a hypothesis that the individual is diabetic.

2. Handle penitent data

It is vital for students to have access to information, followed by evaluation and selection of significant details. Finally, using of facts chosen.

Accessing allows for piecing together detailed reports documented from online searches, virtual libraries and school texts.

Evaluating information got from multiple sources is evaluated for their accuracy, and credibility.

Utilize the students use the data to answer the question. Sometimes, changing hypothesis may be inevitable. Using the earlier example, the symptoms may not demonstrate diabetes situation.

3. Establish working decision

Written answers are presented by students. In view of the choices arrived at, advance the details inside the decision making process. After which a communication regarding the solution is made, for example, writing a detailed paper report, or multimedia production.

Documenting PBL for a class

To control scope of the project, students and teachers should use a well reached documentation to be used as a reference, to make sure the stated learning objectives are achieved.

Elements of evidence

1. Objectives

The teacher might give students the learning outcomes which a problem aims to achieve.

2. Defining the difficulty

Existing problems are brought to attention of the student(s) by forming statements regarding the problem, which comprises of:-

- Places student to act in a specified position
- Includes the description of the issues
- Provides particular work to be undertaken

The length of the problem statement may vary depending on the problem to be investigated.

3. The structure of the team

The teacher should know the role of each team member in the group and how they will communicate with the team members. Communication methods used by group members will determine how tasks are described.

4. Discussion Questions

These are queries replied to enable finding of solutions.

5. Resources

These may include references, web links, books, journals or anything else relevant to the case.

6. Guidelines

The teacher should give appropriate guidelines to help students in dealing with detailed information, as well as, finding solutions. Brief the students on quality and quantity of work expected from them to prevent doing either too much or very little. Qualify and quantify the work expected from a student to prevent extreme scenarios on a project.

7. Dealing with Information

Students may get information from people, print or electronic media. Students must sieve the information to decide on what is relevant and current. This should be done within time frame and resources given. Students should assign tasks amongst the team. Test the theories against information and fill the gaps if found.

8. Solution Development

Consider the available options by selecting the best option. Develop and refine a plan of solution implementation process before you prepare a presentation.

9. Duration of the problem

Depending on the actual problems, PBL projects may be done within a short duration or may be done for one or two week's duration, but should not extend beyond three weeks.

An Example PBL Problem

This is the simplest example of a PBL case. Otieno is a fifty three year old dairy farmer. His cow has milk fever, but interestingly, he has failed to acknowledge this fact. The cow has been attended by a Veterinary Doctor, and the cow weighs 750 Kilogrammes. The cow has a history of drastic weight loss since the first calving. Johnson's cow is suffering from milk fever. He has been adamant to accept that the cow has the condition. You need to prove to Johnson that the cow is suffering from this condition by telling him the characteristics and symptoms of this condition.

- Cows suffering from milk fever often experience added medical problems. Identify the additional problems. Kamau's cow is also suffering from Pica in the same locality. How can you differentiate between milk fever and pica?
- What is the treatment plan to Otieno's cow to overcome milk fever?

From the available literature, there are many theories explaining the causes of milk fever. Identify the causes.

Concerning the implementation of PBL, Barrett and Cashman (2010) clearly outlined the different roles of teacher and student in PBL teams. These roles are illustrated as follows:

The role of the teacher is to:

- Assist students in understanding PBL process and resist the urge to give a lecture.
- Pay attention to students and the learning occurring in the groups.
- Stimulate a friendly and exciting learning atmosphere in the groups
- Always ask questions that stimulate analytic thinking
- Support students to link and connect theory and practice
- Persuade students to cultivate responsible attitude in engaging in self-driven learning
- Allow students to think deeply about what they are learning, the acquisition of key skills and how they perform in their groups
- Facilitate the review of the material with all students

As all students participate on the problem, in addition, some students are given different roles to play within their groups. The roles include: chairperson, scribe, reader and timekeeper.

The role of the chairperson is to:

- Encourage all the group members to participate in the groups.
- Lead the team in completing the assignment
- Encourage group members to abide by laid down rules for the group
- Stimulate asking of questions and active discussion within the group by accommodating different viewpoints.
- Use the PBL process as a platform for the group to work on the problem
- Ensures that a summary is made by one of the team members at the end of assignment
- Ensures that all the team members know the learning issues they are working on.

The role of the scribe is to:

- Record ideas from members on the whiteboard which is used as a shared learning environment.
- Write and highlight the learning issues to be tackled by the group
- Allow other members to illustrate their ideas on the whiteboard
- Write a brief outline on important learning issues from the problem on the whiteboard

The role of the reader is to:

- Read the problem aloud to all members at the beginning of the process
- Go over the problem the second time by reading for members to understand the problem

- Arrest the attention of team members on important elements of the problem

The role of the timekeeper is to:

- Assist teammates in managing their time
- Alert the team on from time to time on time left in the tutorial

The teacher may decide to include other roles such as observer, photographer or roles that mirror specific professional situations.

Name _____ **Date** _____

Discussion Questions (Meet the Problem)

1. What is the problem?
2. What do you **know** about the problem? Brainstorm and list all your ideas.
3. What do you **need to know**?
4. Develop a problem statement that is relevant to the problem.
5. What do you **need to do**? Who? How? Where? When?

Name _____ **Date** _____

Information gathering stage

1. Document your findings that include all data and results.
2. Decide whether the information gathered is relevant to the problem
3. Use only credible sources of information
4. Share your information at the next session.

Name _____ **Date** _____

Information sharing – Group Session

The stage allows each member to share their findings to the whole team

1. Brainstorm and list all ideas of what is known by the team
2. Brainstorm and list all ideas of what the team need to know
3. Look at problem statement again in light of what you **know** and what you **need to know** *by asking whether the problem statement is relevant to the problem*
- 4) What do you **need to do**? Who? How? Where? When?

PBL ASSESSMENT

Weight (%)	Component
35	Case log and process assessments
10	Assessment from alternate instructional strategies
30	Case closed – Final Product
25	Unit Exam

The teacher has the discretion to change assessment methods; however, the majority of assessment should focus on process assessment. The other assessment options include: Individual or group reports, open-ended group assessment questions.

Process Assessment may include: Questionnaires, Prior knowledge and Post-case knowledge assessment.

Problem Based Learning Evaluation of Group Process

Instructions: Assessment of group process is done at the end of each session. The teacher should discuss with group members the progress of group process using questions. The comments are recorded by one of the members in the group. Ground rules are used as a guide for each group.

The questions may include:

- a) What are our strengths today in working together as a group?
- b) What could have gone better in the way we worked together as a group?
- c) Give suggestions about how we can improve next time?

Appendix H: Problem Based Learning Examples on Livestock Production II (Nutrition)

1. Peter's grandmother has been feeding her livestock on a balanced diet daily. She believes that the family has been providing balanced diet when feeding livestock. Peter is curious about the effectiveness of a balanced diet to livestock. The grandmother decided to hire an animal nutritionist to investigate on balanced diet for livestock.
2. Let's suppose that you had been grazing your fathers' cows every day, and you noticed that the quantity of water taken by the animals was varying every day. The varying quantities of water taken by the animals may suggest that there is an underlying problem. What are the steps you will take in solving this problem?
3. Mr. Tom's family owned and operated a livestock farm. The family have been feeding their livestock using livestock feeds bought from a local agrovet shop for the last ten years. They realized of late that their livestock were showing certain deficiency symptoms of vitamins and minerals. Mr. Tom wishes to be a bit adventurous and find out what could be causing these deficiency symptoms in his livestock. In taking on this challenge, he has hired you as a livestock expert for appropriate advice.
4. Wafula plans to start a business selling livestock feeds. Before embarking on the business, he wants to establish the availability of suitable types of livestock feeds that are balanced. He is eager to know if the products will be in high demand. To market the products well, he has to know the nutritional value of the livestock feeds in animals. Assume you are a salesperson in Wafula's shop; carefully, research on these products.
5. James has been feeding his livestock without knowing the daily animal requirements in terms of maintenance ration, production ration and balanced ration. As an agriculture student, explain to the farmer the concept of rations, rationing and factors affecting the different rations given to livestock.
6. A farmer realized that his farm animals were losing feed they eat at a high rate through urine and faeces. This scenario makes his animals to look unhealthy. Explain to the farmer the factors contributing to this phenomenon, as well as, terms used to express feed values.

7. A farmer wanted to compute feed rations for his livestock but he did not know the methods to use and how to proceed in this task. He has contacted you to help him formulate feedstuff for his livestock using the most appropriate method.
8. Using the Pearson's Square Method, compute a 100kg ration with 20% DCP from oats which contains 10 % DCP and simsim seed cake containing 60% DCP.
9. The students in your class are working as team of journalists. An article focusing on digestion and digestive systems of farm animals was published recently in a local newspaper. The article presented extreme views on digestion process in livestock, making the readers more confused. The readers posed several questions to the team of scientific journalists to conduct research on the subject and present their findings to the public. While preparing adequate response to the questions, students investigated the general process of digestion, including different forms of feed material and how it changes from one form to the next until feed is assimilated. Likewise, students will also examine the digestion in pigs and poultry and ruminants, including their digestive systems. The detailed response should include a comprehensive report on digestion and digestive systems of farm animals.
10. Let's assume that your mother has a daughter called Anne. Anne left her pet rabbit in a cage on your mother's doorstep this morning. She left a note asking you to feed the rabbit while she is in town. She recently bought the rabbit and therefore, there was no instructions left on what to feed the rabbit. This could be a problem. How would you, as a scientist, begin solving this problem?
11. Mr. Paul was reading an article on farm animals and discovered that his farm animals had different digestive systems. He wanted to know why these differences exist, yet some animals were feeding on similar feeds. As an animal physiologist, explain the similarities and differences in digestive systems of farm animals to Mr. Paul to enable him understand the differences in his animals digestive systems

**Appendix I: Workshops on Problem Based Learning, Demonstration and Lecture
Teaching Methods**

a) A Three Day Workshop on Problem Based Learning

This workshop is designed to prepare teachers of Agriculture in the planning and Teaching of PBL method.

Time	Session
DAY 1	
9:00 am- 10:30 am	Introduction <ul style="list-style-type: none"> • Briefing on the programme • The Research Project
10:30-11:00 am	Tea Break
11.00 am- 12:45 pm	Planning for Instruction Secondary School Agriculture Syllabus- Livestock Production II topic(Nutrition) <ul style="list-style-type: none"> • Schemes of work and Lesson Planning
12:45 pm -2:00 pm	Lunch Break
2:00 pm- 5:00 pm	<ul style="list-style-type: none"> • Introduction to PBL • Characteristics of PBL and benefits of PBL
5:00 pm	Break
DAY 2	
9:00 am- 10:30 am	<ul style="list-style-type: none"> • PBL project stages • Writing PBL documentation for incorporation in a course
10:30-11:00 am	Tea Break
11.00 am- 12:45 pm	Roles of the teacher and students in PBL teams
12:45 pm -2:00 pm	Lunch Break
2:00 pm- 4:00 pm	PBL assessment
4:00 pm- 5:00 pm	Group work
5:00 pm	Break
DAY 3	
9:00 am- 10:30 am	PBL teachers guide, questions and marking schemes
10:30-11:00 am	Tea Break
11.00 am- 12:45 pm	PBL examples on Livestock Production II
12:45 pm -2:00 pm	Lunch Break
2:00 pm- 3:00 pm	Group work
3:00 pm- 5:00 pm	Plenary session
5:00 pm	Closing of the workshop

A One Day Workshop on Lecture teaching method and Demonstration teaching method

This workshop is designed to prepare teachers of agriculture in the planning and teaching of demonstration and Lecture teaching methods.

Time	Session
DAY 1	
9:00 am- 10:30 am	Introduction <ul style="list-style-type: none">• Briefing on the programme• The Research Project
10:30-11:00 am	Tea Break
11.00 am- 12:45 pm	Planning for Instruction Secondary School Agriculture Syllabus- Livestock Production II topic(Nutrition) <ul style="list-style-type: none">• Schemes of work• Lesson Planning
12:45 pm -2:00 pm	Lunch Break
2:00 pm- 5:00 pm	<ul style="list-style-type: none">• Lecture method of teaching• Demonstration method of teaching
5:00 pm	Break

Appendix J: Schemes of Work for PBL, Demonstration and Lecture Teaching Methods

Week	Lesson	Topic	Sub-Topic	Objectives	Teaching/ Learning Activities	Teaching / Learning Aids	References	Remarks
1	1	Livestock production nutrition (II)	Components of feed	By the end of the lesson, the learner should be able to: i) Define nutrition ii) Explain major components of feed	Defining nutrition Explaining major feed components Lecture teaching methods Problem Based Learning Method	Charts Chalkboard Students book	KLB secondary Agriculture form 2 page 158 Certificate Secondary Agriculture form 2 page 115 Longhorn secondary Agriculture form 2 page 148-149	

	2-3	Livestock Nutrition	Feed nutrients Water Carbohydrate Fats	By the end of the lesson, the learner should be able to: i)describe the feed nutrients ii)describe the feed nutrients iii)explaining the functions of each feed	Describing the feed nutrients explaining the functions of each feed Lecture teaching methods Problem Based Learning Method	students book samples of feed nutrients	KLB secondary Agriculture form 2 page 159-161 Certificate Secondary Agriculture F2 page 115-116,118 Longhorn secondary Agriculture form 2 page 149-152 Teachers guide page 81-82	
2	4	Livestock production (II) nutrition	Feed nutrients Proteins minerals	By the end of the lesson, the learner should be able to: i)explain the functions of each feed ii)describe the	Explaining functions of each feed describing feed nutrients Lecture teaching methods Problem Based	Feed specimen Photographs Farm stores Students book	KLB secondary Agriculture form 2 page 163-165 Certificate Secondary Agriculture F2 page 117 Longhorn	

				feed nutrients	Learning Method		secondary Agriculture form 2 page 157 Teachers guide page 89-92 Gateway Agriculture revision paper 2 page 13	
	5-6	Livestock Production (II) Nutrition	Feed nutrients vitamins	By the end of the lesson, the learner should be able to: i)State various types of vitamins ii)Explain the importance of vitamins iii)Describe the	Stating various types of vitamins Explaining the importance of vitamins Describing the feed nutrients LTM PBL	Feed store Photographs of animals with deficiency Feed specimen Students book	KLB secondary Agriculture form 2 page 163-165 Certificate Secondary Agriculture F2 page 117 Longhorn secondary Agriculture form 2 page 157 Teachers guide	

				feed nutrients			page 89-92 Gateway Agriculture revision paper 2 page 13	
3	7	Livestock production (II) nutrition	Feeds and feedstuffs roughages	By the end of the lesson, the learner should be able to: i)state the classifications of animals feed ii)identify the feed stuffs iii)state the characteristics of feedstuffs	Stating the classes of feed stuffs Identifying the feed stuffs Stating the characteristics of feed stuffs Lecture teaching methods Problem Based Learning Method	Feed stuffs Feed store photographs Students book	KLB secondary Agriculture form 2 page 169-170 Certificate Secondary Agriculture F2 page 118-119 Longhorn secondary Agriculture form 2 page 162-163 Teachers guide page 89-92 Gateway Agriculture	

							revision paper 2 page 14-15	
	8-9	Livestock production (II) nutrition	Concept of rationing Terms used to express feed values	By the end of the lesson, the learner should be able to: i)State the terms used to express feed values ii)Explain the various terms	Stating the terms used to express feed values Explaining the various terms Lecture teaching methods Problem Based Learning method Students sit Agriculture achievement Test I at the end of third week of study	Charts Students book Chalk board	KLB secondary Agriculture form 2 page 172-175 Certificate Secondary Agriculture F2 page 125 Longhorn secondary Agriculture form 2 page 162-164 Teachers guide page 89-92 Top mark Agriculture page 87	

4	10	Livestock production (II) Nutrition	Ratio computation	By the end of the lesson, the learner should be able to: i) Explain the process of ration computation ii) Stating the methods iii) Compute a livestock station	Stating the methods Explaining the process of ration computation Computing livestock ration Lecture teaching methods Problem Based Learning method	Geometric set Students book Charts Tables in the students book	KLB secondary Agriculture form 2 page 176-179 Certificate Secondary Agriculture F2 page 126-128 Longhorn secondary Agriculture form 2 page 166-169	
	11-12	Livestock production (II) nutrition	Digestion in livestock (Cattle, Goats and Sheep)	By the end of the lesson, the learner should be able to: i) Define digestion ii) Describe the process of digestion generally	Defining digestion Describing the process of digestion Lecture teaching methods Problem Based Learning method	Chart Diagrams in the students book Specimens of digestive systems School farm	KLB secondary Agriculture form 2 page 179-182 Certificate Secondary Agriculture F2 page 120-121 Longhorn secondary Agriculture form 2 page 173-175	
5	13	Livestock production (II) nutrition	Digestion in non-ruminants (Pigs)	By the end of the lesson, the learner should be able to Describe digestion and digestive system of a pig	Describing digestion and the digestive system of a pig Drawing diagrams	Chart Specimens of digestive systems Diagrams in the students book	KLB secondary Agriculture form 2 page 182-184 Certificate Secondary Agriculture F2 page 121-122	

	14-15	Livestock production (II) nutrition	Digestion in poultry	By the end of the lesson, the learner should be able to: i) Describe digestion and digestive system of poultry	Describing digestion and digestive system of poultry Drawing diagrams Lecture teaching methods Problem Based Learning method	Diagrams in the students book Specimen of the digestive system Chart	KLB secondary Agriculture form 2 page 185 Certificate Secondary Agriculture F2 page 123-124	
6	16	Livestock production (II) nutrition	Differences and similarities in 6 ruminant and ruminant digestive systems	By the end of the lesson, the learner should be able to: i) State the differences & similarities in both ruminant and non-ruminant digestive systems	Stating the differences and similarities both in ruminant and non-ruminant digestive system LTM and PBL	Diagrams in the students book Specimens of digestive system chart	KLB secondary Agriculture form 2 page 186-188 Longhorn secondary Agriculture form 2 page 175-176	
	17-18	Livestock production (II) nutrition	Appropriate livestock handling techniques while feeding	By the end of the lesson, the learner should be able to Handle livestock appropriately while feeding	Handling livestock appropriately Students sit Agriculture achievement Test II at the end of week six of study.	Farm animals Charts Farm structures Students book book	KLB secondary Agriculture form 2 page 129-132 Certificate Secondary Agriculture F2 page 128-131	

Appendix K: Request Letter for Research Permit



OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: ED11/04073/14

Date: 20th December, 2018

The Director General
National Commission for Science Technology and Innovation,
P. O. Box 30623-00100
NAIROBI.

Dear Sir,

**RE: REQUEST FOR RESEARCH PERMIT – MR. PETER OYIER OGWENO REG.
NO. ED11/04073/14**

This is to introduce and confirm to you that the above named student is in the Department of Agricultural Education & Extension, Faculty of Education & Community Studies, Egerton University.

He is a bona-fide registered PhD student in this University. His research topic is “**Effects of Problem-Based Learning and Demonstration Learning Methods on Students’ Academic Achievement in Secondary Agriculture in Ndiwa Sub-County, Kenya.**”

He is at the stage of collecting field data. Please issue him with a research permit to enable him undertake the studies.

Your kind assistance to him will be highly appreciated.

Yours faithfully,


Prof. Nzula Kitaka
DIRECTOR, BOARD OF POSTGRADUATE STUDIES
NK/vk



Appendix M: Letter of Research Authorization from NACOSTI



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 3310571, 2219420
Fax: +254-20-318245, 318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/19/47509/27736**

Date: **29th January, 2019**

Peter Oyier Ogwen
Egerton University
P.O. Box 536-20115
NJORO

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "*Effects of problem-based learning and demonstration learning methods on students' academic achievement in secondary agriculture in Ndhiwa Sub County, Kenya*" I am pleased to inform you that you have been authorized to undertake research in **Homa Bay County** for the period ending **29th January, 2020**.

You are advised to report to **the County Commissioner and the County Director of Education, Homa Bay County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Homa Bay County.

The County Director of Education
Homa Bay County.

Appendix N: Letter of Research Authorization from County Director of Education



MINISTRY OF EDUCATION

STATE DEPARTMENT OF EARLY LEARNING & BASIC EDUCATION

Telegrams: "SCHOOLING" Homa Bay
Telephone +
When replying please quote
cdehomabay@gmail.com

COUNTY DIRECTOR OF EDUCATION
HOMA BAY COUNTY
P.O BOX 710
HOMA BAY
DATE: 1st FEBRUARY, 2019

REF: MOE/CDE/HBC/ADM/11/VOL.2/114

PETER OYIER OGWENO
EGRTON UNIVERSITY
P.O BOX 536- 20115
NJORO

RE: RESEARCH AUTHORIZATION.

Following your application for authority to carry out research on ***"Effects of problem-based learning and demonstration learning methods on students' academic achievement in secondary agriculture in Ndiwa Sub County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in Homa Bay County for the period ending **29th January, 2020.**

Kindly note that you shall deposit a copy of the final research report to this office within one year of completion both hard and soft copy.

Fredrick
COUNTY DIRECTOR OF EDUCATION
HOMA BAY COUNTY
P.O. Box 710 - 40300, HOMA BAY
Email: cdehomabay@gmail.com

MR. FREDRICK M. KIIRU
COUNTY DIRECTOR OF EDUCATION
HOMA BAY

Cc
County Commissioner
Homa Bay County



Appendix O: Letter of Research Authorization from County Commissioner



OFFICE OF THE PRESIDENT

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telephone: Homa Bay 22104 or 22105/Fax: 22491
E-mail: cc_homabay@yahoo.com
When replying please quote

COUNTY COMMISSIONER
HOMA BAY COUNTY
P. O. BOX 1 – 40300
HOMA BAY

REF. NO. EDUC.12/1 VOL.IV/105

1st February, 2019

The Deputy County Commissioner
NDHIWA SUB COUNTY.

RE: RESEARCH AUTHORIZATION-MR.PETERR OYIER OGWENO

The above named student has been authorized to undertake research on **"Effects of problem-based learning and demonstration learning methods on students' academic achievement in secondary agriculture in Ndhiwa Sub County-Kenya"**

The Research period ends on **29th January 2020.**

The purpose of this letter is to introduce him to you and request that you accord him the necessary assistance.

Thank you.


S.I.MACHARIA
COUNTY COMMISSIONER
HOMA BAY.

cc

The County Director of Education
HOMA BAY COUNTY.

✓ Mr. Peter Oyier Ogweno

**Please note our e-mail address cc_homabay@yahoo.com*

Appendix P: Data Analysis Outputs

Types of Schools

School Type	Numbers of schools	Percent	Number of students	Percent
Extra County	3	16.7	182	23.4
County	3	16.7	169	21.7
Sub-County	12	66.6	428	54.9
Total	18	100.0	779	100.0

Composition of Schools According to Gender in Ndhiwa Sub-County

Gender of schools	Number of schools	Percent	Number of students	Percent
Boys Only	4	22.2	210	27.0
Girls Only	6	33.3	253	32.5
Co-educational	8	44.5	316	40.6
Total	18	100.0	779	100.0

Gender Composition of the Respondents

Gender	Frequency	Percent
Boys	401	51.5
Girls	378	48.5
Total	779	100.0

Adjusted and Unadjusted Means and Variability for Post-intervention Score with Pre-intervention Score as a Covariate

Teaching methods	N	Unadjusted		Adjusted	
		Mean	Std Dev	Mean	Std Error
Lecture	204	43.76	10.40	44.36	.549
Problem Based Learning	280	57.47	13.19	56.81	.469

n= number of participants, Std. dev. = standard deviation, Std. Error =Standard Error

Intervention = Problem Based Learning, Control = Lecture

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	<i>p</i>	Partial Eta Squared
Corrected Model	20019.978 ^a	1	20019.978	194.778	.001	.412
Intercept	6552.320	1	6552.320	63.749	.001	.187
Control (Pretest)	20019.9780	1	20019.978	194.778	.001	.412
Intervention	.000	0	-	-	-	.001
Error	28573.847	278	102.784			
Total	973539.000	280				
Corrected Total	48593.825	279				

Dependent Variable: Post Test Score

a. R Squared = .412 (Adjusted R Squared = .410)

Pairwise Comparisons of the Means Using the Bonferroni Post Hoc Test

Comparison between	Mean	Mean	Std. Difference	Std. Error	<i>P</i>	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Lecture (I) and Problem Based Learning (J) method	44.36	-12.45	.723	.001		-14.189	-10.721
(I-J)	44.36	-12.45	.723	.001		-14.189	-10.721
(J-I)	56.81	12.45	.723	.001		10.721	14.189

Dependent Variable: Posttest score for PBL

Adjusted and Unadjusted Means and Variability for Post-intervention Score with Pre-intervention Score as a Covariate

Teaching methods	N	Unadjusted		Adjusted	
		Mean	Std Dev	Mean	Std Error
Lecture	204	43.76	10.40	44.36	.549
Demonstration	295	48.40	16.608	48.81	.469

n=number of participants, Std. dev= standard deviation, Std. Error +Standard Error

Intervention = Demonstration Learning, Control = Lecture

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	61310.598 ^a	1	61310.598	1170.431	.001	.800
Intercept	22108.570	1	22108.570	422.057	.001	.590
Control (Pretest)	61310.598	1	61310.598	1170.431	.001	.800
Intervention	.000	0	-	-	-	.001
Error	15348.202	293	52.383			
Total	767714.000	295				
Corrected Total	76658.800	294				

Dependent Variable: Post Test Score

a. R Squared = .800 (Adjusted R Squared = .799)

Pairwise Comparisons of the Means Using the Bonferroni Post Hoc Test

Comparison between Lecture (I) and Demonstration Based Teaching (J) method	Mean	Mean Difference	Std. Error	P	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
(I-J)	44.36	-4.248	.714	.001	-5.962	-2.535
(J-I)	48.608	4.248	.714	.001	2.535	5.962

Dependent Variable: Posttest score for DTM

Overall Performance of Boys and Girls Compared Using the Grand Mean

Gender of Students	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Boys	48.852 ^a	.422	48.023	49.682
Girls	51.356 ^b	.408	50.554	52.159

a. Covariates appearing in the model are evaluated at the following values: Pretest Score = 30.8903.

b. Covariates appearing in the model are evaluated at the following values: Pretest Score = 32.8095.

Descriptive Statistics for the Score Obtained by the Boys and Girls for the Three Teaching Methods

Gender of Student	Learning Methods	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Boys	Lecture	43.979 ^a	.833	42.342	45.616
	Demonstration	47.699 ^a	.719	46.286	49.112
	Problem Based Learning	54.879 ^a	.545	53.808	55.950
Girls	Lecture	45.636 ^b	.714	44.232	47.040
	Demonstration	48.785 ^b	.611	47.584	49.987
	Problem Based Learning	59.648 ^b	.840	57.996	61.300

Tests of Between-Subjects Effects for Boys and Girls

Gender of Student	Source	Type III Sum of Squares	Df	Mean Square	F	<i>p.</i>	Partial Eta Squared
Boys	Corrected Model	63329.50 ^a	3	21109.836	343.687	.001	.722
	Intercept	16125.24	1	16125.245	262.533	.001	.398
	VAR00008	38490.610	1	38490.610	626.661	.001	.612
	VAR00007	10531.510	2	5265.755	85.731	.001	.302
	Error	24384.423	397	61.422			
	Total	1113447.00	401				
	Corrected Total	87713.930	400				
Girls	Corrected Model	60684.01 ^b	3	20228.006	328.960	.001	.725
	Intercept	14010.398	1	14010.398	227.846	.001	.379
	VAR00008	46375.266	1	46375.266	754.184	.001	.668
	VAR00007	8754.633	2	4377.317	71.187	.001	.276
	Error	22997.519	374	61.491			
	Total	1040619.00	378				
	Corrected Total	83681.537	377				

a. R Squared = .722 (Adjusted R Squared = .720)

b. R Squared = .725 (Adjusted R Squared = .723)

Dependent Variable: Post Test Score

Pairwise Comparisons

Gender of Student	Mean Comparisons: Lecture (I) minus-Learning method (J) (I-J)	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Boys	Demonstration	-3.720	1.098	.002	-6.360	-1.079
	Problem Based Learning	-10.899	.949	.001	-13.182	-8.617
Girls	Demonstration	-3.149	.963	.004	-5.465	-.833
	Problem Based Learning	-14.012	1.098	.001	-16.652	-11.372

Univariate Analysis

Gender of Student		Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Boys	Contrast	10531.510	2	5265.755	85.731	.001	.302
	Error	24384.423	397	61.422			
Girls	Contrast	8754.633	2	4377.317	71.187	.001	.276
	Error	22997.519	374	61.491			

Descriptive Statistics for the Teaching Methods

Learning method	Mean	Std. Deviation	N
Lecture (Control)	43.7696	10.40892	204
Demonstration Teaching	48.4000	16.14758	295
Problem Based Learning	57.4750	13.19740	280
Total			779

Adjusted and Unadjusted Means and Variability for Post-intervention Score with Pre-intervention Score as a Covariate

Teaching methods	N	Unadjusted		Adjusted	
		Mean	Std Dev	Mean	Std Error
Lecture	204	43.76	10.40	44.36	.549
Demonstration	295	48.40	16.14	48.61	.469
Problem Based Learning	280	57.47	13.19	56.81	.469
Total	779				

n=number of participants, Std. dev= standard deviation, Std. Error +Standard Error
 intervention = Problem Based Learning + DTM, Control = Lecture

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	P	Partial Eta Squared
Corrected Model	123727.880 ^a	3	41242.627	670.353	.001	.722
Intercept	38551.110	1	38551.110	626.606	.001	.447
Control (Pretest)	99565.930	1	99565.930	1618.335	.001	.676
Intervention	19870.018	2	9935.009	161.483	.001	.294
Error	47680.867	775	61.524			
Total	2154066.000	779				
Corrected Total	171408.747	778				

a. R Squared = .722 (Adjusted R Squared = .721)

Pairwise Comparisons

Lecture (I) Learning method (J)	Mean Difference (I-J)	Std. Error	P	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Demonstration	-4.248	.714	.001	-5.962	-2.535
Problem Based Learning	-12.455	.723	.001	-14.189	-10.721

Appendix Q: Published Paper on Problem Based Learning and Lecture Teaching Method



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Empowering Education & Research

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Effects of Problem Based Learning Method and Lecture Teaching Method on Academic Achievement of Students

Peter Oyier Ogweno¹, Nephai.J. Kathuri², Agnes Oywaya³

¹ Department of Agricultural Education and Extension, Egerton University, Nakuru, Kenya

² School of Education & Social Sciences, Kenya Methodist University, Meru, Kenya.

³ Department of Agricultural Education and Extension, Egerton University, Nakuru, Kenya

Correspondence: Peter Oyier Ogweno, Department of Agricultural Education and Extension, Egerton University, P.O Box 536-20115, Egerton, Njoro, Kenya. Tel. +254 723454941, E-mail: peter.oyierob@gmail.com

Abstract

The research examined the effects of Problem Based Learning (PBL) and Lecture teaching method (LTM) on students' achievement in agriculture subject. This research was necessitated by consistent poor performance of students in agriculture subject in the national examination, Kenya Certificate of Secondary Education (KCSE). The aim was to determine and compare the achievement of students in PBL and LTM. Quasi-Experimental design, following a Non-equivalent Control Group Pre-test-Post-test was adopted. PBL was the treatment, while LTM group was control. All the students of agriculture and teachers of agriculture formed the target population. Stratified random sampling was used to sample 12 schools. Six schools were subjected to PBL while the other six schools followed LTM. The sample size was 484 Form Two agriculture students and 12 teachers of agriculture. Data were collected through agriculture achievement test. Descriptive statistics and analysis of covariance (ANCOVA) was used to analyse the data. The results established that PBL has the greatest potential in improving students' achievement in agriculture compared with LTM. The PBL method significantly ($p < .05$) improved the student performance in agriculture. A statistically significant difference was found between students of PBL and LTM. The effects of PBL were more noticeable, therefore, the results are robust enough to inform practicing teachers to adopt PBL method because it has demonstrated its effectiveness in delivering content. The results may inform education experts at tertiary institutions and universities in Kenya on the benefits of implementing PBL method to pre-service teachers.

Keywords: Problem Based Learning, Lecture Teaching Method, Poor Performance, Agriculture Achievement Test, Students Achievement

1. Introduction

1.1 Introduction to the Problem

Agriculture is one of the sectors that contribute to eradication of poverty, hunger and malnutrition and by extension promotion of sustainable development. Equally, the sector is central to unlocking new developments in the various

Appendix R: Published Paper on Problem Based Learning and Demonstration Teaching Method

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EFFECTS OF PROBLEM BASED LEARNING METHOD AND DEMONSTRATION TEACHING METHOD ON SECONDARY STUDENTS AGRICULTURE ACHIEVEMENT IN NDHIWA SUB COUNTY, KENYA

¹Peter Oyier Ogweno

¹Department of Agricultural Education and Extension, Egerton University
Corresponding Author: peter.oyier60@gmail.com

²Prof. Nephat, J. Kathuri

Professor: School of Education and Social Sciences, Kenya Methodist University

³Dr. Agnes O. Nkurumwa

Senior Lecturer: Department of Agricultural Education and Extension, Egerton University

Abstract

Purpose: The study sought to compare the effects of Problem Based Learning (PBL) method and Demonstration Teaching Method (DTM) on achievement of students in agriculture subject.

Methodology: The study used Quasi-Experimental Design which followed a Non-equivalent Control Group Pre-test-Post-test Design, while a Constructivist learning theory guided the study. PBL was the treatment while Demonstration teaching method was used as control. The target population were 7124 students taking agriculture and 52 teachers of agriculture. Accessible population were Form Two Students and 12 schools. Both stratified random sampling and purposive sampling methods were used to obtain a sample size of 575 students and 12 teachers of agriculture. Six schools used Problem Based Learning as treatment, while the other six schools were taught through Demonstration teaching method. Pre-test was administered to PBL and DTM groups before teaching the students and a post-test was also administered to both groups at the end of six weeks of study. Data was collected using Agriculture Achievement Test (AAT) to measure students' achievement. Data was analysed using ANCOVA and descriptive statistics.

Findings: Post-test results established that teaching through PBL resulted in higher students' achievement in agriculture with a mean score of 57.47 compared to DTM mean score of 48.4. There were statistically significant difference in post-intervention scores between the interventions, $F(1, 278) = 1170.43, p < .001$, partial $\eta^2 = .800$ leading to rejection of null hypothesis. Therefore, PBL teaching method was found to be more effective in teaching agriculture as compared to Demonstration teaching method.

Unique contribution to theory, practice and policy: The study recommended that teachers of agriculture should embrace and use PBL as a method of instruction in agriculture subject. Likewise, Tertiary institutions and Universities in Kenya should implement the use of PBL method in their training programmes in training students.

Keywords: Problem Based Learning, Demonstration Teaching Method, Achievement in Agriculture, Quasi Experimental Design

Appendix S: Questionnaire for Teachers of Agriculture

To Agriculture Teacher

I am Peter Oyier Ogweno, a Ph.D. student at Egerton University undertaking a study entitled *“Effects of Problem-Based Learning and Demonstration Teaching Method on Students’ Academic Achievement in Secondary School Agriculture in Ndhiwa Sub County, Kenya”*. You have been randomly selected to give your honest answer to the questions listed in the questionnaire.

INSTRUCTIONS

- a) Please do not write your name in this questionnaire and answer all the questions.
 - b) Indicate your choice using a (✓) or write your answer in the spaces provided.
 - c) All the information you provide will be treated with confidence.
1. Please respond by filling in the blank spaces provided or by ticking (✓)
- a) Your age -----
 - b) Gender-----M [] F []
2. What is your highest professional training?
- a) Diploma in Science Education []
 - b) Diploma in Agricultural Education & Extension []
 - c) Bachelor of Education Science []
 - d) Bachelor of Science in Agricultural Education & Extension []
 - e) Master of Science in Agricultural Education []
 - f) Others (Specify) _____
3. What is your preferred methods of teaching agriculture? You may select more than one option.
- a) Lecture Teaching Method []
 - b) Discussion Teaching Method []
 - c) Demonstration Teaching Method []
 - d) Field Trips Method []
 - e) Project Teaching Method []
 - f) Problem Based Learning []
4. What is your teaching experience in agriculture subject?

- a) 0 - 4 years []
- b) 5 - 10 years []
- c) 11 - 15 years []
- d) 16 - 20 years []
- e) Over 21 years []

THANK YOU