

**SCHOOL FACTORS INFLUENCING IMPLEMENTATION OF
STRENGTHENING MATHEMATICS AND SCIENCE EDUCATION
PRINCIPLES IN TEACHING OF SCIENCE IN PUBLIC PRIMARY
SCHOOLS IN NYANDARUA WEST SUB-COUNTY, KENYA**

Mbugua Sylviah Wawira

**A Research Project Submitted in Partial Fulfilment of the Requirements
For Award of the Degree of Master of Education in Curriculum Studies.**

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DECLARATION

This research project is my original work and has not been presented for award of degree in any university.

.....

Mbugua Sylviah Wawira

E55/67202/2013

This research project is submitted for examination with our approval as university supervisors

.....

Dr. Mercy Mugambi

Lecturer

Department of Educational Administration and Planning

University of Nairobi

.....

Dr. Lucy Njagi

Lecturer

Department of Education Administration and Planning

University of Nairobi

DEDICATION

This research work is dedicated to the memory of my late husband Stephen Mbugua Kiongo, my beloved sons Peter Kiongo Mbugua, Benvictor Ng'ang'a Mbugua, Danrodgers Mugane Mbugua and my granddaughter Babra Wawira Kiongo for their encouragement, patience and perseverance throughout the period of my studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASEI	Activity, student, experience and improvisation
CEMASTEIA	Centre for Mathematics Science and Technology In Africa
DEO	District Education Officer
DQASO	District Quality Assurance and Standard Officer
GOK	Government of Kenya
INSET	In Service Education and Training
JICA	Japan International Co-operation Agency
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examination Council
MIITEP	Malawi integrated In-service Teacher Education Programme
MOE	Ministry of Education
NACOST	National Commission for Science Technology and Innovation
PDSI	Plan Do See Improve
PISA	Programme for International Student Assessment
SMASE	Strengthening Mathematics and Science in secondary schools
WECSA	Western, Eastern, Central and South Africa

ABSTRACT

The study sought to investigate school factors influencing implementation of Strengthening Mathematics and Science Education principles in teaching of science in public primary schools in Nyandarua West Sub County. The objectives of the study were to determine the extent to which learner centred teaching methodologies, PDSI approach, improvisation using local learning resources and teachers' lesson planning influence implementation of Strengthening Mathematics and Science Education principles in teaching of science in public primary schools in Nyandarua West Sub County. It was based on the constructivist theory. The study utilised descriptive survey research design. The target population of the study was forty three public primary schools, sixty science teachers and two thousand five hundred and eighty class eight pupils. Simple random sampling and stratified sampling were used to select teachers and pupils from the selected primary schools. Data was collected using an interview guide for head teachers', teachers', and pupils' questionnaire. Collected data was analysed both qualitatively and quantitatively. The study finding revealed that teachers did not avail adequate teaching and learning resources for teachers to use during science lessons for effective implementation of Strengthening Mathematics and Science Education principles in teaching of science. Learning process is effectively implemented by experienced teachers who prior training and In-service training from a basis of the implementation of SMASE. Based on the study findings, the researcher recommended that school administrators and other facilitators should organise seminars and workshops to build up teachers' confidence among themselves. There is need for more field trips to scientific sites to enable learners get first-hand information. This should be done through group discussions after the trips and individual experiment that would enable pupils to experiment their learning that has been done in class. Teachers should implement all the SMASE principles of teaching science. Therefore, the researcher suggests a study to be carried out to cover an in-depth to access the influence of learner centred strategies on science teaching in the entire Nyandarua County. Further research should be done to identify institutional factors that hinder implementation of learner centred strategies.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Strengthening Mathematics and Science Education project is an In-service education and training for teachers. In-service Education and Training is meant to enhance skills, knowledge and understanding of teachers for effective classroom practices. According to Cohen and Hill (1998), In-service education and Training that focuses on specific Mathematics and Science concepts and the way students learn such content is helpful if it is designed for instructions that help students to improve conceptual understanding. SMASE project's main activity was INSET for serving Mathematics and Science teachers so as to reduce contributing factors of poor performance in those two subjects as outlined by the Baseline Survey of 1998 undertaken by Japan International cooperation Agency JICA (2009).

In 1996, the United States of National Academic of Science produced the National Science Education Standards whose focus is on inquiry based science, which is based on the theory of constructivism rather than on direct instruction of facts and methods (Okunde, 1998). Japan, education system promotes and disseminates scientific knowledge and academic research. The quality of Japanese educationist maintained by mandatory and continuous teachers' development education at every level of their profession (JICA, 2007). Quality teaching in school has made Japan to be among the best in

problem solving assessment in programmes for international student assessment (PISA survey, 2012). The Ministry for Education (MOE) of the Philippines successfully implemented teaching and learning strategies that included practical work, discussion, problem solving, investigation, exposition, practice and cooperative learning (JICA, 2009). Lemlech,(2010) states that greater emphasis on experimentation and inquiry-oriented teaching has made the process of teaching Science as Important as the content of Science.

In Africa, Strengthening of Mathematics and Science Education in Western, Eastern, Central and South African (SMASE-WECSA, 2014) are associates which have 34 member countries formed to strengthen Mathematics and Science education. They form professional networks based on action research that is consistent with global trend in education .In Malawi, the government has integrated In-service Teacher Education programme (MIITEP), which has been designed to improve the quality of teaching and learning at all levels of education system. SMASE/WECSA has been embraced to improve quality of teacher content mastery and pedagogical skill in Mathematics and Science education. In Nigeria, Studies shows that a large number of Students seem to learn very little science in schools, learning seems to be by rote and pupils find learning science to be difficult while pupils copy/ dub textbooks or old notes (Salau, 1996, Okebukala, 1996, Uzoechi, 1996). In Nigeria, Uzoechi, (2006) and Ifebo (2005) found out that lack of adequate instructional materials and human resources contribute to poor performance in primary science hence low achievement of pupils in the subject.

The Government of Kenya embarked on the implementation of SMASE-INSET programme for mathematics and science teachers in primary schools between 2009 and 2013 (Republic of Kenya, 2008). The overall goal of SMASE programme is to upgrade the capabilities of young Kenyans in mathematics and science education. The programme identified Activity Student Experiment and Improvisation (ASEI) and Plan Do See Improve (PDSI) strategies for quality teaching and learning principles of science. Learners' performance can be improved if the learning process is relevant to the learners as advocated by the principle of ASEI/PDSI. When the learner-centred approaches are well used in classrooms practices, there will be positive effect on learners performance in science. (SMASE project from pilot phase 1998 to 2003, cited by Mwangi 2014). Implementation of SMASE INSET programme is aimed at transforming teachers' classroom practice with the ultimate goal being to strengthen pupils' performance in science. Cannon and Newble (2000), define student centred learning as ways of thinking about teaching and learning that emphasize student responsibility and activity in learning rather than content or what the teachers are doing. The conventional teacher-centred approach is focused on the teacher, where the teacher talks and the students just listen.

Learner centred learning methodologies are organised using Activity-based Student-centred teaching/learning Experiment-based and Improvisation (ASEI). It has been modelled according to the current trends of teaching and learning science having been developed from several baseline surveys conducted by CEMASTE (2010). Constrictive participation of the learner in

Learner centred learning methodologies are organised using Activity-based Student-centred teaching/learning Experiment-based and Improvisation (ASEI). Improvisation of local learning resources forms critical inputs in teaching since they assist the learner to synthesize what is being learnt. Ornstein and Hunkins (2010) acknowledge that appropriate teaching methods accompanied by relevant learning resources trigger the desirable learning activities resulting to learning of concepts. SMASE (2013) states that, the foundation of all learning science is the first- hand experience with real things. Science teachers need to work with students to come up with ways to improvise local learning resources thus making students to think critically about the scientific concepts underlying the devices. Planning, Doing (carrying out the planned activity) Seeing (evaluating the outcome of activity) Improvement (PDSI) is a process of checking the progress of an activity against its plan and answering the question of how the activity is being carried out in relation to the intended objectives (CEMASTE, 2011). According to Arunga (2007), teachers are encouraged to rethink the usefulness of the lesson plans as a critical tool for lesson delivery. Apart from schemes of work and lesson plans, teachers carefully plan the lesson and try out teaching and learning activities according to PDSI approach to teaching (CEMASTE, 2010).

Despite intervention of School based Teacher Development (SbTD) and recent intervention by the government the SMASE programme (Republic of Kenya, 2008), there is still poor performance in science subject across the

country which raises concern to all educationalists curriculum developers and other stake holders. Research carried out by Mwangi (2014) Barasa (2015) and Maina (2015) on the national performance of science indicates poor performance in science despite the government's effort to upgrade science teachers consistently from 2009-2013 through strengthening mathematics and science education teacher development. Therefore the researcher seeks to carry out an investigation on how effective is the teacher training in SMASE on pupils performance in science at Kenya Certificate of Primary Education in Nyandarua West sub-county.

Table 1.1:

2009-2014 K.C.P.E mean score for science in Nyandarua sub-counties

Nyandarua/ Year	2009	2010	2011	2012	2013	2014	Average
Sub-counties							
North	50.55	49.78	51.05	53.97	51.11	51.25	51.29
South	51.98	50.25	54.38	55.76	57.07	57.30	54.46
Central	50.31	50.42	52.23	54.23	56.44	56.45	53.51
Kipipiri	50.45	50.12	51.25	51.60	54.26	53.28	51.83
Mirangine	49.87	48.86	48.90	49.12	50.12	50.13	49.50
Kinangop	50.86	50.33	51.25	51.03	52.00	51.12	51.09
West	49.86	47.66	46.90	44.64	45.49	45.00	46.59

Source: DEO's office Nyandarua North, South, Central, Kipipiri, Mirangine, Kinangop and Wet sub-counties, 2015

Table 1.1 illustrates Nyandarua sub-counties KCPE Science mean score for the seven sub-counties, which shows the average performance for the last six years. Nyandarua West recorded the lowest performance in KCPE. This challenges teachers if implementing of SMASE INSET approach in teaching of science in public primary schools and whether the school factors are contributing to poor performance.

1.2 Statement of the problem

SMASE INSET has not been effective in enhancing the pupils' performance in Science in Nyandarua West Sub-county (Table 1.1) although they attended the INSET for four cycles from 2009 to 2013. It was expected that after training, teachers would be able to deliver science knowledge to pupils in a better way leading to better performance. Study carried out by Mwangi (2014) found out that head teachers do not avail adequate teaching and learning resources for teachers to use during science lesson for effective implementation of SMASE. There are limited studies carried out to investigate the influence of SMASE principles in teaching of science in other counties on performance at primary schools levels. Studies conducted by Rotich (2012), Ndirangu (2013) Maina(2015), Barasa (2015) Reveal that performance of students in science before and after SMASSE/SMASE programmes have been below average; Pupils' involvement during the lesson has been partially achieved and that classroom practices have improved but however; not translated into improved performance of the subject as cited by Ndirangu (2013) This has prompted the researcher to investigate whether teachers use skills from SMASE INSET effectively in teaching of science subject in Nyandarua West sub-county.

1.3 Purpose of the study

The purpose of the study was to investigate school factors influencing implementation of Strengthening Mathematics and Science Education

principles in teaching of science in public primary schools in Nyandarua West sub-county.

1.4 Objectives of the study

The study was guided by the following objectives;

- i. To determine extent to which learner centred teaching methodologies influence implementation of Strengthening Mathematics and Science Education principles, in teaching of science in public primary schools in Nyandarua West sub-county.
- ii. To determine the extent to which Plan Do See Improve (PDSI) approach influence the implementation of Strengthening Mathematics and Science education principles in teaching of science in public primary schools in public primary schools in Nyandarua West sub-county.
- iii. To establish the extent to which improvisation using local learning resources influence the implementation of Strengthening Mathematics and Science Education principles in Teaching of Science in public primary schools in Nyandarua West sub-county.
- iv. To establish the extent to which teachers' lesson planning influence the implementation of Strengthening Mathematics and Science Education principles in teaching science in public primary schools in Nyandarua West sub-county.

1.5 Research questions

- i. To what extent do learner centred teaching methodologies influence implementation of Strengthening Mathematics and Science Education principles in teaching of science in public primary schools in Nyandarua west sub-county.
- ii. To what extent does Plan Do See Improve approach influence the implementation of strengthening Mathematics and Science education influence implementation of Strengthening Mathematics and Science Education principles in teaching of science in public primary schools in Nyandarua west sub-county.
- iii. How does improvisation using local learning resources influence the implementation of Strengthening Mathematics and Science education principles in teaching of science in public primary schools in Nyandarua west sub-county.
- iv. How does teachers' lesson planning influence implementation of Strengthening Mathematics and Science Education principles in teaching of science in public primary schools in Nyandarua west sub-county.

1.6 Significance of the study

The outcome of this study may be helpful the DQASO to advice science teachers on the best ways to implement SMASE project teaching methodologies, to reinforce areas that contribute to students' achievement in

science , school administrators such as head teachers, deputy head teachers and senior teacher, all educational stakeholders , MoE and KICD to design better teaching methodologies for science.

1.7 Limitations of the study

Some of the limitations that the researcher experienced were: Strengthening Mathematics and Science Education programme is relatively a new project in primary schools since it started in 2009 and ended up in December 2013 and therefore there was limited literature which was a barrier to the research. However the researcher used the CEMASTE (2009-2010) report on monitoring and evaluation region INSET to investigate this challenge. Some teachers did complete the full cycle of the INSET programme to fully implement the SMASE project. The researcher used teachers who had undergone the full cycle of the INSET programme as much as possible and those who were co-operative after identifying them through the head teacher. The researcher only covered one sub-county had an unique setting thus; the study could not be used to generalize results to the whole country. For conclusive results, all the other sub-counties in Kenya should be studied. However, this could not be possible because of research constrains by finance and time. The researcher assured them that the information would be confidential and would be used purely for academic purposes.

1.8 Delimitations of the study

This study was conducted in public primary schools in Nyandarua West sub-county because SMASE-INSET was meant for public primary teachers teaching in public schools and not for private schools. The study was limited to Head teachers and Science teachers who participated and completed SMASE INSET programme and class eight pupils. SMASE INSET is centred on two subjects, that is Mathematics and Science. The study was limited to science subject only.

1.9 Assumption of the study

The following were assumptions of the study;

- i. That all the respondents were co-operative in providing appropriate responses to questionnaires.
- ii. That science teachers had completed the full SMASE INSET cycles were using ASEI-PDSI approach in their classes.
- iii. The KCPE results were a true reflection and acceptable measures of teachers' effective implementation.
- iv. Teachers were trained and qualified in teaching science.

1.10 Definition of significant terms

ASEI refers to the movement that advocates for activity focused teaching and learning which is learner-centred learning, experiments and improvisation.

Constrains refers to that restricts or hampers restrictions of skills

Influence refers to teaching having the capacity to use the required teaching and learning resources and methodologies to improve learners' performance.

INSET refers to educational and training activities engaged in teachers following their initial professional certification and to improve their professional in order to educate learners more effectively.

Implementation refers to a stage where ideas in school growth plan are put into action.

Improvisation refers to the producing locally available materials in teaching and learning as advocated by SMASE programme.

Knowledge refers to information and understanding about a subject which a person has in his or her mind.

Learning refers to acquisition of knowledge, skills and attitudes towards a subject that may result to better performance.

Learning resources refers to materials that an educator uses in classroom teaching to achieve objectives.

Learner-centred refers to teaching based on the pace, motivation and participation of learners.

Lesson planning refers to the teachers' detailed description of the science lesson instruction according to PDSI approaches.

Methodology refers to a way of carrying out actual teaching in a classroom.

PDSI refers to the approach that aims at helping teaching practice of ASEI activity at the classroom level.

Performance refers to a measure of a students' academics achievements

Pre-service refers to a training of a prospective teachers prior to initial basic qualification of teachers.

Programme refers to a set of related measures or activities with a long term aim.

Resource refers to the physical facilities and materials which aid in the teaching and learning of science.

SMASE refers to a teacher development programme for primary school teachers of mathematics and science.

Teaching refers to proving educational knowledge and skills to the learners.

1.11 Organisation of the study

The study is be organised into five chapters. Chapter one is introduction on the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitation of the study, delimitation of the study, basic assumption, definition of significant terms and organisation of the study. Chapter two explores the review of the related literature to the study. This includes concept of SMASE In-Service programme, school based factors influencing implementation of

SMASE such as influence of SMASE teacher development programme on learner centred teaching methodologies, Plan-Do-See Improve approach, improvisation using local learning resources and teachers' lesson planning, summary of literature review, theoretical and conceptual framework of the study. Chapter three consists of the research methodology, detailing the research design, target population, sample and sampling procedures, research instruments, validity of instruments, reliability of instruments data collection procedures and data analysis techniques and ethical considerations. Chapter four comprises of data interpretation, findings and discussions. Chapter five consists of the summary of the study, conclusion recommendations of the study drawn from the data analysis in chapter four.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

The study presents the related literature pertaining to school factors influencing implementation of Strengthening Mathematics and Science education principles in teaching of science. The literature review is organised in the following themes; the concept of implementation of Strengthening Mathematics and Science Education SMASE INSET programme, influence of SMASE teacher development programme on learner centred teaching methodologies, Plan Do See Improve approaches, improvised local learning resources and teachers' lesson planning on SMASE implementation. It also presents the summary of reviewed literature, theoretical and conceptual framework adopted by the study.

2.2 The concept of implementation of Strengthening Mathematics and Science Education

Implementation is putting new ideas into practice (Fullan, 2001). Implementation includes a transition period in which implementers in the context of the school becomes increasingly skilful, consistent and committed to use an innovation. According to Kibe (2008), studies on quality of education in Kenya indicate low quality and poor performance especially in mathematics and science subjects compared to other social science subjects. According to

Waititu (2008), SMASE came into being when the consistently poor performance in Mathematics and Science became a matter of serious concern. Broad curricular, lack of facilities and inadequate staffing were cited as the major causes of the problem. The Ministry of Education and other stakeholders felt there had been an intervention, hence the Strengthening of Mathematics and Science Education was implemented. CEMASTEIA (2011) conducted a survey and from the results it was evident that there were numerous problems in science performance. Some of them included the theoretical approach of teaching, Inappropriate teaching methodology was used whereby most teachers used teacher centred methodology without pupils' involvement in the lessons. (SMASE-WECSA, 2012) has a network of professional reference groups that share similar professional experiences, knowledge of good classroom practices. This is relevant and consistency with global trends in education designed to address ownership and sustainability of teachers' development programmes (SMASE-WECSA, 2006) currently (SMASE-AFRICA 2012).

2.3 Learner centred teaching methodologies and implementation of Strengthening Mathematics and Science Education

Teaching of Science subjects should be learner centred (SMASE 2009). There must be student-centred activities involving a lot of improvisation in the experiments which helps to demystify science (SMASE,1999). Brown and Adams (2001), changing nature of the teacher in constructivist .The principle of ASEI movement and PDSI approach was noted to be very compatible with

Kenya's educational aspirations because there was a need to move from knowledge-based to activity based teaching, teacher-centred to learner-centred, lecture method to experiment and research based strategies and then from full scale to small scale experiments and improvisation. SMASSE, 2009)/SMASE (2002).

2.4 Influence of Plan Do See Improve Approach and implementation of strengthening Mathematics and Science Education

According to SMASE (2013) PDSI (Planning, Doing (carrying out the planned activity) Seeing (evaluating the outcome of activity) followed by Improvement is a process of checking the progress of an activity against its plan and answering the question of how the activity is being carried out in relation to the intended planned objectives. Through planning entry behaviour knowledge, skill and attitudes are facilitated and incorporated into teaching and learning process. Planning and using systematic approach to teaching the entry behaviour or prerequisite knowledge and skills is one of the contributing factors that determine the outcome of good or poor performance. Planning also involves teachers utilizing the guidance gotten during SMASE. Mwangi (2014) argues that involvement of pupils in planning activities and lessons objectives may include monitoring the lesson process against the planned activities and lesson objectives. On the other hand CEMASTE (2012) argues that teachers make use of feedback to modify the lesson as it continues to remove misconceptions as well as improve on their teaching methodology.

PDSI approach enables the teachers to plan instructions based on knowledge of subject matter, ensuring that the topic objectives are SMART (Specific, Measurable Achievable, Realistic and Time bound) (CEMASTE, 2013).

According to SMASE (2010) the principle in PDSI ensures planning against the activities in relation to the intended objectives .

2.5 Influence of improvisation of local learning resources and implementation of Strengthening Mathematics and Science Education

Improvisation of locally available resources helps science teachers who often do not have access to the resources needed to optimally perform experiments. Innovative teachers can use cheaper products to simulate experiments. Teachers can help students learn improvisation as an important Life skill to help them think critically about the scientific concepts underlying the devices (Ndirangu, 2013). According to Gituthu (2014) only 30 percent of teachers in secondary schools improvise resources in experiment while 70 percent rarely do. This denies the students a chance to raise their interest and curiosity.

2.6 Teachers' lesson planning and implementation of Strengthening of Mathematics and Science Education

The third cycle of SMASE programme was actualization of ASEI/ PDSI approach. The teachers here were taught to develop ASEI/PDSI lessons which were tried out by their peers and then teach actual learners in the classroom (SMASE, 2009). ASEI is an abbreviation of Activity, Student, Experiment and

Improvisation. PDSI is an abbreviation of “Plan” (planning a lesson),”Do” (carrying out the planned activities or lesson), “See” (assessing students understanding and evaluating the lesson) and “Improve” (improving the lesson based on the evaluation). PDSI is a continuous reflection process which allows a teacher to improve science lesson, subsequent lessons and lesson delivery skills in general (CEMASTE, 2010). Apart from schemes of work and lesson plans, teachers carefully plan the lesson and try out the teaching and learning activities as required by the PDSI approach to teaching. The first part of PDSI is planning of the lesson and instruction outlining lesson activities based on ASEI principles (CEMASTE, 2010). The second part of PDSI is “Do”. The teacher carries the planned lesson activities as intended. The third part of PDSI is “See”. Teachers evaluate teaching and learning process during and after the lesson objectives and planned activities. The last part of PDSI is “Improve”. The teacher reflects on the performance, evaluation reports and effectiveness in achieving the lesson objectives. The teacher integrates good practices and feedback in subsequent lessons (Mwigwi, 2012)

2.7 Summary of literature Review

The literature is presented in the following sections; concept of implementation of Strengthening Mathematics and Science Education in teaching Science project, influence of learner centred teaching methodologies, influence of PDSI approach, improvisation of local learning resources, and teachers’ lesson plans. (Maina and Barasa 2015) have based their studies in factors influencing

SMASE in Science performance. Mwangi (2014) studied on influence of SMASE project approach in Kandara division, Murang'a county, and suggests further research be extended to public primary schools in other parts of the country. There is limited research that has been carried to investigate the influence of school factors on implementation of SMASE principles project approach at the primary level in Nyandarua West sub-county. The study is aimed at filling this knowledge gap by investigating how school factors influence implementation of SMASE principles in teaching of science in Nyandarua West.

2.8 Theoretical framework

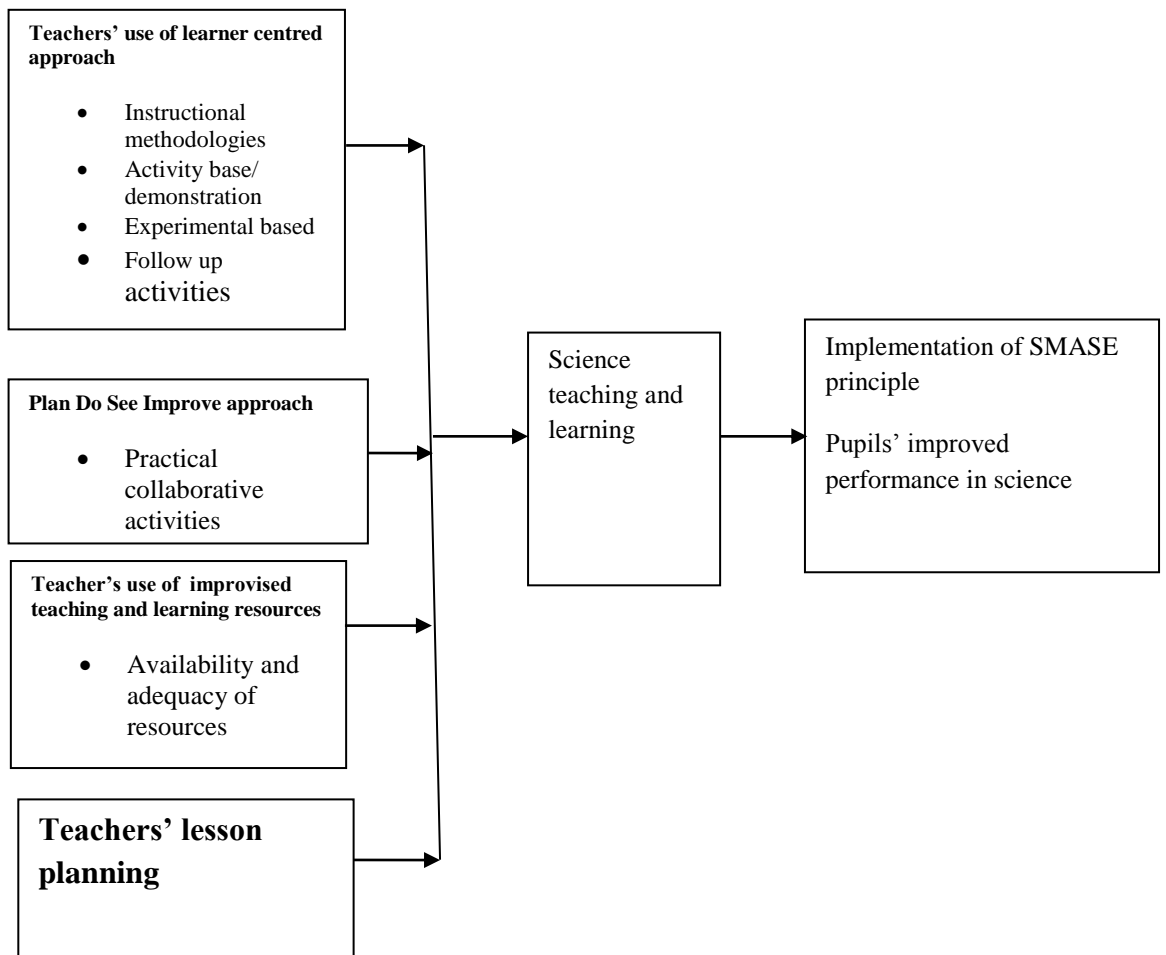
The research study was based on constructivist theory by Bruner (1966). The theory states that learning is an active process in which learners construct new ideas based upon their current or past knowledge. The learner selects and transforms information, constructed hypothesis and makes meaning from information and experiences while relying on a cognitive structure to do so. The theory assumes that learners bring experiences and understanding of the classroom. They do not encounter new information out of the context but rather applying what they know to assimilate information, to accommodate or reframe that they know to match new understandings which they have gained. The theory advocates for active participation of learners in the learning process rather than being passive members of knowledge. The theory is considered appropriate for the study because SMASE teacher development programme

advocates plan to see and improve paradigm which posits that teachers should plan learner centred approaches based on ASEI that ensured resources integrating with the learning activities. Thus enabling all the learners' senses are actively involved to enable them construct new experiences by applying what they know to assimilate, accommodate to match knowledge being gained. According to CEMASTEIA (2010) active involvement of learners through learning resources assist learners to synthesize what is learnt and thus improve science performance. The theory also acknowledges learners prior knowledge on which learners construct new knowledge. The SMASE programme encourages teachers to plan their lessons considering learners' prior knowledge/ practical experiences on the topic and build new concepts on it. Through discussion, the teacher should remove any misconception and help learners draw correct scientific concepts.

2.9 Conceptual frame work.

Orodho (2004) defines conceptual framework as a model of representation where a researcher conceptualizes or represents a relationship between variables in the study and shows the relationship graphically or diagrammatically. The framework of this study is presented in figure 2.1

Figure 2.1 Conceptual framework showing school factors influencing implementation of SMASE principles in teaching of science



The conceptual framework shows the relationship between variables influencing the implementation of SMASE principles in teaching Science. Proper implementation of teachers' use of learner centred teaching methodologies, will influence pupils' performance in science. Proper implementation of PDSI approach, teachers' use of improvised teaching and learning resources and lesson planning will influence pupils' performance in science. Lemlech (2011) Once change is initiated, there are intervening factors

which affects the outcome. In this case the influence of SMASE Principles in teaching Science affects the performance of Science.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology which was used in the study to collect data; research design, target population, sample size, sampling procedures, research instruments, instrument validity and reliability, procedures of data collection, data analysis techniques and ethical considerations.

3.2 Research Design

This study utilized descriptive survey research design. According to Mugenda and Mugenda (2003), a survey is an attempt to collect data from members of a population in order to determine the status of the population in respect to one or more variables. It is a self-report study that requires the collection of quantifiable information from the sample. Descriptive survey is a method of collecting numerical data to answer questions about the status of the phenomena under study. The design allows the researcher to collect data about peoples' opinion, attitudes, habits, or any other educational or social issue (Orodho, 2004). This design was deemed appropriate as it enabled the researcher to explore incidences and relationship between variables. The teachers' variables such as learner centred teaching methodologies, PDSI approach improvisation of local learning resources were surveyed to evaluate

how SMASE INSETs influenced the teaching of Science in public primary schools for the performance of Science in schools.

3.3 Target Population

The target population for this study was 43 public primary schools in Nyandarua west sub-county, 43 head teachers and 60 science teachers who attended the SMASE INSET programme. A population of 1,720 class 8 pupils since they have been in school for long; have more science knowledge and can read and response to the questionnaire easily and 43 head teachers in these primary schools were targeted due to the role they play in curriculum implementation. The whole target population was 1,823 respondents (Table 3.1).

3.4 Sample size and sampling procedures

Sampling is the process of selecting a number of individuals for a study in such a way that the individuals selected represents a larger group thus representing the characteristics found in the entire group (Orodho, 2003). According to Mugenda and Mugenda (2003) a sample of 10% to 30 % of the respondents can represent a target population. This study used 30 percent of Science teachers and head teachers and 10 percent of pupils. In this case, 13 out of 43 public schools were used for the study. 13 head teachers were sampled, 18 science teachers and 172 class eight pupils. Stratified sampling was used to get sub-groups on gender and age of respondents to select teachers and pupils from the selected primary schools. Simple random sampling is important in reducing

the influence of extraneous variables in a study (Mugenda and Mugenda 2003).The study adopted stratified sampling of 13pupils per school. To obtain 13 schools and 172 pupils, the researcher wrote 43names of schools on pieces of papers and on them the word ‘yes’ was written on 13 pieces and 22 were written ‘no’. The papers were folded and put in a container. Then the researcher handpicked papers which were written ‘yes’. These constituted the sampled schools. For the selection of pupils the researcher enquired the number of pupils in class eight in the sampled schools and wrote pieces of papers, the word ‘yes’ on thirteen pieces of papers and the lest ‘no’. The papers which were written ‘yes’ and were handpicked constituted the sampled pupils in that particular school. The results are as presented in table 3.1

Table 3.1 Sampling framework

Category of respondents	Target population	Sample size	percentage
Head teachers	43	13	30
Science Teachers	60	18	30
Pupils	1720	172	10
Total	1823	203	

Source: DEO’s office Nyandarua West sub-county

Table 3.1 represents sample size of the population in Nyandarua West sub-county. Total target population was 1823 and the sampled size was 203.

3.5 Research Instruments

Data for the study were collected using an interview guide for head teachers, questionnaires for teachers and pupils. An interview guide is an oral questionnaire that gives immediate feedback and is administered face to face. According to Kombo and Tromp (2006) Questionnaires are the most suitable research instrument for descriptive research design. Both open ended and closed ended questions were used. According to Mugenda and Mugenda (2003) questionnaires allows the respondents to express themselves freely. Questionnaires were also used because they have the ability to collect large amounts of information.

Questionnaires for head teachers, teachers and standard eight pupils were used to collect data. Questionnaires enables the researcher to collect information that can be easily analysed. They allow for anonymity of respondents (Mugenda & Mugenda, 2003). The questionnaires comprised sections; Section A and B. Section A consisted respondents' demographic information while section B consisted information on school factors influencing Strengthening Mathematics and Science Education principles in teaching of Science.

3.6 Validity of data collection instruments

Expert judgement from the university supervisors was used to assess the extent of the items in the instruments, address and the objectives as well as whether the format of the instruments will give correct impression. Split half of the technique was used to check for the validity of the research instrument using two schools that were not be used for the final study, two teachers, one Head teacher and thirty eight pupils to identify items that will be inadequate in measuring the variable to either improve or discard the items.

3.7 Reliability of instruments

To determine the reliability of the instruments, the researcher used test-retest method during piloting. The researcher administered the questionnaires on two different occasions. The response was given in the second administration of the questionnaires which were correlated with the respondents of the first administration. The reliability was then calculated using Pearson's product moment correlation coefficient formulae.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

$$\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}$$

r coefficient correlation

n number of respondents in each test

x scores in first test

y scores in second test

\sum Summation sign

The range of coefficient between -1 to +1 is deemed that the research tools have a very high degree of reliability (Gay, Mill & Airasian, 2000). This study's research questionnaires yielded a correlation coefficient of 0.80 for head teachers, 0.82 for science teachers and 0.78 for pupils which was quite sufficient for the study.

3.8 Data collection procedure

The researcher obtained an introducing letter from the University of Nairobi. A research permit was obtained from the National Commission for Science Technology and innovation (NACOST). The researcher presented copies of the research permit to the Nyandarua county commissioner, Nyandarua county director of education and the Nyandarua West- District Education Officer in order to obtain the necessary authority to proceed with the study. The researcher booked an appointment with sample schools through the head teachers to visit and administer the questionnaires. According to Mugenda and Mugenda (2003) administering the questionnaires personally gives the

researcher time to establish rapport, explain the meaning of items that may not be clear to the respondents. The researcher went to the school and informed the head teachers the purpose of the research was to research on school factors influencing implementation of SMASE Principles in science teaching in public primary schools .The researcher informed them that their schools had been selected to participate in research and requested them to respond to the questionnaire items honestly and best to their knowledge .She informed them that it was for academic purposes. The researcher gave the head teachers the interview guide and provided them with questionnaire for Science teachers. The researcher also provided learner centred teaching methodologies, PDSI approaches, improvisation of local learning resources and lesson planning and questions for pupils.

3.9 Data analysis techniques

To analyse the data obtained from the research study, questionnaires were crosschecked to ascertain their accuracy, completeness and uniformity of information. Quantitative data obtained from demographic section and other closed-ended questions were analysed using descriptive statistics, and computed as percentages and frequencies. Bar graphs and pie charts were used to present the data. Qualitative data generated from open-ended questions were organized into themes and patterns categorized through content analysis based on variables from the objectives. Interview guide questionnaires were reported

through narratives. Data was coded and computed using statistical packages for social science.

3.10 Ethical Considerations

Mugenda (2013) describes that in research process, ethics focus on the application ethical standards in the planning of the study, data collection and analysis, dissemination and use of the results. The researcher sought clearance from the administration and planning department from the university to conduct the study. She also applied a research permit from NACOST to conduct the study. The researcher explained the research objectives to the head teacher and science teachers. All participants were informed that there would be no psychological risk and no financial benefits and their participation would be voluntarily applied in this study. They were assured of their anonymity and confidentiality of their responses where they would not be required to write their names on the questionnaire.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents a descriptive analysis of the data gathered on the school factors influencing implementation of strengthening mathematics and science education principle in teaching of science in public primary schools in Nyandarua West sub-county. The study was guided by the following specific objectives; to determine the extent to which learner centred teaching methodologies influence implementation of SMASE principles in teaching of science in public primary schools; to determine the extent to which Plan Do See Improve (PDSI) approach influence the implementation of SMASE principles in teaching of science; to establish the extent to which improvisation using local learning resources Influence the implementation of SMASE principles in teaching of science; to establish the extent to which teachers' lesson planning influence the implementation of SMASE principles in teaching of science. Descriptive analysis technique was used to organize, summarize and interpret quantitative information. Data was then presented in form of frequency table sand charts where applicable. This presentation is based on the questionnaire administered.

4.1.1 Questionnaire return rate

Completion rate is the proportion of the sample that participated as intended in all the research procedures. The returned questionnaires were from 165 pupils, 18 teachers and 13 head teachers in primary schools in Nyandarua West sub-county. Analysis and data interpretation was based on these returns. The results are as presented in Table 4.1.

Table 4.1 Questionnaire return rate

Respondents	Sample size	Return
Head teachers	13	13(100)
Teachers	18	18(100)
Pupils	172	165(95.5)
Total	203	196 (98.1)

From table 4.1 all the teachers and 95.5 percent of the pupils returned their questionnaires. Mugenda and Mugenda (2003) a rate of 70 % is very good. The return rate was hence considered good to provide required information for data analysis.

4.2. Background characteristics of the respondents

This section presents the characteristics of personal attributes of individual respondents. Pupil's attributes included their gender, age, class marks for last term and current score for science. The head teachers' attributes included their gender, age and highest professional qualifications. The rationale behind inclusion of these attributes in the analysis is that they help to shed some light on how the characteristics have influenced on the Strengthening Mathematics and Science Education principle in teaching of science.

4.2.1 Gender of respondents

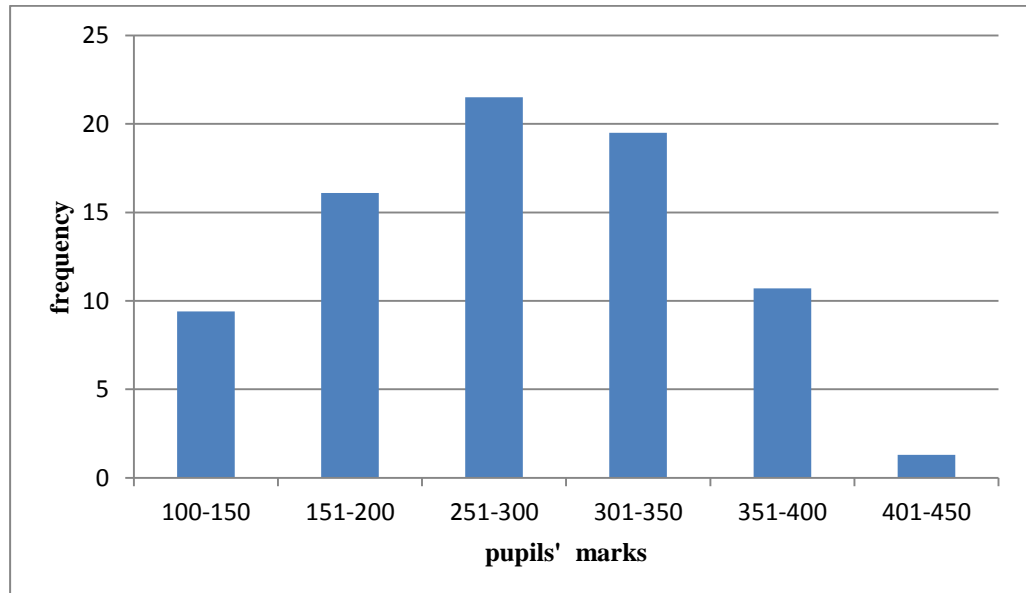
The pupils were asked to indicate their gender, age and class marks for last term and current score for science. The results for pupil's gender and age are as shown in Table 4.2.

Table 4.2 Gender versus age of pupils

Gender	Age			
	12-13 years old	14-15 years old	Total	
Boys	n	45	20	65
	%	71.0%	29.0%	100.0%
Girls	n	82	18	100
	%	77.5%	22.5%	100.0%
Total	n	127	38	165
	%	51.7%	48.3%	100.0%

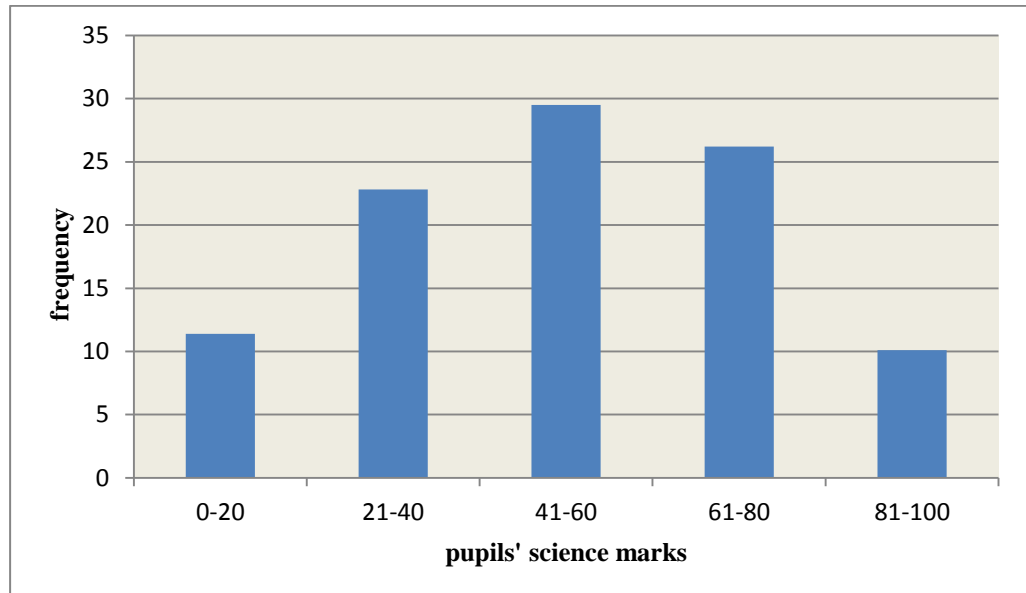
The information of the pupils' gender and age was sought to establish the number of boys and girls in standard eight in sampled schools. Table 4.2 indicates the distribution by gender and age. This was useful in order to establish if standard eight pupils were rightfully placed in the right class. The pupils were asked to indicate their marks in the last term. The Figure results are as shown in the figure 4.1.

Figure 4.1 Marks for the Last Term



This figure show that slightly above half of the pupils had attained half of the required marks out of five hundred marks. The pupils were again asked to indicate their current performance in science. The results are as shown in figure 4.2

Figure 4.2 Pupils Current Performance in Science



This figure shows that at least three quarters of the pupils had attained 41 and above marks in science while only a small percentage of 11.4% of the pupils had a minimal performance in science of 0-20marks. This could have been as a result of many things, one being the teachers teaching methodology, the PDSI approach, improvisation using local learning resources or teachers' lesson planning.

4.2.2 Head teachers and teachers demographic data

The study sought to establish head teachers and teachers demographic data. The results are as shown in Table 4.3.

Table 4.3 Head teachers' and teachers' gender distribution

Gender	Head teachers		Teachers	
	Frequency	Percent	Frequency	Percent
Male	40	75.0	28	30.8
Female	3	25.0	32	69.2
Total	43	100.0	60	100.0

Table 4.3 shows, that the majority of the head teachers (75%) were male, while majority of the teachers (69.2%) were female. More men were in the headship. These findings concur with Cubillo and Brown (2010) who noted that the teaching profession is predominated by women. However, women are less well represented in headship than they are in teaching jobs.

4.2.3 Head teachers' and teachers' gender and age

The item on the head teachers and teachers, sought the information on their gender and age with the aim of establishing the distribution in the schools and if their gender and age have influence on principles of teaching science in public primary schools. They were asked to indicate this information so as to help in establishing whether they have any impact in balancing gender and age in the teaching of science subject. The age of head teachers and teachers is important. The results are as presented in Table 4.4

Table 4.4 Head teachers' and teachers' age bracket

Age (years)	Head teachers		Teachers	
	Frequency	Percent	Frequency	Percent
Below 30 year	0	0.0	2	7.7
30 -39 years	0	0.0	10	61.5
40-49 years	3	25.0	4	23.1
Over 50 years	10	75.0	2	7.7
Total	13	100.0	18	100.0

Table 4.4 shows that all the head teachers were over 40 years old while majority of the teachers (61.5%) were aged between 30 to 39 years. The findings are an indication age is a determinate of effective educational administration ability. This is in-line with a study done by Kingangi (2009) that indicate that the ability to solve administrative issues effectively increases with increase in age.

4.2.4 Head teachers' and science teachers' education qualifications

The head teachers and science teachers were required to indicate they level of professional qualifications. This is important to determine the level of competence in implementation of SMASE program. The study further sought

to find out the education qualification of head teachers and science teachers and presented the findings as shown in Table 4.5

Table 4.5 Head teachers' and teachers'. highest academic qualification

Professional	Head teachers		Teachers	
	Frequency	Percent	Frequency	Percent
MED	2	16.7	2	7.7
BED	8	66.7	3	15.4
Diploma	3	16.7	4	23.1
Certificate	0	0.0	9	53.8
Total	13	100.0	18	100.0

Table 4.5 indicates that all the head teachers and teachers had attained different levels of professional qualification with majority 66.73% of the head teachers having a Bachelor's degree and 53.8% of the teachers having a P1 Certificate. This was an implication that all teachers and head teachers were in the capacity to carry out their role in schools, as stipulated in the Basic Education Act (2013), the TSC Act (2012) and Sessional Paper number 5 on Policy Reforms for Education, Training and Research in the 21st century Therefore the respondents were reliable to give valid data for the study.

4.3 Learner centred teaching methodologies influence on implementation of SMASE principles in teaching of science

Activity Student Experiment and Improvisation (ASEI) lesson design considers the quality of classroom activities as critical to achieving effective teaching and learning (SMASE, 2010). Teachers are the main agents of curriculum implementation and therefore, the learner should be at the centre of the process. ASEI aims at helping teachers appreciate the benefits of active learner involvement in the teaching and learning process. Teachers are guided on how to use a variety of activities for effective lesson delivery. Mwangi (2014) denotes that the use of practical activities in learning needs to be emphasized. This is done through arranging the learning process systematically. This study sought to identify activities pupils are involved in science classes which are learner centred. The results are as shown in Table4.6.

Table 4.6 Pupils' performance of activities in Science

	Daily	Weekly	Fortnight	Yearly	Total
Individual experience	52	77	36	0	165
%	30.2	49.0	28.0	0.0	100.0
Group discussion	63	81	21	0	165
%	36.9	49.0	14.1	0	100.0
Observe teachers' demonstration	85	80	0	0	165
%	51.0	48.0	0.0	0.0	100.0
Go for field trips	0	0	0	0	165
%	0.0	0.0	0.0	0.0	100.0
Do project work	33	90	42	0	165
%	18.1	60.4	23.5	0.0	100.0
Do peer training	100	65	0	0	165
%	65.8	34.2	0.0	0.0	100.0

All the pupils indicated that they attended field trips once a year. This implies during field trips pupils are able to learn different lessons that could be offered in science according to the sites visited. Majority (65.8%) of the pupils noted that they did peer-training daily in their class and 34.2% of them did it weekly. This implies that pupils were also taking the challenge of teaching each other in class in what they had understood as the teacher was teaching them especially in science experiences.

About 58.4% of the pupils noted that they were involved in project work in their class weekly while 23.5% of them were involved in a fortnight project work and 18.1% were involved daily in project work. This implies pupils were given activities to carry out as a project in their class activities as a learning activity. Slightly above half of the pupils(51.0%) said that they observed teachers' demonstration daily while 49.0% did it weekly.

Teachers' demonstration in a practical lesson should be observed by pupils to help them imitate the activity and they try out on the activity on their own. About 49.0% of the pupils engage in group discussions in weekly basis and individual experiences respectively. On the other hand group discussions were also done on daily basis by 36.9% of the pupils and 14.1% did their in a fortnight while 30.2% of the pupils did individual experiences daily and 20.8% of them did them in as fortnight. This implies that pupils gained hand-on experience when they carried out individual experiences and also when they held group discussions. The results agree with Danahar & Umar, (2010) argues that learners engage in experiment

activities where they manipulate variables.

On the other hand JICA (2007) argues that ASEI emphasis on shift from recipe and demonstration type of experiments to investigative and hands on type of experiments. Pupils involved in well- designed experiments, they learn how to observe, manipulate, measure, reason, and develop skills for gathering information. From the teachers and head teachers questionnaires, majority of the teachers (74.1%) and 66.7% of the head teachers that pupils were involved in individual experiences and group discussions in weekly basis while (25.9%) of the teachers and 33.3% of the head teachers indicated that pupils were involved in individual experiences daily. This implies that teachers gave pupils time for individual experiences in science lessons and they also involved the school management in the same.

All the teachers and head teachers indicated that teachers were observed by pupils while demonstrating on science activities, daily, weekly and also while planning for field trips which took place once a year. This implies that teachers demonstrated in science class activities and this was aided by learning and teaching aids provided by the school.

All the teachers also indicated that they gave pupils projects to carry out at home and bring them to school. This was also observed by the head teachers since they had gone through the schemes of work given and had sometimes supervised teachers as they implemented their lesson plans. All the teachers indicated they encouraged daily peer teaching for pupils to remind others in class what they had

learnt in the previous class.

The result concurs with Mwangi (2014) who said that practical performance can only be emphasized on the process and product for a given project. This is also in line with the findings of the Peer Reviewed Scientifically Based Methods of Instruction (2011). Poor performance of students in science has often been regarded as symptomatic of poor learning approaches (Dewey, 2011).

The ASEI pedagogical shift focus of lesson is on the learner, while the lessons' objectives are geared to improving the learners' academic achievement and quality of learning. Emphasis help learners construct and reconstruct meaning directly from their encounters with the empirical world. Learning activities enable science practical subjects to build a bridge between the realm of objectives and observable properties on one hand and the realm of ideas on the other. Hence this study sought to know from the pupils whether they got homework. The results are as presented in Table 4.7

Table 4.7 Pupils given homework versus current performance in science

Current performance		Marks	Marks	Marks	Marks	Marks	Total
In science		0-26	21-40	41-66	61-86	81-100	
Homework in							
Science							
Yes	n	16	30	38	22	5	111
	%	15.3	23.5	30.6	24.5	6.1	100
No	n	2	12	15	16	9	54
	%	3.9	21.6	27.5	29.4	17.6	100
Total	n	18	42	53	38	14	165
	%	11.4	22.8	29.5	26.2	10.1	100

Majority of the pupils had received some homework (98 [65.8%]) while 51[34.2%]) did not get homework. Among the pupils who got homework,15.3% of them got a score of 0-20 marks while 23.5% of them got 21-40marks, 30.6% of them getting 41-60 marks, 24.5% attained 61-80 marks and6.1 attained 81-100 marks in science this shows that majority of the pupils (62.2%) with homework had attained a mark more than 41-100 marks in science while 48.8% of them had a low mark of 0-40 marks. On the other hand thou there was a high percentage of

pupils who performed better but did not have homework in science at 74.6%. This implies that pupils who were given homework or not did not help them attain good grades but teaching activities used by the teachers in class helped hand though there was a high percentage of pupils who performed better but did not have homework in science at 74.6%. This implies that pupils who were given homework or not did not help them attain good grades but teaching activities used by the teachers in class helped them. The results from pupils concurs with head teacher and teachers that good grades were gotten where pupils had the mastery of the subject. CEMASTE (2011) acknowledges that active pupil's participation in learning is key in quality education and also contributes to better outcome in examinations.

4.4 Improvisation using local learning resources on SMASE principles in teaching of science influence pupils' performance

Improvisation of locally available resources helps science teachers who often do not have access to the resources needed to optimally perform experiments. Innovative teachers can use cheaper products to simulate experiments. Therefore teachers can also help students learn improvisation as an important life skill to help them think critically about the scientific concepts underlying the devices (Ndirangu, 2013). This study sought from the pupils whether teachers had teaching aids when teaching. The results are as shown in Table 4.8

Table 4.8 Pupils' response on science teacher use of teaching aids

Performance in		Excellent	Good	Average	Poor	Total
science						
Yes	n	6	36	56	29	129
	%	4.9	27.9	45.1	22.1	100.0
No	n	0	0	20	16	36
	%	0	0	59.3	40.7	100.0
Total		6	36	76	36	165
		4.0	22.8	47.7	25.5	100.0

Teaching aids with Performance

From Table 4.8 the study clearly shows pupils performance being better for schools that had teaching aids that is 4.9% of the pupils had performed excellently in science while 27.9% of them were good and 45.1% of them were average and only 22.1% of them were poor. On the other hand pupils from schools that did not have teaching for science performed average (59.3%) and poor (40.7%) respectively. This implies that teachings aids had an impact on pupils' performance in science. The results agree with those of the head teachers (83.3%) and teachers (81.5%) who indicated availability of

teachings aids in their schools while 16.7% of the head teachers and 18.5% of the teachers indicated lack of teaching aid. The results from the pupils concurs with Dewey (2011) who observed that teaching resources enhanced retention of cognitive skills to about 80% of what is learnt and they not only enhance communication between teachers and learners but also facilitates child centred learning. The results from teachers concur with those of Nyawamu (2010) established that lack of teaching equipments in most schools discourage teachers from doing their best. The pupils were asked to indicate how often teaching aids were used in class. The results are shown in Table 4.9

Table 4.9 Times teaching aids are used and performance in science times

Performance	Excellent	Good	Average	Poor	Total
Always n	5	25	30	18	78
%	7.0	31.0	38.0	23.9	100.0
Sometimes n	1	10	21	10	42
%	2.6	25.6	51.3	20.5	100.0
Rarely n	0	2	8	2	12
%	0	16.7	66.7	16.7	100.0
Not at all n	0	0	18	13	31
%	0	0	59.3	40.7	100.0
Total Count	8	37	77	43	165
%	4.0	22.8	47.7	25.5	100.0

From table 4.9, it is clear that performance for pupils where teaching aids were used always was high with 7.0% being excellent, 31.0% have a good performance, 38.0% of them have average performance. Pupils from schools where teaching aids were used rarely performance was good and poor for 16.7% respectively and 66.7% were average. For the pupils where the teaching aids were not used at all 59.3% of the pupils performed averagely while 40.7% of them performed poorly.

Teachers from schools where teaching aids were available and always used it and sometimes indicated that the performance was both excellent, good and average for majority of their pupils. This also concurred with head teachers from schools where teaching aids were available and used always and sometimes. This implies that pupils' performance was affected by also the use of teaching aids. Inadequate teaching and learning resources affect effective curriculum implementation leading to poor performance. Mobilizing of resources should be ensured for teachers to effectively implement curriculum implementation curriculum. Since adequate resources boost efficiency in curriculum.

Availability of Science textbooks

Teaching and learning resources are key elements in the effective delivery of the curriculum (CEMASTE, 2013). Lack of these resources leads to teacher centred learning and hence leads to passive learning. Learning resources are critical inputs in the teaching because they assist learner to synthesize what is learnt and thus improve performance. The study sought to know the availability of science textbooks and performance in science. The results are as shown in Table 4.10.

Table 4.10 Availability of science textbooks and performance in science

Availability of science						
textbooks	Performance in science				Total	
	Excellent	Good	Average	Poor		
Yes	n	8	36	55	35	134
	%	6.3	26.8	41.7	25.2	100.0
No	n	0	0	21	10	31
	%	0	0	72.2	27.3	100.0
Total	ns	8	36	76	45	165
	%	5.4	22.8	53.0	25.5	100.0

In Table 4.10, majority of the pupils 85.2% indicated that science textbooks are available and hence had an effect of performance in science and 14.8% of the pupils who indicated that they lacked science textbooks. Gituthu (2014) concurs only 30 percent of teachers in secondary schools improvise resources in experiment while 70 percent rarely do. This denies the students a chance to raise their interest and curiosity. The pupils also indicated that 96.6% of the pupils indicated that they shared a copy of the science textbook while 3.4% of them had a copy of each for the science textbook.

4.5 Plan Do See Improve Approach influence on SMASE principles in teaching of science

PDSI (Planning, Doing (carrying out the planned activity) Seeing (evaluating the outcome of activity) followed by Improvement is a process of checking the progress of an activity against its plan and answering the question of how the activity is being carried out in relation to the intended planned objectives (SMASE, 2013). Through planning entry behaviour which is background knowledge, skill and attitudes are facilitated and incorporated into teaching and process. Planning and using systematic approach to teaching the entry behaviour or prerequisite knowledge and skills which is one of the contributing factors that determine the outcome of good or poor performance. This study sought to find out from the pupils whether they participated in activities during the science lessons. The results are as shown in Table 4.11.

Table 4.11 Pupils response to the time that the following Activities are carried out in Science lesson

Activities	Daily	Weekly	Termly	Total
Participate in lesson preparation	33 (18.1%)	92 (58.4%)	40(23.5%)	165 (100.0%)
Give suggestions during the lesson	60 (36.9%)	79 (49.0%)	26(14.1%)	149 (100.0%)
Report your findings	85 (51.0%)	80 (49.0%)	0	165 (100.0%)
Comment on the lesson delivery	32 (18.1%)	93 (58.4%)	40 (23.5%)	165 (100.0%)
Ask questions on unclear concepts	98 (65.8%)	67 (34.2%)	0	165 (100.0%)
Share your experience with others	50 (30.2%)	79 (49.0%)	36 (20.8%)	165 (100.0%)

Majority of the pupils (65.8%) indicated that they asked questions on unclear concepts daily. This implies that pupils were eager to learn new concepts and understand them. About 58.4% of the pupils also indicated that they gave comments on the lesson delivery and participated in lesson preparation weekly respectively. The others factors that were highly rated on daily basis include report their findings (51.0%) while 49.0% reported on weekly basis. This implies pupils

participated in giving comments on lesson delivery and also gave their reports findings to their teacher daily. The result agrees with Arunga (2007) who noted that during planning teachers should take into consideration the learner's background such as learning difficulties, needs, interests, misconceptions and previous experience in relation to the topic. This is supposed to enable learners to understand the concepts and appreciate what they are learning and apply in their real life

4.6 Teachers' lesson planning influence in implementation of SMASE principles in teaching science

The fourth objective for this study was to establish the influence of teachers' lesson planning influence in implementation of SMASE principles in teaching science in public primary schools in Nyandarua West sub-county.

4.6.1 Teachers' responses on influence of lesson planning

The researcher sought information from teachers on lesson planning, the teacher respondents were required to indicate the level of agreement where necessary. The data is presented in Table 4.12.

Table 4.12 Teachers' responses on lesson planning

Statement	S		A		D		U		SD	
	F	%	F	%	F	%	F	%	F	%
Teachers' consideration of	4	22.2	7	38.9	1	5.6	6	33.3	0	0.0
Pupils' background										
Preparation of ASEI/PDSI	1	5.6	3	16.7	8	44.4	2	2.2	2	11.1
Lesson plan										
Use pupils' suggestion	0	0.0	5	27.8	6	33.3	7	38.9	0	0.0
For teaching										
Consider pupils' feedback	3	16.7	6	33.3	4	22.2	21	11.1	31	6.7
Before lesson										
Do you allow pupils to	0	0.0	3	16.7	1	5.6	12	66.6	2	11.1
Evaluate the lesson										

Table 4.12 shows majority at 61.1 percent of teachers agreed with the statement that teachers consider learners background before planning science lesson while 33.3 percent of teachers were undecided.

On the preparation of ASEI/PDSI lesson plan, the study found out that 44.4 percent of teachers disagreed while 22.2 percent of teachers were undecided however, only 22.3 percent of teachers agreed to prepare ASEI/PDSI lesson plan as advocated by SMASE INSET.

According to Arunga (2007), teachers are encouraged to rethink the usefulness of the lesson plans as critical tool for lesson delivery. This implies that very few science teachers in public primary schools in Nyandarua West Sub County prepare ASEI/PDSI lesson plan as required by SMASE training. Preparation of ASEI/PDSI lesson plan is in agreement with CEMASTEА, (2010) that emphasizes instructional activities.

Pertaining teachers' use of pupils suggestions for teaching science, the study revealed that 33.3 percent disagreed while 38.9 percent of teachers were undecided but only 27.8 percent agreed to use pupils' suggestions in teaching science. This means that majority of teachers in Nyandarua West Sub County had not embraced the aspect of learners involvement in the learning process. Teachers' consideration of pupils' feedback to improve on the lesson, the findings indicated that 50 percent of teachers agreed while 22.2 percent disagreed. Teachers make use of feedback to modify the lesson as it progresses in order to eliminate misconceptions as well as improve subsequent instruction (CEMASTEА, 2012). This indicates that PDSI approach has not been fully implemented.

On allowing pupils to evaluate teachers' lesson, the study revealed that majority at 66.7 percent of teachers were undecided. This is not in agreement according to Mwigwi (2012) who notes that teachers evaluate the teaching and learning process by reflecting on performance and effectiveness in achieving the lesson objective.

4.6.2 Head teachers' responses on ASEI/PDSI lesson planning

The researcher sought information from the head teachers to confirm teachers' lesson planning. **Key; Yes** (agreed to teachers' planning) and **No** (disagreed)The data is presented in Table 4.13.

Table 4.13 Head teachers' Responses on The Teachers' Use of ASEI/PDSI Lesson Planning

Item	Yes		No	
	F	%	F	%
Science teachers' preparation of ASEI/PDSI Lesson plan	5	29.4	8	70.6
Teachers' consideration of learner Background before lesson planning	3	17.6	10	82.4
ASEI/PDSI activities delay syllabus Coverage	5	29.4	8	70.6
PDSI activities help teachers In teaching science	8	70.6	5	29.4

Science teachers' preparation of ASEI/PDSI lesson plan; Teachers' consideration of learner background before lesson planning The findings on Table 4.13 shows that the majority at 70.6 percent of head teachers stated that science teachers do not prepare ASEI/PDSI lesson plan while 29.4 percent of head teachers indicated they did. On Learners' background before planning science lesson, majority at 82.4 percent of head teachers indicated they did not plan considering learners background while 17.6 percent stated they did. This contradicts 39 percent of teachers who agreed with the statement that they consider learners' background before planning the lesson.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter provides a summary of the study, summary research findings, conclusions and recommendations as well as suggestions for further research.

5.2 Summary of the study

The purpose of the study was to investigate school factors influencing implementation of strengthening mathematics and Science Education principles in teaching science in Nyandarua West sub-county. The study aimed to achieve this by assessing learner-centred teaching methodologies, PDSI approach Teachers' use of improvised teaching and learning resources as well as teachers' lesson planning. ASEI-PDSI strategies influence pupils' science performance in KCPE. It was based on constructive theory by Bruner in 1966. The study adopted a descriptive survey design and targeted 43 public primary schools with 43 head teachers, 60 science teachers and 1720 class eight pupils. Simple random sampling technique was used to sample 30% of teachers and 10% of pupils in all public primary schools. Therefore the study sample comprised of 13 head teachers, 18 teachers and 172 standard eight pupils. Data were collected by the use of questionnaires. Collected data were analysed both qualitatively and quantitatively and presented in frequencies and percentages in form of tables and figures. All the questionnaires from 13 head teachers, 18

teachers and 165 pupils questionnaires were returned, realizing an instrument return rate of 98.4%, which was very satisfactory for the purpose of the study.

The findings of the study on Learners' centred teaching methodologies influence of SMASE principles in teaching science is that all the pupils indicated that they attended field trips once a year. This implies during field trips pupils are able to learn different lessons that could be offered in science according to the sites visited. Majority (65.8%) of the pupils noted that they did peer-training daily in their class. About 58.4% of the pupils noted that they were involved in project work in their class weekly. From the teachers and head teacher questionnaires 74.1% of the teachers and 66.7% headteachers said that group discussion and individual experiences in science lessons were carried out on weekly basis. Performance of pupils was also tested against their homework, 65.8% indicating that they had homework and 62.2% of the pupils attained between 40-100 marks in their current science exam.

The findings on the study on Plan Do See Improve approach of SMASE principles in teaching of science influence the performance of science. Majority of the pupils (65.8%) indicated that they asked questions on unclear concepts daily. About 58.4% of the pupils also indicated that they gave comments on the lesson delivery and participated in lesson preparation weekly respectively. About 96.3% of the teachers agreed that there was need for immediate follow up of assignment enhance academic performance while 92.5% of the teachers agreed that evaluation is very necessary for effective

teaching and learning and 85.2% indicated that it is not possible to have activities in every lesson. ASEI lesson plan was difficult to prepare as prescribed during the SMASSE in-service training.

The findings of the study on Improvisation using local learning resources influence of SMASE principles in teaching science. 59.3% of the pupils indicated they had an average performance with the availability of learning resources on SMASE. Head teachers (83.3%) and teachers (81.5%) indicated availability of teachings aids in their schools. When teaching aids are used always the performance of pupils was average performance. On the availability of science textbooks majority of the pupils 85.2% indicated that science textbooks are available and hence had an effect of performance in science.

The main findings of the study on influence of teachers' lesson planning on learners' science performance found out that majority of teachers at 60.1 percent considered learners background before planning science lesson. Learners' needs, previous experiences in relation to the topic and learning difficulties are considered (CEMASTE, 2010). From the study findings, majority of science teachers at 72.2 percent do not use pupils' suggestions for teaching science, this is important because the teacher integrates good practices and feedback in subsequent lessons. Whether teachers consider pupils feedback to improve on science lesson, the findings revealed that half of the teachers considered. In this case, teachers make use of feedback to modify the lesson as it progresses in order to eliminate misconceptions as well as improve

subsequent instruction (CEMASTE, 2012). Majority of teachers in the study at 88.8 percent do not allow pupils to evaluate their lesson. The main findings of the study on teachers' use of learner centred approaches. Learner-centred approaches through Activity, Student Experiment and Improvisation pedagogic paradigm and Plan Do See and Improve are the focus of SMASE INSET. The study findings revealed that majority of science teachers at 83.3 percent use teacher demonstration, while using learner-centred approaches, learners are exposed to hands on activities thus, gain first-hand experience and will know how to use all their senses. Most of the teachers under the study at 94.4 percent used guided group discussions. This variable has influence on the pupils' performance in science subject. According to SMASE (2004) group discussions provide students with opportunities to express opinions and explain ideas based on their prior experiences. The study revealed that 94.4 percent of teachers use activity based teaching. The use of activity based teaching influence pupils' performance in science. This is in agreement with SMASE (2002) the learners are involved through hands-on, minds-on, eye-on and mouth-on activities and develop their knowledge.

5.3 Conclusions

From the study findings, the researcher concluded the following based on research objectives:

The plan do see improve approach on SMASE influences pupils performance as indicated by pupils asking questions on unclear concepts daily. Pupils also

participated in lesson delivery and participated in lesson preparation weekly. The teachers and the Head teacher's also indicated that pupils were helped to understand concepts that were not clearly understood during the lesson. This would enable the pupils to perform better in their KCPE.

From the findings of the study, it can be concluded that ASEI/PDSI approach has not been fully embraced by science teachers as expected by SMASE INSET. This is because those trained by SMASE have failed to embrace hands on activities but instead reverted back to teacher centred methods of teaching such as lecture methods and teacher demonstration in the classroom. PDSI strategy is not fully implemented after SMASE training due to lack of adequate planning of science lessons by teachers. Failure of majority science teachers to prepare and use lesson plan during science lessons is a major set back in the implementation of learner centred strategies and this influences performance of learners at national examinations.

The study findings reviewed that not all science teachers have fully implemented improvisation using local learning resources expected after SMASE In-service. Through SMASE training, majority of teachers have learnt to integrate various teaching aids in their lessons and involve learners in preparation of the teaching aids. This is reviewed from the learners' responses where majority at 18.3% scored above average. This has influenced science performance in public primary schools.

Failure of majority of science teachers to prepare and use lesson plans during science lessons is a major setback in the implementation of learner centred strategy and this influences performance of learners at national examinations.

5.4 Recommendations

Based on the findings and conclusions of the study the following recommendations were made:

- i. There is need more field trips to scientific sites to enable pupils get first-hand information. This should also be done through group discussion after the trips and individual experiences that would enable pupils to experiment their learning that have been done in class. This is to be done by the Head teachers and science teachers.
- ii. There is need for the school without teaching and learning aids, science textbooks to avail them to enable pupils to get information which they have not learnt from other areas in school. This would enable them to complete their homework. This is to be done by the Head teachers.
- iii. There is need for teachers to employ PDSI to enable pupils understand concepts that they did not understand during lesson time to enable them understand it better when asking questions.
- iv. Teachers should implement what they have learnt in SMASE INSETS so as to ensure that pupils understand the concepts of the lesson well.
- v. The government through the Ministry of Education and other stakeholders should finance adequately public primary schools and

introduce a policy that all public primary schools should build school laboratory and equip them. This will encourage teachers to carry out experiments and improvise teaching and learning resources. Failure of most teachers to implement PDSI strategy implies that they did not own SMASE in-service.

- vi. There is need to involve teachers at all levels of planning this is because from research findings, it indicated majority of teachers do not prepare lesson plans. Therefore the ministry of education in conjunction with CEMASTE and Kenya Institute of curriculum development provide prepared ASEI/PDSI lesson plans to all the topics in science so that teachers can have uniform information to refer to during teaching. In order to motivate science teachers SMASE certificates should be awarded and recognized by the Teachers Service Commission for promotion/ upgrading. Public primary school administrators should encourage their teachers to enhance professional development through in-service programmes particularly SMASE related courses.

5.5 Suggestions for further research

There is need for further research to be conducted in the following areas:

- (i) An in-depth study to assess the influence of learner-centred strategies on science teaching in the entire Nyandarua County. This is vital because there are historical, geographical, institutional and other differences the sub counties.

(ii) Further research should be done to identify institutional factors that hinder implementation of learner-centred strategies.

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**APPENDICES
APPENDIX I:**

LETTER OF INTRODUCTION

**SYLVIAH W MBUGUA
UNIVERSITY OF
NAIROBI CEES
P.O. BOX 92
KIKUYU.**

To the head teacher,

Dear Sir/Madam

REF: PARTICIPATION IN RESEARCH

I am a post graduate student in the University of Nairobi, pursuing a masters degree in curriculum studies. I am carrying out research on school factors influencing implementation of strengthening of Mathematics and Science Education principles in Science teaching in public Primary Schools in Nyandarua West Sub-County Kenya. Your school has been chosen to participate in the research. You are requested to respond to the questionnaires items as honestly as possible and to the best of your knowledge. This research is purely for academic purposes.

Thank you.

Yours faithfully,

SYLVIAH WAWIRA MBUGUA

APPENDIX II

QUESTIONNAIRE FOR HEAD TEACHERS

You are kindly requested to fill this questionnaire indicating your honest response by putting a tick against your response or filling blanks next to the items as indicated. Please do not write your name or name of your school anywhere in this questionnaire.

Section A: Background information

1. What is your gender-----Male () Female ()
2. What is your highest professional qualification?----- Med() BEd ()
Diploma () P1 () Others, specify-----
3. For how long have you served as a head teacher of this school?-----
4. Have you attended teacher training in SMASE? Yes () No ()

Section B: Learner Centred teaching methodologies

How often do pupils perform the following activities in science

	Daily	Weekly	Fortnight	Termly	Yearly
Individual experiment					
Group discussion					
Observe demonstrations By the teacher					
Go for field trips					
Do project work					
Do peer teaching					

5. (a) Do science teachers give homework? Yes () No ()

(b) If yes, is the homework marked? Yes () No ()

6. (a) Do science teachers use teaching aids when teaching? Yes () No ()

(b) If yes, how often? Always () sometimes () rarely ()

7.(a) Does the school provide pupils with science textbooks? Yes ()

No ()

(b) If yes, do pupils get a copy each or you share? A copy each () share ()

8. How often do pupils carryout experiments in science lessons? Very often ()
 often () rarely () not at all ()

(a) Does the head teachers collect and check pupils' science notebooks?
 Yes () No ()

(b) If yes how often? Once in a month () once in a term ()
 once in a year ()

Section C: PDSI approach and pupils science performance

Consider the following statement and tick to indicate level of agreement where necessary.

Statement	S	A	A	D	U	S	D
The PDSI approach helps teachers to focus on learning objectives							
PDSI approach helps students to understand difficult concepts							
PDSI activities delay syllabus coverage							
PDSI approach has been fully Implemented in science teaching							
PDSI approach strategies are fully Implemented after SMASE training							

Section D: Improvisation of teaching and learning resources and principles in teaching of science

9. Does your school provide teaching resources like models and reference materials to science teachers? Yes () No ()

10. Do science teachers involve pupils in the improvisation of teaching and learning materials in classroom? Yes () No ()

11. Are there more teaching and learning aids in the classroom ? Yes ()
No ()

Section E: Teacher lesson planning and Principles in teaching of science

Consider the following statement and tick to indicate level of agreement where necessary.

Statement	S	A	A	D	U	SD
Consider learners' background before Planning science lesson						
Prepare ASEI/PDSI lesson plan						
Use pupils' suggestion for teaching science						
Consider pupils' feedback to improve On your science lesson						
Do you allow pupils to evaluate your lessons						

Thank you for your cooperation

APPENDIX III

QUESTIONNAIRE FOR SCIENCE TEACHERS

Please answer the following questions in this questionnaire as honestly as possible. Your responses will be treated confidentially. Your assistance is highly appreciated in advance. Please do not write your name or name of your school in the questionnaire. Please put a tick in the appropriate bracket or fill in the information in the blank spaces provided

Section A: Background information

1. What is your gender-----Male () Female ()
2. What is your highest professional qualification?----- Med() BEd ()
Diploma () P1 () Others, specify-----
3. For how long have you served as a head teacher of this school?-----
4. Have you attended teacher training in SMASE? Yes () No ()

SECTION B: Learner centred teaching methodology

How often do you perform the following activities in science?

	Daily	Weekly	Fortnight	Termly	Yearly
Individual experiment					
Group discussion					
Observe teacher's demonstration					
Go for field trips					
Do project work					
Do peer teaching					

5.(a) Do you as science teacher give homework? Yes () No ()

(b) If yes, is the homework marked? Yes () No ()

6. (a) Do science teacher use teaching aids when teaching?

Yes () No ()

(b) If yes, how often?

Always () sometimes () rarely ()

7(a) Does the school provide pupils with science textbooks?

Yes () No ()

(b) If yes, do pupils get a copy each or you share?

A copy each () share ()

8. How often do pupils carryout experiments in science lessons?

Very often () often () rarely () not at all ()

9 (a) Does the head teachers collect and check pupils' science notebooks?

Yes () No ()

(b) If yes how often?

Once in a month () once in a term () once in a year ()

Please consider the following statement and tick (√) to indicate the extent of agreement.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
An ASEI lesson plan is difficult to prepare						
A lot of time is required to prepare comprehensive lesson notes						
My students rarely give correct answers						
It is not possible to have an activity in every lesson						
Evaluation is very necessary for effective teaching and learning						
Immediate follow up of assignment enhance academic performance						

Section C: Plan do see improve approach

Please consider the statement written and then tick () to indicate the level of agreement.

	SA	A	U	D	SD
ASEI/PDSI lesson plan is difficult to prepare					
Evaluation is very necessary for effective teaching					
Do ASEI/PDSI activities help students understand difficult concepts					
Does ASEI/PDSI activities delay syllabus coverage					

10. Which of the following statements describe your opinion about SMASE-INSET? (Tick as appropriate)

- a). SMASE-INSET has improved the teaching and learning of science.
 True() False ()
- b).. SMASE-INSET has made no difference in the performance of science subject? True() False ()
- c). SMASE –INSET is a waste of time and resources. True () False ()

Section D: Improvisation of teaching and learning resources and pupils science performance

To what extent do you agree or disagree with each of the following statements on teaching and learning resources. **KEY:** SA (Strongly Agree), A(Agree), U (Undecided), D(Disagree), SD(Strongly Disagree)

Statement	S A	A	U	D	SD
Do you improvise teaching Material during science lesson					
Use of teaching and learning aids Promotes teaching and learning of science					
Do you engage the pupils in making Some of teaching and learning material					
Does the school administration support In provision of teaching and learning material					
Teaching and learning resources are Readily available in your school					

Section E: Teacher’s lesson planning and pupils’ science performance

Consider the following statement and tick to indicate the level of agreement where necessary.

Statement	S	A	D	U	SD
ASEI/PDSI lesson is difficult to prepare					
It is not possible to have an activity in every lesson					
Evaluation is very necessary for effective teaching					
Do ASE/PDSI activities help students Understand difficult concepts?					
Do ASEI/PDSI activities delay syllabus coverage?					

Thank you for your cooperation

APPENDIX IV

QUESTIONNAIRE FOR PUPILS

Please answer all the questions by ticking () against your answer after carefully reading through them. Do not write your name or the name of your school.

SECTION A: Background information

1. What is your gender? Boy () Girl ()
2. How old are you?
3. How many pupils are in your class?.....
4. How many marks did you score last term?

100-150 () 151-200 () 201-250 ()

251-300 () 301-350 () 351-400 ()

401-450 () 451-500 ()
5. What is your current performance in Science?

0-20Marks () 21-40 Marks () 41-60 Marks ()

61-80 Marks () 81-100 Marks ()

SECTION B

How often do you perform the following activities in science?

	Daily	Weekly	Fortnight	Termly	Yearly
Individual experiment					
Group discussion					
Observe teacher's demonstration					
Go for field trips					
Do project work					
Do peer teaching					

6 .(a) Does your science teacher give you homework? Yes () No []

(b) If yes, is the homework marked? Yes () No ()

7. (a) Does your science teacher use teaching aids when teaching? Yes [] No []

(b) If yes, how often? Always () sometimes () rarely ()

(a) Does the school provide you with science textbooks? Yes () No ()

(b) If yes, do you get a copy each or you share? A copy each () share ()

8. How often do you carry out experiments in science lessons?

Very often () often () rarely () not at all ()

9.a) Does the head teachers collect and check pupils' science notebooks?

Yes () No ()

(b) If yes how often?

Once in a month () once in a term () once in a year ()

10. Do you enjoy science lessons? Very much () not very much ()

not sure () not at all ()

Thank you for your cooperation

APPENDIX V

RESEARCH AUTHORIZATION



**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

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/16/28567/12064**

Date:
11th July, 2016

Sylviah Wawira Mbugua
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "*School factors influencing implementation of strengthening Mathematics and Science education principles in teaching science in public primary schools in Nyandarua West Sub County Kenya,*" I am pleased to inform you that you have been authorized to undertake research in **Nyandarua County** for the period ending **11th July, 2017.**

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

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.


BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nyandarua County.


The County Director of Education
Nyandarua County.

APPENDIX VI

RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MS. SYLVIAH WAWIRA MBUGUA
of UNIVERSITY OF NAIROBI, 0-20300
Nyahururu, has been permitted to
conduct research in Nyandarua County
on the topic: SCHOOL FACTORS
INFLUENCING IMPLEMENTATION OF
STRENGTHENING MATHEMATICS AND
SCIENCE EDUCATION PRINCIPLES IN
TEACHING SCIENCE IN PUBLIC PRIMARY
SCHOOLS IN NYANDARUA WEST SUB
COUNTY KENYA
for the period ending:
11th July, 2017

Permit No. : NACOSTI/P/16/28567/12064
Date Of Issue : 11th July, 2016
Fee Received :Ksh 1000




Sylviah Wawira Mbugua
Applicant's Signature


[Signature]
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

- 1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.**
- 2. Government Officers will not be interviewed without prior appointment.**
- 3. No questionnaire will be used unless it has been approved.**
- 4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.**
- 5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.**
- 6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice**



REPUBLIC OF KENYA
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION



National Commission for Science, Technology and Innovation
RESEARCH CLEARANCE PERMIT
Serial No. A 10091
CONDITIONS: see back page