

**EFFECTIVENESS OF TEACHING PREPARATIONS ON STUDENTS'
ACHIEVEMENT, ATTITUDE, MOTIVATION AND CLASSROOM
INTERACTIONS IN MATHEMATICS IN PUBLIC SECONDARY SCHOOLS,
MAKUENI DISTRICT, KENYA**

BY

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DECLARATION BY THE CANDIDATE

This thesis titled “Effectiveness of teaching preparations on students’ achievement, attitude, motivation and classroom interactions in mathematics in public secondary schools, Makueni district, Kenya” is my original work and has not been presented by anybody else in any university or for any other award.

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DEDICATION

This thesis is dedicated to my wife Brigid Nzanza, and sons Gift and Crispus for their unwavering support and patience during my period of study.

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ABSTRACT

As more and more Kenyans attach great value to education, there is need to look at use of instructional products on academic performance of students. Enough evidence abounds to show that students have problems in understanding concepts and skills, which are not systematically presented in mathematics. This study was designed to investigate the instructional potential of instructional plans in the teaching and learning of vectors in mathematics.

The study adopted the Solomon Four-group quasi-experimental design, which compared performance of control (C) and experimental (E) groups drawn from district public secondary schools in Makueni district. Three instruments were used to collect data from 163 Form two students. These were: Mathematics Achievement Test (MAT), Students' Attitude Questionnaire (SAQ), and Mathematics Lesson Observation Checklist (MLOC).

The study generated both qualitative and quantitative data that was analyzed both descriptively and inferentially. Raw data was summarized descriptively by use of frequencies, percentages, means and standard deviations while inferential statistics i.e. one-way ANOVA and independent samples t-test were used to test the statistical significance at 0.05 level of significance.

The findings indicate that the use of Instructional Plans in teaching and learning of vectors resulted in significant learning gains, improved students' attitude, motivation and classroom interactions. Thus the use of Instructional Plans enhanced the teaching and learning of vectors mathematics.

The study recommends use of the instructional plans for improved students' achievement in mathematics and integration of the same in professional development programs. The study suggests that further research be conducted on teacher characteristics vis-à-vis students' achievement in mathematics.

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ABBREVIATIONS AND ACRONYMS USED

ANOVA – Analysis of Variance

CI – Classroom Interactions

ICT – Information Communication Technology

KCSE – Kenya Certificate of Secondary Education

KIE – Kenya Institute of Education

KNEC – Kenya National Examinations Council

MAT – Mathematics Achievement Test

MLOC – Mathematics Lesson Observation Checklist

M.O.E – Ministry of Education

NCTM – National Council for Teachers of Mathematics

QASO – Quality Assurance and Standards Officers

SAQ- Students' Attitude Questionnaire

SMASSE – Strengthening of Mathematics and Sciences in Secondary Education

CHAPTER ONE

INTRODUCTION

1. 1 Background of the Problem

Mathematics is one of the key subjects offered by all education systems of the world. In Kenya it is a compulsory subject at the secondary school level (MoE., 2004; TIQET, 1999). This is because it plays a pivotal role in providing a means to the study of other disciplines like Physics, Chemistry and Geography among others. Economists require it in calculation of Gross Domestic Product (GDP) and Gross National Product (GNP). The government and business community apply mathematics daily in their transactions. For example, the calculations of government income and expenditure, per capita income, profit and loss all need mathematical input. The British Cockcroft Report (1982) summarized the usefulness of mathematics by noting that it would be very difficult for one to live a normal life in the society without use of the mathematics. While most people recognize the essential role it plays in everyday life, mathematics is a subject that appears to be little understood by many secondary school students.

The Kenya National Examination Council (KNEC), is the body responsible for the administration of secondary school examinations in Kenya. At the end of four years cycle of secondary education, KNEC measures performance in the various disciplines of the curriculum by administering the Kenya National Certificate of Secondary Education, KCSE. It awards grades on a 12-grid scale ranging from A to E. A candidate who scores a grade above D+ is considered to have passed in that subject while attainment of grade D and below is considered to have failed.

In its annual reports, KNEC has reported that between the years 2000 and 2004, there were more than 70% fails posted each year in mathematics as can be seen from Table 1.1.

Table 1.1: National KCSE Mathematics Analysis by Gender in the years 2000-2004

Year	2000		2001		2002		2003		2004	
	A-D+	D-E								
Male%	15.46	38.34	17.00	36.81	18.16	25.31	18.45	35.24	18.20	35.63
Female%	7.79	34.38	9.83	36.79	10.07	36.45	9.95	36.34	9.94	36.60
Total	23.25	76.72	26.83	73.60	28.23	71.76	28.40	71.58	28.14	72.23

Source: *KNEC reports, 2000-2004.*

The performance shown in Table 1.1 is a pointer that performance in this subject is still far below expectations. This is because between the years 2000 and 2004, more than 71% of the students scored grades between E and D.

Moreover, the national mean score between the years 2002 and 2005 has progressively declined from 39.39% to 31.91% as can be seen in Table 1.2.

Table 1.2: Candidates' overall performance in Mathematics for the years 2002-2005

Year	Candidates	Maximum mark	Mean score	Std. deviation
2002	197,118	200	39.39	37.95
2003	205,232	200	38.62	36.19
2004	221,295	200	37.20	35.85
2005	259,280	200	31.91	31.00

Source: K.N.E.C. Report, 2006

The students' performance in national examinations as shown in table 1.2 suggests that the candidates who sat the examinations during these years had mastered less than 39% of the prescribed syllabus.

The performance trends in Makueni district depict a similar trend. Between the years 2003 and 2006, the mean score has oscillated between 17.21% and 16.24 % as can be seen in Table 1.3.

Table 1.3: Candidates' overall Performance in Mathematics in Makueni district for the years 2003-2006

Year	2003	2004	2005	2006
Mean score %	17.12	16.48	16.56	16.24

This trend is an indicator that something is wrong as far as performance in mathematics is concerned in this district. This requires investigation because it is far

below a quarter of the total marks and hence the graduates are ill-equipped to face the grilling in the society to which mathematics knowledge is required.

An analysis of the KCSE mathematics papers reveal that questions on vectors are tested every year. The scores in questions in this topic are always low and those candidates who answer these questions are unable to conceptualize how to approach them (KNEC, 2006). It is imperative that students perform well in this area since vectors form a basis for study of other topics like navigation, latitudes and longitudes and matrices among others (KNEC, 2006). The report further advises that teachers need to prepare adequately before they subject learners to the concepts and skills in the teaching-learning process. This is in line with Dean (1982) suggestion that teachers have difficulty in explaining mathematical ideas and concepts not because they do not know, but because they fail to prepare adequately.

Consequently, in order for the teacher to communicate with the learner well, there is need to have clear objectives which indicate what the children are going to learn (O'Hara, 2004). In addition, the objectives enable the teacher to remain focused during the teaching (Sotto, 1999). There is also need to select useful learning tasks that will draw attention to what the learners will be doing. The tasks should allow learners to work on them individually, in pairs, or in small collaborative groups (Pollard and Filer, 2000). Students' perception of mathematics and the environment in which the content is learnt might be negatively affected by the teachers' approach in presenting the subject matter (Costello, 1991). In good teaching, teachers need to be clear, illustrate frequently and be systematic so as to make the knowledge easy to

learn (Costello, 1991). This enables the learner to tackle that which they need to learn in a simple and elaborate way.

In the USA, the National Council for Teachers of Mathematics (NCTM, 2000) observed that students learn mathematics mainly through experiences their teachers provide. Simpson (2001) noted that many learners in science and mathematics do not read textbooks. They come to class expecting to be given information by the teacher. Therefore the teaching that learners are exposed to shapes their understanding of mathematics and their attitudes towards the same. In such cases, mathematics teachers' quality of planning is an important input in the teaching and learning of mathematics.

Debate on quality of education concentrates on a smaller number of issues, the most frequent being students' level of performance (NCTM, 2000). However, this notion of quality in performance cannot be limited to the students alone. It should take into account the quality of teachers as well as the teaching – learning processes that contribute to the realization of these results. Too (2004) and Ausubel (1978) concur to observe that students learn by connecting new ideas to prior knowledge and so it is essential that teachers establish what students already know. Too (2004) further notes that the teachers should know how to plan their lessons and design experiences that are worthwhile for learning of mathematics. These experiences should identify what learning interactions would take place. Tum (1996) equally notes that performance in an examination is a reflection of the quality of teaching that students are exposed to and the attitudes held towards the subject.

Studies have been conducted to determine possible causes of the low achievement in mathematics. Eshiwani (1983), Kiragu (2002), and Too (2004) found that both at primary and secondary school levels, availability of instructional resources had a positive relationship to performance. Waithira (2008) found that monitoring of teachers' instructional process by inspectors tends to improve instruction and raise achievement. The aforementioned studies do not concentrate on lesson preparation as a central undertaking in the learning of mathematics. Simpson (2001) observes that teachers have deep knowledge about curriculum goals, challenges students encounter, effective presentation of ideas and assessment of students' understanding.

The poor performance being witnessed may be an indicator that educational training institutions are not adequately equipping teachers with sufficient pedagogical skills and content to handle students' problems in mathematics (Nyambura, 2004). It could also mean that teachers do not fully practice their professional skills such as making adequate preparations in readiness to attending their lessons. Since secondary school teachers have apt content qualifications, the attention should be focused on practice of pedagogical skills. Research is therefore needed to find out the extent to which teachers' use of instructional plans impacts on students' achievement, attitude and motivation and classroom interactions at secondary school level.

1.2 Statement of the Problem

Programs in education produce qualified teachers of mathematics for secondary schools. However, the general performance in mathematics among secondary school students has been poor for many years (KNEC, 2006). This has the amplifying effect that Kenya may not achieve her goal of industrialization as envisaged in the vision

2030 for which mathematical knowledge is necessary. This has raised concern on quality of teachers and their input in the teaching/ learning process.

Since teachers have been professionally trained to handle students' learning problems, whenever there is unsatisfactory performance, they are the immediate persons to be criticized. The teacher needs to make instructional judgments, respond to learning questions and manage the learning environment. Lesson preparations enable the identification of lesson objectives to be achieved and organization of learning tasks to be undertaken. Besides, it allows for identification of the evaluation procedures to be applied during and after the lesson. It is the responsibility of the teacher to create an environment where mathematical thinking is encouraged and the aforementioned is achieved.

With the persistent low performance in mathematics earlier mentioned, the teachers' input into teaching of mathematics becomes suspect. Even schools with experienced and long-serving teachers also show low performance trends. This raises doubts on quality of teachers' contributions to the learning process, which should be reflected in instructional planning. No specific and precise guide to instruction has been used to facilitate students' understanding of mathematical concepts and skills in vectors. This study therefore investigated the effects of prior instructional planning on secondary school students' engagement and understanding of vectors.

1.3 Purpose of the Study

The purpose of this study was to establish the effectiveness of teachers' use of Instructional Plans on Form two students' achievement in mathematics. It also

sought to establish the effects the plans have on attitude and motivation towards mathematics, as well as classroom interactions during mathematics lessons.

1.4 Objectives of the Study

The following specific objectives guided the study.

- 1) To investigate the effect of Instructional Plans on students' achievement in vectors.
- 2) To investigate the effect of teachers' use of Instructional Plans on students' attitude and motivation towards mathematics.
- 3) To investigate the effect of Instructional Plans on students' classroom interactions during mathematics instruction.

1.5 Hypotheses of the Study

The following null hypotheses were statistically tested:

- Ho₁: Teachers' use of Instructional Plans has no significant effect on students' achievement in mathematics.
- Ho₂: There is no significant difference in attitude and motivation towards mathematics between students taught by teachers using Instructional Plans in their lessons and those taught by teachers not using Instructional Plans.
- Ho₃: The use of Instructional Plans has no significant effect on classroom interactions during mathematics instruction.

1.6 Significance of the Study

The findings of this study will be important to the following:

- (a) Mathematics teachers: The findings shall provide a framework for addressing students' understanding of mathematical concepts and skills through appropriate instructional strategies. It is hoped that the Instructional Plans could become an integral part of mathematics instruction in vectors. Finally, the findings will enable the teachers to view the difficulties students have as important. Through planning, the teachers would be able to identify strategies that would enable them to achieve the desired change in the students.
- (b) School administrators: The findings shall provide the school administrators with empirical data on teachers' level of instructional planning, especially in vectors, a topic in mathematics. The study will provide suggestions to them on how to uplift their role in quality audit leading to better performance in mathematics.
- (c) Quality Assurance and Standards Officers (QASO)-The findings shall provide the QASO with empirical data on contribution of instructional plans on students' achievement in mathematics. This will enable them to consider instructional planning as one of the priority areas in professional development programs. This will further ensure that teachers are sensitized on the need to prepare their lessons adequately so as to improve the students' performance in mathematics at the secondary school level.
- (d) The findings shall also provide an insight into preparation of instructional plans that reflect the direction of main interactions in class during mathematics lessons. This will introduce a new dimension in preparation of lesson plans.

1.7 Assumptions of the Study

This study was carried out under the following assumptions:

- (a) That the students had not been exposed to the topic of vectors.
- (b) That the students had been randomly assigned to classes during admission to form one.
- (c) That all the students are capable of learning vectors.

1.8 Scope of the Study

- (a) The study focused on the category of public district secondary schools. This is because there are more district secondary schools as compared to provincial and private secondary schools.
- (b) Form two students were chosen because the topic of vectors is taught at this level (K.I.E., 2002).
- (c) The topic vector was chosen because students' performance in this area is relatively poor in KCSE examinations and so the topic is rated as among the problematic ones in mathematics (KNEC, 2006). The topic has concepts that appear abstract which students seem to have inadequate understanding. These include: magnitude, translation, column vectors, and position vectors.

1.9 Limitations of the Study

Several limitations should be considered when interpreting the results of this study.

- (i) The implementation of this study was limited to the time made available by the school administration. Due to this reason, it would be inappropriate to compare the results of this study with those that had sufficient time.

(ii) The Instructional Plans used in this study were limited only to the topic of vectors in Form 2, as outlined in the KIE syllabus. The generalizability of the findings therefore is limited to mathematics concepts taught in this topic.

1.10 Theoretical Framework

This study subscribed to Bruner's (1966) theory of instruction. In this theory, Bruner points out that a theory of instruction is a prescription of rules for achieving knowledge or skills, and providing techniques for measuring or evaluating outcomes. He argues that a theory of instruction is concerned with what one wishes to teach can best be learnt. He specifies four salient features that the theory must embrace. These include: predisposition to learn, a grasp of knowledge structure, hierarchy and sequencing of subject content, and ability to reward and reinforce learning efforts. The teacher needs to be adept at all these four constituents of learning. To Bruner (1966), with sufficient understanding of the structure of a field of knowledge, more advanced concepts can be taught appropriately at much earlier ages. Thus, to Bruner, effective learning is achieved by planning and structuring learning experiences that arouse the curiosity of the learner. The theory further emphasizes that the experiences provided should recognize the different levels of thinking of learners. Bruner says that it is the responsibility of the teacher to identify the concepts that form the basic structure of the subject.

This theory was chosen because it provides knowledge on how teachers can develop cognitive abilities of learners by preparation of instructional products and processes. The theory further guides the teacher in structuring and sequencing of learning

activities. Preparation before class instruction includes content familiarization, lesson plan preparation and sourcing of instructional resources.

The mathematics curriculum is organized hierarchically and spirally (Eshiwani, 1993; KNEC, 2006). The teacher should therefore use this to make lesson preparations that will identify the pre-requisite concepts and those that will come later. This makes the learners to have better understanding of the concepts by integrating them into existing knowledge base.

With sufficient knowledge of content structure, the teacher can therefore develop a lesson where the concepts are arranged hierarchically. This will further enable the students to understand the concepts and so improve their achievement, attitude and motivation. Sequencing of the learning tasks will again promote classroom interactions. Since learning of mathematics is an ongoing process of building on the previous, the sequencing should be well-planned to create room for students to be rewarded and feel motivated. This will further result in more classroom interactions of the students with resources, teachers and amongst themselves. These variables explained can be represented in a conceptual form as shown in Figure 1.1.

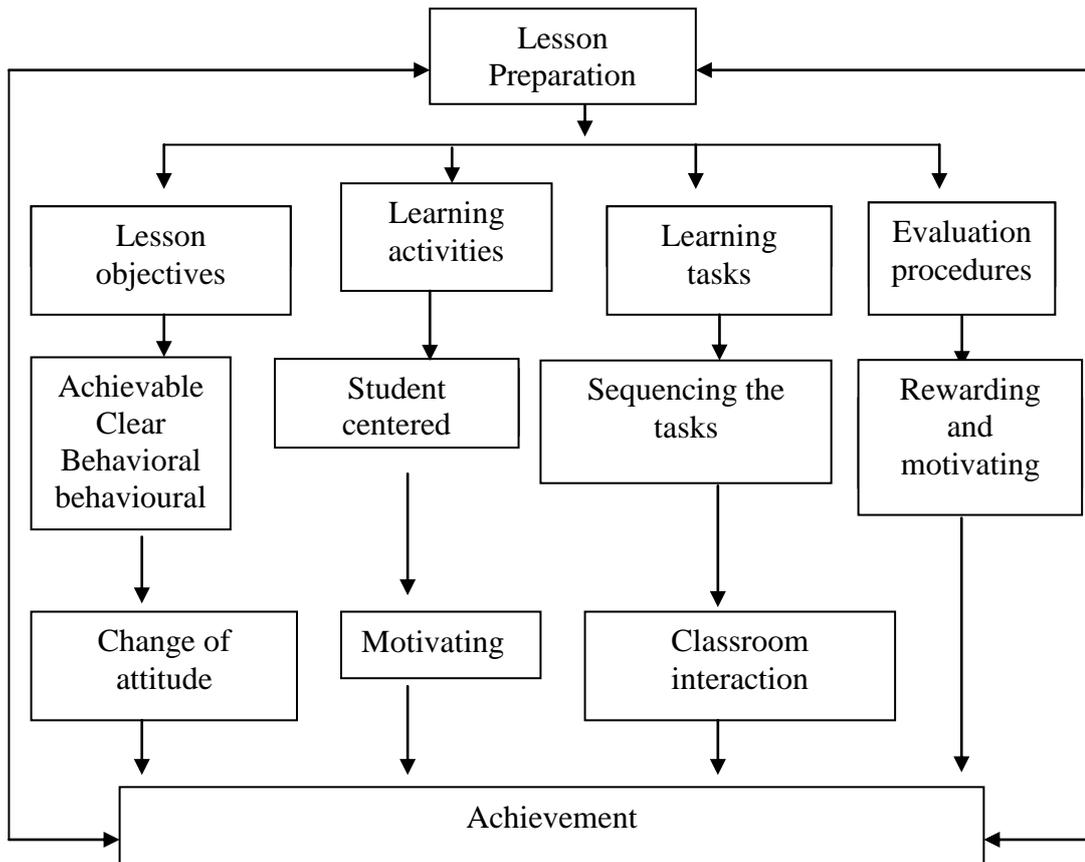


Figure1.1: Conceptual Representation of the Variables.

The framework shows that when lesson objectives have been identified, are clear, achievable, behavioral and measurable, then the students will be able to have a change of attitude since they know what they are expected to learn. Again, identification of learning activities means that the students will have a chance to participate in the teaching-learning process and therefore be motivated. The learning tasks, when well sequenced will provide room for more classroom interactions. This is expected to enhance their understanding of concepts in vectors. Finally, identification of evaluation procedures that are rewarding and motivating will result in improved achievement in mathematics.

1.11 Definition of Terms

Achievement- the overall score that the student obtains in the mathematics test administered.

Competence - refers to the knowledge in and practice of instructional design.

Entry behavior - the students' level of knowledge they have prior to the start of teaching learning of the topic.

Effectiveness -used to refer to the ability of the Instructional Plans to aid the teacher in attaining the desired learning outcomes i.e. achievement, change in attitude and motivation and classroom interactions.

Instruction- this is the goal directed teaching process that has been pre-planned.

Instructional planning - refers to the detailed and systematic description of activities to be carried out in order to achieve the stated objectives during instruction.

Lesson preparations - used to refer to teacher's readiness to attend to a lesson. It includes instructional products such as schemes of work, lesson plans, lesson notes and availability of instructional aids.

Mean Gain- this is the difference between the pre-test and post-test scores by students.

Pedagogical skills -the skills which teachers have acquired to perfect the art of teaching for meaningful learning.

Skill performance- the logical working and correct computation of mathematical problems and drawing of vector diagrams.

Teaching preparations- this is used in this study to refer to planning of a lesson which shows transition from known to unknown, sequencing of learning activities, objectives to be achieved, the main classroom interactions during the lesson and full-scale to small-scale group activities.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This literature review has examined teaching mathematics, students' achievement in mathematics and teachers' lesson planning in instructional process. It also dwells on the role of objectives in learning, preparation of learning experiences, teacher's instructional skills and students' achievement and learning environment. Finally, it looks at identification and use of suitable instructional resources, assessment and evaluation of learning.

2.2 Teaching Mathematics

Mathematics is conceived to be about numbers, shapes, algebra, measurements and a variety of other more specialized but nevertheless familiar topics which give the subject its flavor (Costello, 1991). However, learning mathematics means more than this. It involves some memory capacity. The ability to acquire and retain knowledge, learn new facts, skills, conceptual structures, problem-solving, and development of attitudes are all envisioned in mathematical progression.

The basic task of effective teaching is to set up a learning experience in which pupils effectively engage in the mental activity that brings about those changes in the pupils' cognitive and effective structures which constitute the desired learning (Sotto, 1999). Simpson (2001) defines teaching as an activity aimed at the achievement of learning and practiced in such a manner as to respect the student's integrity and capacity for independent judgment. Accordingly, teaching involves giving reasons,

showing and weighing evidence, and drawing conclusions on relevant evidence. Learning is an active process and is achieved by a variety of activities (Costello, 1991). The various avenues in which learning is approached include: listening, asking questions, writing and analyzing. All these involve thinking.

Doll (1989) argues that the teacher should develop a set of objectives for acquiring knowledge, developing ability to think, effecting attitude change and developing skills in a variety of skill areas. Doll (1989) further notes that at every stage, the teacher of mathematics is confronted with three basic problems mainly:-

- i) Helping the students to develop understanding and mastery of new concepts, principles, relationships and skills.
- ii) Helping the students to maintain understanding and skills already attained and;
- iii) Helping the students to secure maximum transfer of learning to their physical and social environment.

Smith, B.O as cited by Perrot (1992) suggested that a teacher should be prepared in the four areas of knowledge i.e.

- i) Command of the theoretical knowledge about learning human behavior.
- ii) Display of attitudes that foster learning and genuine human relationships.
- iii) Command of knowledge in the subject matter to be taught.
- iv) Control of technical skills of teaching that facilitate pupils' learning.

Apart from having knowledge of mathematics beyond what the teacher is required to teach, the NCTM(2000) report on mathematics teaching points out that the teacher must have understanding and acceptance of students. Mathematics, when properly

planned, approached and organized can give moments of success to anyone and the satisfaction of mastery of the skill(s) even more pleasure (NCTM, 2000). Oyaya and Njuguna (1999) indicated that good teaching should be one involving planning which indicates transition from known to unknown, identification of learner activities and full-scale to small-scale group activities.

Mathematics teaching at all levels should include opportunities for exposition by the teacher, discussion between teacher and pupils and amongst pupils. Appropriate activities should be identified so as to consolidate the learned content and application to everyday situations. Hence this study evaluated how teachers' use of Instructional Plans which have identified various teaching methods impacted on students' achievement in mathematics. Further, teaching – learning of mathematics requires the collaboration and interactions of the teacher and pupils in the mathematics lessons. These interactions include: teacher to students, students to teachers, and students to resources.

2.3 Students' Achievement in Mathematics

Mathematics plays a central role in a person's daily life. The Cockcroft Report (1982) has identified mathematics as very useful at home, workplace, commerce and industry. Mathematics is considered important because it develops students' logical thinking, accuracy and spatial awareness (Cooney, 1992). It is considered a catalyst for scientific and technological advancement (Simpson, 2001). Despite this essential role which mathematics plays, students' achievement in national examinations is low. The mean mark of mathematics by students in the 2007 KCSE was 19.32% which was a drop from 19.58% in 2006 (KNEC, 2007). The same report revealed

that in 2007, over 54% of candidates scored less than 30.0%. The report further showed that in 2005, students' achievement in mathematics had been 20.39%. This showed that the students' achievement in mathematics was declining.

The low performance has been a source of concern for teachers, parents and other stakeholders. Unless an immediate measure is taken, the students could continue to achieve dismally and the amount of loss would remain high. This study was carried out to establish the effects of planned learning activities on students' achievement.

Efforts have been made to deal with low students' achievement in mathematics. Kihara (2003) found out that use of strategies that encourage interactions contributed to students' motivation, positive attitude and high achievement in the subject. This is because a teaching- learning process that involves students in active learning process gives students reasonable control over their learning. Programmed learning activities would provide students with opportunities to develop their skills and attain mathematical concepts. Hence teaching and learning activities were evaluated to establish their effects on students' achievement and classroom interactions.

Studies by Kihara (2003) and SMASSE (2004) showed that where students, teachers and resources interacted, then high achievement scores were recorded unlike where the teachers used expository approaches. Nyambura (2004) found out that most teachers spent most of their teaching time demonstrating how to solve questions, ask questions and lecturing. This gave students limited opportunities to participate in mathematics lessons and so became passive listeners rather than active participants in mathematics lessons. As a result, students became bored and uninterested in

mathematics. This may have led to low achievement in mathematics. Identified learning activities would provide students with mathematics activities that are interesting and meaningful to them. This is because the students will be involved in the active learning process. Hence this study was carried out to establish how the planned learning activities influenced students' achievement.

Teaching approaches that are expository in nature are popular with 85% of teachers, while interactive approaches accounted for 15% (Miheho, 2002). This means that instead of teachers involving students in problem-solving, the students spent much time copying formulae, examples and procedures without understanding. Such practices led to poor mastery of content. Hence low students' achievement in mathematics persisted. Planned learning activities would provide students with opportunities for problem-solving and so improve their skill performance. Hence programmed learning activities were evaluated to establish their effects on students' achievement and attitudes towards mathematics.

2.4 Teachers' Instructional Skills and Students' Achievement

The whole instructional process is viewed as consisting of a body of principles which relate to each other. This involves the teacher applying pedagogical practices which can range from only small enhancements of practices using what are essentially traditional methods to more fundamental changes in their approach to teaching. Cox et al (2000), in their study of ICT and pedagogy observe that teachers' pedagogies and pedagogical reasoning influence their use of instructional practices and thereby pupils' attainment. The study notes that when teachers use their knowledge of both the subject and the way pupils understand the subject, then the effect on attainment

is greatest when the pupils are challenged to think and question their own understanding.

Resources should be used as a way of changing the way teachers and pupils interact with each other and with the learning tasks. Biggs and Pollard (2003) point out that there is need for teachers to employ proactive and responsive strategies in order to guide, facilitate and support appropriate learning activities. This is effected when the teacher applies the pedagogical skills acquired to select and organize instructional resources and integrate them in the classroom activities.

For effective instruction, a wide range of practices, which form teachers' pedagogical frameworks are: understanding of the relationship between the instructional resources and the concepts, skills in the subject, and need to know how to prepare and plan lessons where resources are used in ways which will challenge pupils' understanding and promote greater thinking. The pedagogical skills enable teachers to recognize which kinds of class organization will be most effective for particular learning tasks and whether to work on their own, in pairs or as a whole class (Knight, 2002). Shulman (1997) says that teachers should develop scaffolding activities that will help pupils participate in enquiry process and regulate pupils' feedback. This includes activities such as task definition, specification and sequencing of activities and provision of materials that will make it easier for the learner to undertake learning successfully. Cox et al (2000) identified the key feature of more effective teachers as use of explanations. The study noted that teachers need to match instructional skills with the intended learning outcomes of an activity. Likewise, pupils' progress is most significantly influenced by a teacher who displays

both high levels of professionalism and good teaching skills which lead to the creation of a good classroom climate.

It is the role of the teacher to know pupils' understanding and identify pivotal cases that would build on pupils' ideas and inspire them to reflect on and restructure their views (Cox et al 2000). As Njuguna (1998) found out, academic achievement of students is dependent on both their abilities and aspirations, the environment in which learning takes place as controlled and manipulated by the teacher. This agrees with Shulman (1997), findings that teachers should use their pedagogical skills to filter their knowledge bases and present that which is relevant. Njuguna (1998) also notes that students' performance and effective participations during instruction is influenced by nature of teacher's programming of the instructional process. Cox et al (2000) point out that individual differences dictate the pedagogical practices so that there is need for the teacher to employ proactive and responsive structures to support and guide learning, monitor progress, and encourage retention.

The teacher needs to be well versed with different ways of assessing pupils' attainment. These vary from assessing written tasks, assessing presentations, and through oral and written skills. As Narcino-Brow, Oke and Brown (1992) point out, the major part of teacher's pedagogy lies in the planning, preparation and follow-up of lessons in which the teacher retains a leadership role. In light of the above pedagogical skills findings, this study sought to look at the effects of lesson preparations on students' achievement in Makueni district.

From this literature, it emerges that the teacher's pedagogical reasoning and skills influences use of resources, shapes learning opportunities and integration of resources in the planning. The studies emphasize that teacher's effectiveness can only be assessed by teacher's observation in class by identifying the behaviors that distinguish effective teachers from non-effective ones. This study dwelt on how the Instructional Plans affected classroom interactions, a major area that has been omitted by previous studies.

2.5 Teacher's Lesson Planning in Instructional Process

Most researchers agree that lesson planning is an important aspect in a successful teaching enterprise. For example, Nacino-Brow, Oke and Brown (1992) observe that although the lesson plan is probably the most important element in the instructional process, some and even in-experienced teachers often neglect it. Pollard and Filer (2000), argue that a good lesson cannot be taught without preparations and that poor lessons are due to faulty preparations. They further show that in preparing to teach a lesson, the lesson plan comes out as a very prominent feature.

Pollard and Filer (2000) have defined a lesson plan as a document that reveals the logical organization of content and instructional events designed to meet specific educational goals and objectives. Lesson planning takes place when the teacher attempts finding answers to questions such as: who is to be taught? What is to be taught? How will it be taught? These questions are preparatory activities of a teacher before he proceeds with teaching. Allan and Louis (1988) agree that conducting a lesson involves pedagogical skills, attitudes and a way of thinking. All these facets of instruction are only useful through careful planning. Thus before teachers make

an attempt of conducting a lesson, they ought to know how to ensure that pedagogical relations prosper in their lesson.

Allan (1990) has consistently argued that lesson planning allows teachers to make conscious choices about what they are going to do. O'Hara (2004) notes that effective planning provides a clear focus and purpose for lessons and assists teachers in focusing on their practice. This makes it easier to reflect on events, to modify future teaching, to anticipate learners' needs and to have responses ready. The teacher sets priorities and decides on teaching plans.

Knight (2002), adds that lesson plans allow teachers to have rational goals and choose sensible means for reaching the ends they have in mind. In addition, they can determine what is and what is not important from the lesson plan. They assist teachers learn not to make timing and targeting errors. Absence of effective planning can have serious consequences for teaching and learning. It can lead to both teacher inefficiency and ineffectiveness in the classroom and to learning that is at best patchy and uncoordinated. According to Allan (1990), the preparations help teachers make instructional decisions such as when to stay with a topic and when to move on, on basis of a particular teaching context and particular group of students. The very definition of the term "plan" denotes a pre-emptive approach to issues; it implies justified and reasonable anticipation of what ought to take place in sometime to come. Cox et al (2000) note that where little planning has occurred, the evidence shows that the pupils' class work is unfocussed and leads to less than satisfactory outcomes.

From the foregoing literature review, the following conclusions can be drawn. First: that the lesson plan allows teachers to focus on their lessons. Secondly, that there is a significant relationship between lesson planning and identification of what is and is not important for the lesson. Thirdly, that planning helps teachers modify their way of thinking. Generally, the researches do not show how instructional planning by the teachers influences students' achievement. For this reason, this study researched on how the pre-planned lessons influenced students' achievement the Kenyan context.

2.5.1 Selection of Content for Mathematics Lessons

In his works, Bruner (1966) has emphasized that the choice of subject matter is one of the essential steps to be included during instructional planning. In doing this, Bruner suggests that first the teacher should show concern for the subject matter to be taught. Secondly, the teacher should then apply appropriate principles of ordering and finally should involve planning activities for students' practice to ensure mastery of the subjects matter. Pollard and Filer (2000) recommend that the subject matter to be taught should include three main aspects i.e. mathematical concepts, mathematical facts and mathematical skills. Piaget (1964) agrees that the most basic learnable aspect in mathematics is the concept. The concepts are acquired through learning experiences presented to the learner in a systematic manner.

The instructional plan for concept development should be concerned with four main aspects i.e. identification of the concepts, stages of development of the concepts, ordering the concepts in logical sequence in which they should be taught and spacing the concepts in terms of the time it will take to teach them (Biggs, 1999). The secondary school mathematics syllabus by Kenya Institute of Education (KIE) has

specified the topics from which the subject matter for each level is to be taught. The teachers in turn are expected to study the syllabus, identify the concepts, facts and skills which should be taught in a systematic manner.

The KNEC (2002) report attributes the poor performance in mathematics to lack of understanding of the basic mathematical skills which may be blamed on inadequate instructional planning. Biggs (1999) has emphasized the need for teachers to ask questions during planning for teaching of mathematical concepts namely:-

- i) What is the intellectual ability and conceptual background of the students?
- ii) What has been the past experience in either learning the concept or teaching it to previous classes?
- iii) How important is the concept?

To Biggs (1999), effective teaching of mathematics will require the teacher to first identify the concepts in terms of learning abilities in the class. Emphasizing the need for teachers to focus on the concepts for effective learning, Simpson (2001) has suggested some rules for effective teaching of concepts namely that the teacher should provide:-

- i) Plenty of practical examples so that the learner can move from the concrete to the abstract.
- ii) Learners with opportunity to provide their own examples.
- iii) Non-examples to help the learner to compare the defining characteristics of the examples with non-examples e.g. examples of numbers that are surds and numbers that are not surds.

Skemp (1971) in his theory of learning mathematics believes that mathematical thinking processes can be effectively developed if the teacher is able to distinguish between learning of facts and acquisition of concepts. Thus, acquisition of concepts, which should be the basis of mathematical thinking, requires an arrangement of a set of experiences to enable new concepts to be built on previously acquired concepts while factual knowledge maybe presented to the learner in any order. Skemp (1971) further makes a distinction between schematic learning and rote learning. In schematic learning, new concepts are built on previous related concepts while rote learning may involve memorization of unrelated ideas. He therefore advocates for schematic learning in mathematics because the method facilitates understanding of the concepts and the learner is more likely to retain concepts learned for a longer period. The basic idea in Skemp's theory of learning is that planning is essential for effective teaching. This planning should take into consideration the learners' prior knowledge that is relevant to new concepts to be taught.

Cooney (1992) argues that learning of mathematical skills has to do with knowing how to do something. He further notes that the skills could be acquired through imitation and practice. Therefore to teach a mathematical skill effectively, teachers must provide students with sufficient opportunities for practice. Kihara (2003) noted that students have problems learning mathematics because they are forced to memorize rules and practice the skills before understanding the concepts. It is therefore paramount that teachers should critically and carefully analyze the content to be taught and so include the concepts, skills and facts. This study investigated how the organization of the concepts, skills and facts as reflected in instructional plans

affects students' achievement, attitude, motivation, and classroom interaction in mathematics lessons.

2.5.2 The Importance of Objectives in Learning

Perrot (1992) defines objectives as the specific learning aims that should be achieved in the prescribed learning period. Their role in effective teaching –learning situation depends on how they are stated. (Cooper, 1998) cautions that objectives that are not properly stated may not adequately address the teaching- learning problems. He points out some ways in which objectives may be inappropriately stated by a teacher. One of the ways is when the teacher states the objective in terms of what the teacher will do e.g. “To demonstrate the drawing of triangle”. Such an objective has shortcomings in that it does not show what the learner will do and how selection of learning experiences will be done. Other ways of stating inappropriate objectives is when the teacher states them as sub-topic outlines e.g. “To teach calculation of income tax”. Such a statement fails to inform the teacher and even the learner what will be done to the subject matter.

The teacher may also write or state the objectives inappropriately using words which are not specific or behavioral e.g. “to know”; “to understand” (Cooper, 1998). Such words do not specify the behaviors that the learner will demonstrate to show that learning has taken place. The appropriate statements of learning objectives are therefore those that state the students' terminal behavior i.e. what the students can or will be able to do at the conclusion of the learning experience that he could not do before the exposure (Simpson, 2001). An example is “The learner should be able to correctly calculate the income tax payable using the income tax slabs.” Thus,

appropriate statements of objectives for instructional purpose should have action verbs which describe observable behaviors. Such words should reflect easy assessment and include: apply, evaluate, solve, locate, simplify, differentiate, formulate. Words which do not indicate observable behaviors like learn, appreciate, understand, and know should be avoided because they do not tell the behavior that the teacher will observe to show that learning has taken place.

Knight (2002) notes that there is need for teachers to be conscious of the importance of objectives in effective teaching. He identifies the four roles of objectives which are reflected in the statement as: communicating purpose of learning to the learners, selecting and structuring the content to be taught, deciding on appropriate learning activities and appropriate means of evaluation.

Merger and Clack (1988) cited by Rowntree (1990) investigated how the writing of objectives and communicating purpose of learning to students affected achievement. The study revealed that students who knew the objectives of the unit and had appropriate resources had a greater achievement than those who had no prior knowledge of the same.

Despite the benefits of behavioral objectives being known, some researchers and educationists have expressed their reservations about the value of objectives in learning (Knight, 2002). One of the arguments against their use is that they over-emphasize trivial and easily measured behavior. Others think it is not easy to appraise objectives in the affective domain and some aspects of cognitive domain such as creativity. However, this should not rule out the role of objectives in

effective teaching – learning situation. Some of the objections given against use of objectives maybe a reflection of misuse of the objectives by teachers (Pollard and Filer 2000). Nevertheless, if teachers do not state or specify their teaching objectives, they may run the risk of getting what they did not anticipate. This study attempted to find out whether teachers who used instructional plans with well stated objectives influenced students’ achievement of concepts and skills in mathematics.

2.5.3 Identification and Use of Suitable Instructional Resources

Kihara (2003) found out that 83% of students in national schools gave an assurance that teachers used instructional resources during teaching-learning mathematics. The commonest resources used being mathematical models and instruments. Using instructional resources could provide opportunities to visualize the facts of the case reflected on the relationship of the ideas being discussed. This is possible when students utilize resources that become useful in “anchoring” concepts to encourage conceptualization. Appropriate resources allow students to do practical work that is both thought-provoking and interacting. This encourages interest in mathematics.

A well-planned lesson is one that provides learning activities that involve manipulation and use of resources. Hence preparations that included use of worksheets with identified tasks were evaluated to establish their effects on students’ achievement. The students’ learning activities could determine what instructional resources could be needed. Costello (1991) in review of mathematics studies observed that re-contextualizing the curriculum could bring many mathematical tasks within the reach of most students, some of which were formerly considered beyond their capabilities. That means that students’ use of resources could change the way

mathematics is learnt. Students could discover that the concept that seemed abstract and complex could be understandable when resources are used for learning purposes.

Most teachers say that they fail to use instructional resources because of lack of funds (Odundo, 1999). However, the appropriate use of simple, inexpensive resources in learning activities would be as good as use of commercially produced resources. The use of planned worksheets was thus evaluated to find out how it affects students achievement, attitude and motivation and classroom interactions.

2.6 Students' Attitude and Motivation Towards Mathematics

Attitude can be defined as a learned predisposition to respond positively or negatively to an aspect or experience (Mwamwenda, 2002). The predisposition affects ways of thinking, feeling, perceiving and behaving in a certain way and more so attribute of interest and opinions about mathematics.

One of the comprehensive investigations of the influence of attributes on performance was conducted by Fenemma and Sherman (1978). They developed a series of short scales to measure the general attitude towards mathematics focusing on specific components of attitude believed to be related to performance. The learners were asked about their perception of mathematics as useful, the extent to which they saw their teachers as being supportive.

In the teaching and learning of mathematics, the attitude held by the student is a very important aspect because it determines what is learned and how it is learned. This means that it encourages or discourages students' participation in mathematics

lessons. Kihara (2003) found out that if the attitude is positive, it encourages more participation and reasonable control over own learning. This helps students to enjoy learning the mathematics and so increase achievement in the subject. Miheso (2002) found that teachers who used exposition methods of teaching accounted for 85% teaching while interactive methods accounted for only 15%. This implied that the teacher talked 75% and students on 15%. Hence teachers did almost everything and students passively listened to teachers' presentations. This creates a learning environment that was unsuitable as students could get bored, disinterested and so developing poor attitude towards mathematics. Miheso (2002) further concludes that if the teaching is geared towards classroom control and compliance, then these result in a threatening environment where classroom interaction is minimal. If there is over controlling the students, then they could feel intimidated and stop participating in the learning process. This could contribute to poor attitude and hence low achievement. It would be expected that the students' interactions with fellow students and the teacher is increased if the teacher creates a warm learning environment that will help students gain some reasonable control over own learning. Programmed learning activities and tasks were therefore evaluated in this study to establish if they encouraged positive attitude towards mathematics.

Students' attitude towards mathematics could also depend on teacher characteristics, which could influence students' achievement. SMASSE report (2004) notes that teacher's negative attitude towards mathematics, poor mastery of content and poor teaching methods could have caused negative students' attitude towards mathematical and hence low achievement in the same. Teachers with negative attitude towards students could spent less time in lesson preparations (planning), tell

students' failure and discourage students from seeking help from others leading to students developing negative attitude towards mathematics and so lead to low achievement. Further, the report points out that teachers with positive attitude could motivate students to do well leading to improved achievement.

A teacher who is friendly, warm, humorous and democratic allows students reasonable control over their own learning. This would encourage students to put efforts in mathematics learning. Hence teaching – learning activities were observed and evaluated to establish how they affect or determine students' attitude in mathematics.

2.7 Classroom Interactions and Students' Achievement

The study by Di Bentley (1992) showed that classroom management usually determines the learning environment and interactions. Classroom management is usually geared towards establishing classroom control so that students' abilities in the subject could be developed. Effective learning environment is one in which the teaching –learning process varies according to factors such as the role of the teacher, role of the learner and nature of instructional activities (Wasike, 2003). These may be influenced by the teacher and students' roles during instruction although the nature of learning activities is largely dependent on learners' participation.

Classroom environment in which new knowledge is acquired by connecting it to some existing individual knowledge structure (accommodation) encourages interactions between classroom members and so have meaningful learning. Meaningful learning leads to good achievement. Orton (1987) suggested that the

teacher is expected to try out all activities before presentation. This helps to ensure that everything works perfectly well and thus improves student's achievement. This study evaluated how instructional planning affects classroom interactions and students' attitude in mathematics.

The work of Di Bentley (1992) showed that most likely causes of classroom disarray were dissatisfaction of mathematics students. That means the students might need satisfaction in active learning activities and provide them with opportunities to succeed in learning tasks. Interactive activities provide learners with opportunity to succeed in mathematics learning situations. This study investigated how the planned learning tasks and activities impacted on classroom interactions.

2.8 Assessment and Evaluation of Learning

Assessment is a term used to cover any situation which some aspect of a pupils' education is measured by the teacher, Cooney (1992). This evaluation can be in the form exercises, assignments, homework, supervised tests or end term examinations. Pollard and Filer (2000) note that assessment forms a vital element of every stage of planning. Without assessment and the consequent re-evaluation of planning that result, it is true to say that effective teaching cannot be maintained. The nature of the task set is always fundamental to the effectiveness of the learning taking place. The measure of the performance is shown in terms of comments, grades or marks awarded.

The assessment can either be formative or summative. NCTM Report (2000) observes that pupils doing homework, even if it is not marked, learn more than those

doing no homework. Too (2004) noted that if the homework is marked and revision done by every pupil with the help of the teacher, then the pupil will learn more. The study further points out that analysis of studies on effects of homework in various subjects showed that completion of assignments yields positive effects on academic achievement.

It is evident that assessment and evaluation of learning forms an important aspect in the teaching- learning process. The researchers have emphasized on evaluation and assessment in the classroom. They have underscored the importance of factoring in assessment and evaluation in the preparations stage. This study aimed at establishing effects of assessment as incorporated in the instructional plans on students' achievement in mathematics.

2.9 Summary of Literature Review

The literature has dwelt in detail with teaching of mathematics, teaching strategies, teachers' lesson planning in instructional process, learning in mathematics and assessment of learning. From the discussion, it can be concluded that understanding of mathematics concepts and skills can be identified by the preparations that teachers make. It is clear from the literature that achievement, attitude, motivation and classroom interactions can be sustained if the teacher makes adequate preparations for the lessons. Therefore, for effective teaching and learning of mathematics, there is need to establish how students interact in class and their perceptions about the mathematics. When this is done, it may be possible to identify appropriate remedial measures that are needed to improve the lesson preparations and so enhance meaningful learning.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a description of the research design adopted, study population and sampling procedures. It also includes a section on instrumentation which discusses the piloting, validity and reliability of the instruments. Finally, the procedures of data collection and analysis are described.

3.2 Research Design

The study adopted the Solomon Four – Group Quasi Experimental design. This design is considered rigorous enough to provide the most effective tools for determining cause and effect relationship (Koul, 1990). The design adequately controls other variables that are likely to affect the validity of the study. The design involves random assignment of subjects to four groups with two groups being the control and the other two as experimental. One class from each sampled school constituted one group of subjects hence four schools were use for this study. As Kathuri and Pals (1993) and Gorard (2001) point out, Solomon Four design can use existing groups as basis for experimentation. The design is illustrated in Table 3.1.

Table 3.1: Solomon Four – Group Quasi-Experimental design

Group	Pre-test	Treatment	Post-test
E ₁	O ₁	X	O ₂
E ₂		X	O ₃
C ₁	O ₄		O ₅
C ₂			O ₆

Source: Royse 2003:199

- Key: E₁ -Experimental group 1
E₂ - Experimental group 2
C₁ - Control group 1
C₂ -Control group 2
O₁, O₄ - Pre-tests
O₂, O₃, O₅, O₆ - Posttests
X - Treatment

3.3 Study Population

The target population consisted of all secondary school students from public secondary schools in Makueni district. The district has 121 public secondary schools comprising of 95 in the district category and 26 in the provincial category (District Education Office, Makueni, 2007). To guard against gender bias, co-educational schools were selected for the study. There were 25 such co-educational schools with an estimated population of 3,880 students. The study focused on Form Two mathematics students in the district schools category. The list of schools was obtained from the District Education Office, Makueni.

3.4 Sampling Procedures

Both purposive and random sampling procedures were used in the study. Purposive sampling was used to identify the schools in the district category. Simple random sampling technique was used to draw the required four schools out of the accessible 25 co-educational schools. In the sampled schools, which had more than one stream, simple random sampling technique was again used to select one stream that participated in the study. This technique was considered appropriate because it ensured that all schools had an equal chance of being included in the study sample. Also, the simple random sampling gives samples, which yield data that can be generalized (Borg, 1987; Mugenda and Mugenda, 1999).

3.4.1 Sample Size

Four co-educational schools were sampled and one Form Two class randomly sampled from each school that took part in the study. The actual sample size that participated in the study was 163 students. During data coding, it was found that 8 students' questionnaires had incomplete responses and were excluded, giving a sample size of 155 students. These subjects were used in their four classes that were assigned to Experimental and Control groups as shown in the Table 3.2.

Table 3.2: A Table Showing Students' Population that Participated in the Study

	GROUP				TOTAL
Population	E ₁	E ₂	C ₁	C ₂	
	34	38	46	37	155

3.5 Instrumentation

Three instruments were used to collect data in this study to meet the stated objectives. These were: Mathematics Achievement Test (MAT), Students' Attitude Questionnaire (SAQ), and Mathematics Lesson Observation Checklist (MLOC).

3.5.1 Mathematics Achievement Test

The researcher developed a Mathematics Achievement Test (MAT) to assess students' knowledge and skill performance in the topic of Vectors. The MAT contained items on: vectors and scalar quantities, displacement vectors, addition of vectors, scalar multiplication, column and position vectors, midpoint, magnitude and translation of a vector. A total of 24 items were developed based on the table of specification designed for the above sub-topics. These were tested against the first three cognitive levels as outlined in the Bloom's taxonomy as shown in Table 3.3.

Table 3.3: Table of Specification for MAT items

Sub-topic	Level			Total
	Knowledge	Comprehension	Application	
Vectors and scalar quantities	3	2	1	6
Vectors in the Cartesian plane	2	1	2	5
Magnitude of a vector	-	3	1	4
Translation of a vector	-	2	1	3
Equivalent vectors	1	-	-	1
Position vectors	-	-	1	1
Column vectors	1	-	1	2
Mid-point	1	-	1	2
TOTAL	8	8	8	24

Each of the 24 items was analyzed for difficulty and discrimination indices. After item analysis, it was found that all the MAT items had a difficulty level of between 0.31 and 0.75. The discrimination index was found to lie between 0.25 and 0.50. These indices were found acceptable according to Ebel and Fresbie (2004).

The MAT had two sections, A and B. Section A assessed students' understanding of concepts in vectors and vector representation and consisted of 10 items. Section B assessed students' skill performance in computation, interpretation and application of vector knowledge. It consisted of 14 structured items.

3.5.2 Students' Attitude Questionnaire (SAQ)

This questionnaire had 3 parts: A, B, and C. Part A had the instructions. Part B had two sections I and II. Section I sought background information and contained 15 Likert-type items that solicited students' views about their attitudes and motivation towards mathematics. These items were adapted from Fenemma and Sherman (1978) attitude items and were modified to suit this study. Section II had 10 Likert items that sought their views on classroom interactions (CI). Part C had open-ended questions that required students to express their views about their learning experiences in mathematics and vectors in particular.

3.5.3 Mathematics Lesson Observation Checklist

A Mathematics Lesson Observation Checklist (MLOC) was adapted from the Allan's Observation Model, (AOM) by the researcher. The MLOC was used to observe some lessons on the topic vectors. The purpose of this observation was to collect data on student-teacher interactions, student-student interaction and student-resources interactions during the instruction process.

The MLOC consisted of 6 teacher-activity related items and 9 student-related activity items. The student-related activities were focused on teacher's reinforcement, simplicity of presentation, questioning and responding and periods of inactivity or silence. The teacher-related activities focused on supervision of learning activities, demonstration of mathematical skills, reinforcement and explanation of concepts and skills.

3.5.4 The Pilot Study

Piloting of the research instruments was done in a school with thirty one (31) students. The MAT and SAQ were administered to the students in an examination situation. The same instruments were administered to the same group after a lapse of two weeks.

The SAQ responses for the test and re-test were scored manually and a reliability coefficient using Pearson Product Moment formula was calculated. One item in the SAQ on attitude was deleted because it was not measuring the variables under study. Three others on motivation were re-structured because they were not clear to the students.

After piloting, the MAT was marked, scored and the Pearson Product Moment reliability coefficient manually calculated between the test and re-test scores. One item in the MAT was re-structured.

The MLOC was also piloted by observing two lessons using the MLOC within the two weeks. Thereafter, two items on students' activities were found to be collecting similar information and so one item was struck out. One item on teacher- activities was deleted and 3 other items were restructured.

3.5.5 Validity and Reliability of the Instruments

Science and Mathematics Education experts checked for face, content and construct validity of the research instruments. Their comments were incorporated in the final instruments that were used in the study. After piloting, the reliability coefficient of

the SAQ and MAT using the Pearson Product Moment formula were found to be 0.78 and 0.82 respectively. These reliability measures were considered appropriate since they are within the acceptable range of 0.7 and above (Royse, 2003).

3.6 Instrument Administration and Data Collection

The SAQ and MAT were first administered to the Experimental group one (E_1) and Control group one (C_1). The purpose was to ascertain their entry behavior and homogeneity. Groups E_1 and E_2 were then exposed to ten (10) lessons in Vectors using the instructional plans while groups C_1 and C_2 were exposed to the same content but without use of instructional plans. It is worth noting that the teachers involved in teaching the experimental groups were inducted for a period of one week by the researcher on implementation of the instructional plans. Details of the Instructional Plans are shown in appendix II. In the process, the researcher observed some lessons and tallied the observations in MLOC in all the four groups involved in the study.

After all the groups had completed the topic, the same SAQ and the MAT were post-tested to all the students in the four groups. The researcher then scored and coded data collected from both the SAQ and MAT for analysis.

3.7 Data Analysis

The Likert items in the SAQ were scored manually in the range 1-5. The data was then coded and data files prepared for computer analysis. The raw marks (scores) from the MAT were summarized using means, standard deviations and percentages. Statistical tests of significance were analyzed using the one –way analysis of

variance (ANOVA) and tested at α -level of 0.05. The one-way ANOVA was used because it enabled the researcher to make decisions about the existence of differences in the population under study (King'oriah, 2004; Ingule and Gatumu, 1996). To establish exactly where the mean differences lay between the groups, and the direction of the difference, an independent samples t-test at alpha level of 0.05 was performed.

The counts in the MLOC were transcribed into scores and percentages calculated. The three hypotheses posted for study were analyzed using the one-way ANOVA and the independent samples t-test. To beef up the findings, tabular presentations and qualitative data from MLOC were analyzed specifically for objective three.

CHAPTER FOUR

RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction

The analysis and discussion of the data collected for the study are presented in this chapter. The chapter is divided into six sections. The first section gives an overview of the study and a brief on sample description. The second section is a description of the distribution of the pre-test scores. In section three, statistical analysis and interpretations are presented. Each hypothesis is discussed and tested at $P < 0.05$ level of significance. The fourth section is a presentation of the qualitative data. Section five discusses the findings in detail while section six gives a summary of the findings.

4.2 Overview of the Study and Sample Description

The study involved a total of 155 students who were in four groups: Experimental groups (E_1, E_2) and Control groups (C_1, C_2). All the groups were exposed to the same content in the topic of vectors. This content was taught in a total of ten (10) lessons within a span of two weeks, for each group. Alongside the study objectives, three null hypotheses were put forward for testing. These were:

H_{01} : Teachers' use of Instructional Plans has no significant effect on students' achievements in Mathematics.

H_{02} : There is no significant difference in the attitude and motivation towards mathematics between students taught by teachers using the Instructional Plans and those taught by teachers who did not use the Instructional Plans.

Ho₃: Teachers' use of Instructional Plans has no significant effect on classroom interactions during mathematics instruction.

The research instruments used were: Mathematics Achievement Test (MAT), Students Attitude Questionnaire (SAQ) and Mathematics Lesson Observation Checklist (MLOC).

4.3 Performance before Treatment

Pre-tests in the MAT and SAQ were done by the Experimental group one (E₁) and Control group one (C₁). The results are shown in Table 4.1.

Table 4.1: Comparison of Mean Scores and Standard Deviations of the pre-test scores in MAT and SAQ

Scale	Group			
	E ₁		C ₁	
	Mean	SD	Mean	SD
MAT A	12.24 ^a	5.16	11.87 ^a	4.31
B	2.53 ^b	4.52	2.52 ^b	2.93
Overall	14.77	9.68	14.39	7.24
SAQ	63.53 ^c	11.26	57.93 ^c	10.70

a, b, c denote comparable means.

As shown in Table 4.1, the mean scores of both groups (E₁ and C₁) were comparable in both MAT and SAQ. However, to establish if these mean scores for MAT were significantly different at 0.05 level of significance, a one-way analysis of variance, (ANOVA) was performed. The results obtained were as summarized in Table 4.2.

Table 4.2: One-way ANOVA Results of the Pre-test Scores of the MAT

Source	Df	SS	MS	F-ratio	p-value
Between groups	1	63.14	63.14	0.91*	0.23
Within groups	79	5481.02	69.38		
Total	80	5544.16			

* denotes not significant at $P < 0.05$; $F_{0.05 [1,79]} = 4.00$

The mean scores of both groups (E_1 and C_1) in the SAQ were close to each other at 63.53 and 57.93 respectively. To establish if these mean scores were significantly different at 0.05 level of significance, a one-way ANOVA was used. Table 4.3 shows the results obtained.

Table 4.3: One-way ANOVA Results of Pre-test Scores on SAQ

Source	dF	SS	MS	F-ratio	P-value
Between groups	1	85.41	85.41	0.97*	0.24
Within groups	79	6955.95	88.05		
Total	80	7041.36			

* denotes not significant at $P < 0.05$; $F_{0.05 [1,79]} = 4.00$

An examination of the results of Tables 4.2 and 4.3 indicates that the mean scores of both E_1 and C_1 on both the MAT and SAQ are not statistically different. This is an indication that the groups in question were comparable, homogenous with statistically similar entry behavior. It means the groups were not varied in attitude, motivation and classroom interactions. This therefore made the groups suitable for the study.

4.4 Students' Performance after Treatment

In this section, the post-test results and their interpretations based on objectives and hypotheses of the study are presented.

4.4.1 Effects of Instructional Plans on Students' Achievement

In order to determine the effects of instructional plans on the subjects' achievement in mathematics, the students' pre-test and post-test scores in the MAT items were closely examined to identify any commonalities. The objective of the MAT was to ascertain whether or not there were significant understanding of concepts and skills in vectors by students in the different groups. Scores attained in the MAT measured this.

It is worth noting that the MAT assessed the students' general ability in understanding mathematics content – i.e. demonstration of factual, conceptual and procedural knowledge about concepts associated with mathematics. The hypothesis H_{01} was stated as follows:

H_{01} : Teachers' use of instructional plans has no significant effect on students' achievement in mathematics.

The results obtained are summarized in Table 4.4, which shows the frequency distribution of the pre-test and post-test scores obtained by the subjects in the MAT.

Table 4.4: Frequency Distribution of the Pre-test and Post-test Scores Obtained by the Subjects in the MAT

Marks	Test	Group							
		E ₁		E ₂		C ₁		C ₂	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
0-25	Pre-test	31		-	-	40	87.0	-	-
		91.2							
	Post-test	0	0	0	0	0	0	0	0
26-50	Pre-test	3	8.8	-	-	6	13.0	-	-
	Post-test	5	14.7	2	5.3	16	34.8	11	29.7
51-99	Pre-test	0	0	-	-	0	0	-	-
	Post-test	29	85.3	36	94.7	30	65.2	26	70.3

The data in Table 4.4 indicates that the frequency distributions of the pre-test scores of E₁ and C₁ follow similar trends. It is shown that in both groups, 31 (91.2%) and 40 (87.0%) students scored between 0 and 25 marks while only 3 (8.8%) and 6 (13.0%) students scored 26 marks and above respectively. None of the students scored above 50 marks. This is indicative that the students in groups E₁ and C₁ had low understanding of the concepts in vectors.

The post-test scores distribution shows that no student scored below 25 marks in all the groups. However, in the groups E₁ and E₂, only 5 (14.7%) and 2 (5.3%) students scored marks in the range 26-50 respectively. In the C₁ and C₂ groups, there were 16 (34.8%) and 11 (29.7%) students who scored marks in the same range. In the groups E₁ and E₂, 29 (85.3%) and 36 students (94.7%) respectively scored marks in the

range 51-99, while 30 (65.2%) and 26 (70.3%) students in the groups C₁ and C₂ scored similar marks. These trends reveal that the implementation of the mathematics course benefited all the students. The scores of the students had improved remarkably. However, the percentages obtained by the students in the treatment groups (E₁ and E₂) in the post-test are much higher (85.3% and 94.7% respectively) than those in the control groups C₁ and C₂ at 65.2% and 70.3% respectively in the range 51% - 99%.

There is some indication that the use of instructional plans was modestly effective in promoting the students' factual, conceptual and procedural understanding of the mathematical concepts. A further comparison of the means and standard deviations was done for both the pre-tests and post-tests of the MAT for all the groups. The results are shown in Table 4.5.

Table 4.5: Comparison of the Performance in Section A of the MAT

Scale	Overall	Group							
		E ₁		E ₂		C ₁		C ₂	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Pre –test	12.06	12.24	5.16	-	-	11.87		-	-
Post-test	26.80	29.06	3.16	25.84	4.77	4.31		26.38	
Mean Gain	14.74	16.82	-		-	26.48		3.85	
						2.96		-	-
						14.61	-		

Table 4.5 shows that the difference in the mean scores for groups E_1 (29.06) and E_2 (25.84) in the post-test is small, showing these performances are not so different from each other. The mean scores for C_1 (26.48) and C_2 (26.38) in the post-test are also comparable. Overall, the groups' mean gain on students' achievement in knowledge of concepts in vectors was 14.74.

These results show that the subjects in E_1 attained a mean gain of 16.82, which is higher than the mean gain of 14.61 of the control group C_1 . Again, the mean gain of E_1 is higher than overall mean gain and the mean gain of C_1 is lower than the overall mean gain. This is an indicator that the experimental group gained more than the control group. Similarly, the lack of significant difference among the post – test mean scores of the experimental groups (E_1, E_2) on the MAT was probably due to the instructional plans to which they were exposed. In order to determine whether the difference in mean scores between the two groups (experimental and control) was significant, a one – way ANOVA was performed. Table 4.6 summarizes the results.

Table 4.6: An ANOVA of the Post – test Scores of the Groups in Section A of the MAT

Source	dF	SS	MS	F-ratio	P – value
Between groups	3	227.17	75.72	2.69*	0.00
Within groups	151	4250.32	28.15		
Total	154	4472.15			

* denotes significant mean difference at $P < 0.05$; $F_{0.05 [3,151]} = 2.609$

The results in Table 4.6 reveal that the differences in the post-test mean scores of section A of the MAT are statistically significant. This suggests that the students who were taught using the Instructional Plans performed better than those who were taught without use of the same in section A of the MAT.

Considering the results in Tables 4.4, 4.5 and 4.6, it can be concluded that the post-test mean scores obtained by subjects in groups E₁ (29.06) and E₂ (25.84) were not significantly different at P<0.05. Also, the mean scores of groups C₁ (26.48) and C₂ (26.38) were not different. However, to see if the mean scores obtained by subjects in groups E₁ and C₁ ; E₂ and C₁ ; E₂ and C₂; C₁ and C₂; E₁ and E₂ were statistically different and to determine the direction of the difference, an independent samples t-test was performed and the results are shown in the Table 4.7.

Table 4.7: Independent Samples t-test of the Post-test Mean Scores of MAT

Groups	DF	t-value	2 -tail	Critical value
E ₁ V _S C ₁	78	4.74*	0.02	1.67
E ₁ V _S C ₂	69	3.56*	0.84	1.67
E ₂ V _S C ₁	82	6.06*	0.01	1.67
E ₂ V _S C ₂	73	4.55*	0.25	1.67
C ₂ V _S C ₁	81	0.79	0.01	1.67
E ₂ V _S E ₁	70	0.26	0.01	1.67

*demonstrates significant at P<0.05

The results of Table 4.7 show that there is a significant difference in achievement between the experimental and control groups. The significant t-values indicate that

the experimental groups gained more than control groups. However the t-values of C_2 Vs C_1 ($t=0.79$) and E_1 Vs E_2 ($t=0.26$) show that the respective mean scores were not statistically different. This suggests that the students who were taught using the Instructional Plans performed comparably similarly. Those taught without the Plans performed similarly to each other.

4.4.2 Effects of Instructional Plans on Students' Skill Performance in Mathematics

The section B of the MAT ascertained students' competency in skill performance in vectors before and after the students were exposed to mathematics lessons using instructional plans and those taught without use of the instructional plans. The results are presented in Table 4.8.

Table 4.8: Comparison of the Performance in Section B of the MAT

Scale	Overall	Group							
		E ₁		E ₂		C ₁		C ₂	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-test	2.53	2.53 ^a	4.52	-	-	2.52 ^a	2.93	-	-
Post – test	35.64	41.41 ^b	14.99	42.26 ^b	12.49	27.96 ^c	8.26	30.92 ^c	8.81
Mean-Gain	33.11	38.88	-	-	-	25.44	-	-	-

^{a,b,c} denotes the mean scores are comparable.

The results of Table 4.8 show that the pre-test mean scores obtained by the subjects in groups E₁ (2.53) and C₁ (2.52) were not much different before the start of teaching of concepts in vectors. After the subjects were exposed to the concepts in the topic,

the subjects in the E_1 scored higher than C_1 . However, group E_2 was close to E_1 and C_2 to C_1 in performance. This suggests that there were differences in the mean scores obtained between the Experimental groups (E_1 and E_2) and Control groups (C_1 and C_2). This implies that students' skill performance in vectors in the treatment groups was better than that of Control groups by 13.44. In order to establish whether the mean differences were significant, a one-way ANOVA test was done and the results are summarized in Table 4.9.

Table 4.9: ANOVA Results of the Post –test Scores of Subjects in Section B of the MAT

Source	dF	SS	MS	F-value	P-value
Between groups	3	6,911.58	2,303.86	22.27*	0.03
Within groups	151	15,620.96	103.45		
TOTAL	154	22,532.54			

*indicates significant at $P < 0.05$; $F_{0.05 [3,151]} = 2.609$

From the results of Table 4.9, the F-ratio of 22.27 indicates that the mean scores of the groups were significantly different. In order to determine the direction of the difference, an independent samples t-test was performed and the results obtained are shown in Table 4.10.

Table 4.10: Independent Samples t-test of Post-test Scores in Section B of the MAT

Group	DF	t-value	2-tail	Critical value
E ₁ Vs C ₁	78	4.74*	0.84	1.67
E ₁ Vs C ₂	69	3.56*	0.92	1.67
E ₂ Vs C ₁	82	6.06*	0.71	1.67
E ₂ Vs C ₂	73	4.55*	0.64	1.67
C ₁ Vs C ₂	81	1.13	0.17	1.67
E ₁ Vs E ₂	70	0.85	0.23	1.67

*Significant at $P < 0.05$

The results in Table 4.10 show that the mean scores obtained by the subjects in the Experimental groups were significantly different and higher than those in the Control groups. This is shown by the t-values of Experimental groups against the Control groups as E₁ Vs C₁ (t= 4.74) ; E₁ Vs C₂ (t= 3.56) ; E₂ Vs C₁ (t= 6.06) and E₂ Vs C₂ (t= 4.55) at $P < 0.05$ level that were obtained.

From the results of Tables 4.8, 4.9, and 4.10, it can be concluded that the post-test mean scores of Experimental groups (E₁ = 41.41) and (E₂ = 42.26) are not statistically different. However, there is a statistically significant difference between the Experimental and Control groups at 0.05 level of significance. The t-values confirm the same statistical difference.

In view of the foregoing presentations, the Instructional Plans were found to be instrumental in improving student's understanding of concepts and skills in vectors.

The null hypothesis that use of Instructional Plans has no significant effect on students' achievement in mathematics was rejected. This implied that the Instructional Plans were instrumental in improving student's understanding of concepts and skills in vectors.

4.4.3 Effects of Instructional Plans on Students' Attitude and Motivation Towards the Mathematics Course

The study utilized SAQ to determine attitude and motivation of the students due to using the Instructional Plans. The SAQ determined whether there was a significant difference between the students' attitude and motivation before and after using the Instructional Plans. This was compared to the responses of students taught without using Instructional Plans. Students were asked to reflect on how they perceived the learning of vectors in mathematics. The responses gave clues on perception about the teaching and learning of mathematics. The students' attitude and motivation towards mathematics were thus revealed. Table 4.11 presents pre-tests data on students' responses to question 2 of SAQ on learning experience in mathematics.

Table 4.11. Pre-test Responses to Learning Experience in Mathematics

Response	GROUP			
	E ₁		C ₁	
	Frequency	(%)	Frequency	(%)
Very interesting	3	8.8	4	8.7
Interesting	6	17.6	9	19.6
Boring	20	58.8	27	58.7
Very boring	5	14.8	6	13.0

From table 4.11, majority of the students (73.6% and 71.7% in both groups respectively) indicated that they did not find the learning of mathematics interesting. This is an indication that there is need for mathematics teachers to plan so as to change the students' attitude and motivation. The reasons given for this loss of interest in mathematics were:

- (i) Concentration on only on the bright students by the instructors
- (ii) Speed of content delivery is too fast.
- (iii) Use of few examples to illustrate concept
- (iv) Dull and uninteresting presentation

After the students had been exposed to the concepts in vectors, they were asked to reflect on how they found the learning of vectors. Table 4.12 presents the data on their responses.

Table 4.12: Post-test Responses on Learning of Vectors

Response	Group							
	E ₁		E ₂		C ₁		C ₂	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Very easy	21		25	65.8	23	50.0	21	56.8
	61.8							
Easy	5		2	5.3	4	8.7	6	16.2
	14.7							
Difficult	5		7	18.4	11	23.9	4	10.8
	14.7							
Very difficult	3		4	10.5	8	17.4	6	16.2
	8.8							

Table 4.12 shows that 76.5% students of E_1 and 71.1% students of E_2 found learning of vectors to be easy and 58.7% students and 73.0% for C_1 and C_2 respectively. This indicates that the experimental groups ($E_1 ; E_2$) and the control group C_2 had positive attitude towards mathematics. The reasons given by students in group C_2 for this positive attitude, quoted verbatim, were:

- (i) The teacher encourages us to do as many questions as possible.
- (ii) The teacher does not ignore us, especially those of us who are poor.
- (iii) The teacher uses simple language.
- (iv) The teacher is young and understands us.
- (v) The teacher is very friendly to us.
- (vi) The teacher gives us motivation.

Likert items in the SAQ were analyzed to test hypothesis two. The null hypothesis two was stated as:

H_{02} : There is no significant difference in the attitude and motivation towards mathematics between students taught by teachers using Instructional Plans and those taught by teachers who did not use them.

To test this hypothesis, the Likert items in the SAQ were scored between values 1 and 5. The scores were summed up and means and standard deviations calculated. The results are summarized in Table 4.13.

Table 4.13: Comparison of Performance in SAQ

Scale	Overall	Groups							
		E1		E2		C1		C2	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-test	62.97	64.21		-	-	61.73		-	-
		11.26				10.70			
Post-test	71.67	77.68		76.39		62.57		70.03	
		12.74		8.61		12.31		10.92	
Mean gain	8.70	13.47		-		0.84		-	

Table 4.13 shows that the pre-test mean scores of E₁ (64.21) and C₁ (61.73) are comparable. Also the post-test mean scores of all the groups E₁ (77.68), E₂ (76.39), are not different from each other. However, the post-test mean scores of C₁ (62.57) and C₂ (70.03) vary. The reasons for the high scores in attitude and motivation by C₂ are given in section 4.4.3. Overall, the mean gain of the subjects in group E₁, is 12.63 higher than that of group C₁.

Generally, the post-test mean scores of the Experimental groups (E₁ and E₂) are higher than the means of the Control groups (C₁ and C₂). This indicates that the subjects in the Experimental groups scored higher on attitude and motivation than those in the Control groups. A further analysis of the post-test mean scores using the one-way ANOVA produced the following results.

Table 4.14: ANOVA Results of the Post-test Scores in the SAQ

Source	DF	SS	MS	F-ratio	P-value
Between groups	3	5,934.23	1978.08	64.58*	0.000
Within groups	151	4,624.49	30.63		
TOTAL	154	10,558.72			

*This indicates significant at $P < 0.05$; $F_{0.05 [3,151]} = 2.6049$

The results of Table 4.14 confirm that the mean scores between the groups on the SAQ differ significantly at 0.05 levels. However, to determine the direction of the difference, an independent samples t-test was performed. Table 4.15 shows the results of the t-test.

Table 4.15: Independent Samples t-test for the Scores by Subjects in the SAQ on Attitude and Motivation.

Groups	dF	t-test	Critical value
E ₁ V _S C ₁	78	5.30*	1.67
E ₁ V _S C ₂	69	1.74*	1.67
E ₂ V _S C ₁	82	3.97*	1.67
E ₂ V _S C ₂	73	6.03*	1.67
SC ₂ V _S C ₁	81	1.63	1.67
E ₁ V _S E ₂	70	0.47	1.67

*Indicates significant at $P < 0.05$

From to the results of Table 4.15, the t-value of E_1 Vs E_2 ($t= 0.47$), there is no differences in attitude and motivation between the Experimental groups. However, t-values of C_1 Vs C_2 ($t=3.97$); E_1 Vs C_1 ($t=5.30$); E_2 Vs C_1 ($t=6.03$) and E_2 Vs C_2 ($t=1.63$) indicate that the mean-scores are statistically different. Again, the differences in the control groups in attitude and motivation are significant. This is because of the high mean score by the C_2 . Overall, the significant differences are in favor of the treatment groups.

From the foregoing presentations, it can be noted that although the groups E_1 and C_1 were pre-tested in the SAQ, their post-test scores are not significantly different from those of E_2 and C_2 who were not pre-tested (tables 4.13, 4.14, 4.15). The implication here is that the pre-test in the SAQ did not have impact on the post-test mean scores. This means that the significantly higher scores in the experimental groups were due to the use of the Instructional Plans and not by chance.

The above-discussed findings indicate that the null hypothesis two (H_{02}) in respect of students' attitude and motivation towards the mathematics course was rejected. From the data available (table 4.15), there was significant difference in the attitude and motivation between the experimental groups (E_1 ; E_2) who were taught using Instructional Plans and the control groups (C_1 ; C_2) who were taught without use of Instructional Plans. Students who learned mathematics concepts in the topic of vectors using the Instructional Plans approach achieved higher motivation and showed a more positive attitude towards the mathematics course than those taught without use of the same.

4.4.4 Effects of Instructional Plans on Students' Classroom Interactions During Mathematics Instruction

Part II of the SAQ determined difference in classroom interactions before and after using instructional plans. This difference was compared to the one obtained without use of the instructional plans. The null hypothesis tested was:

H₀₃: The use of instructional plans has no significant effect on classroom interactions during mathematics instruction.

The effects were ascertained by the one-way ANOVA of the mean scores as measured on a five point Likert scale. In addition, data collected using the MLOC supplemented the quantitative findings. It's worth noting that the tallies in MLOC were transcribed to scores. Table 4.16 shows the mean scores of the pre-test and post-test on classroom interactions

Table 4.16: Comparison of the Pre-test and Post-test Mean Scores and Standard Deviations on the Classroom Interactions (CI)

Scale	Overall	Groups			
		E ₁	E ₂	C ₁	C ₂
		Mean SD	Mean SD	Mean SD	Mean SD
Pre-test	27.06	27.05 ^a 5.07	- -	27.07 ^a 6.01	- -
Post-test	33.48	38.12 ^b 4.46	35.87 ^b 5.25	29.89 ^c 3.72	30.03 ^c 4.04
Mean Gain	6.42	11.07	-	2.82	-

a,b,c indicates comparable mean scores.

An examination of the results in Table 4.16 shows that the mean scores of the pre-test in groups E₁ (27.05) and C₁ (27.07) are not much different from each other. Further, the mean scores in the post –test in the groups E₁ and E₂ (38.12 and 35.87 respectively) are not very much different from each other. The mean scores for the control groups C₁ and C₂ at 29.89 and 30.03 respectively are also comparable. However, the following can be identified:

- i) The mean gain of E₁ (11.07) is higher by 8.25 points than that of C₁ (2.82).
- ii) The mean gain of the subjects in experimental groups (E₁ and E₂) is higher than the overall mean gain.
- iii) The mean gain overall on the classroom interactions is 6.42

These results indicate that the classroom interaction in the experimental groups was different from those in the control groups i.e. E₁ , E₂ > C₁ , C₂. However, in order to determine whether this difference was significant, a one-way ANOVA of the post-test scores was performed and the following results obtained.

Table 4.17: ANOVA Results of the Post-test Scores on the Classroom Interactions (CI)

Source	dF	SS	MS	F-ratio	P-value
Between groups	3	958	319.3	6.43*	0.002
Within groups	151	7,500	49.67		
TOTAL	154	8,458			

*Indicates significant at P<0.05 ; F_{0.05 [3,151]} =2.6049

Results of Table 4.17 indicate that the F- ratio is statistically significant because the calculated F- Value of 6.43 exceeds the critical value of 2.6049 at alpha level of 0.05. However, the analysis does not show the direction of the difference and so to determine this direction, an independent samples t-test was performed. Table 4.18 shows the t-values.

Table 4.18: Independent Samples t-test for the Subjects in the SAQ on Classroom Interactions

Groups	dF	t-value	2 – tail Sig.
E ₁ V _S E ₂	70	1.07	0.04
E ₁ V _S C ₁	78	8.75*	0.00
E ₁ V _S C ₂	69	7.85*	0.02
C ₂ V _S C ₁	80	0.19	0.01
E ₂ V _S C ₁	81	5.91*	0.00
E ₂ V _S C ₂	73	5.41*	0.00

* Means significant at P<0.05.

From the results of Table 4.18, the t – values of E₁ V_S E₂ (t=1.07) and C₁ V_S C₂ (t=0.19) are not statistically different. However the t – values of groups E₁ V_S C₁ (t=8.75) and E₂ V_S C₂ (t=5.41), E₂ V_S C₁ (t=5.91) and E₁ V_S C₂ (t= 7.85) indicate that the mean scores in the post –test are significantly different and in favor of the treatment groups.

From the analysis of the pre-test and post-test scores, it can be noted that although groups E₁ and C₁ were pre-tested, their post-test mean scores are not statistically different from those of groups E₂ and C₂, (35.87 and 30.03 respectively). This means that the pre-test did not have any influence on the post –test mean scores of the

classroom interactions. This implies that the significantly higher mean scores obtained by the treatment groups (E_1 and E_2) as compared to the Control groups (C_1 and C_2) were due to the teachers' use of the Instructional Plans and not by chance.

4.5 Further Analysis

The quantitative analysis of the results revealed that the use of Instructional Plans had effects on students' achievement, attitude and motivation and classroom interactions during mathematics course. The quantitative data collected was supplemented by qualitative data on the classroom interaction collected during mathematics lesson by use of Mathematics Lesson Observation Checklist, MLOC.

The purpose of the MLOC was to collect qualitative data on whether the use of Instructional Plans had significant effect on classroom interactions during lessons on the topic of vectors. Data on the interactions i.e. student – teacher, student-student, and student-resources was collected from at least three lessons from each of the four groups. This data was used to test hypothesis three which was stated as follows:

H_{03} : Use of instructional plans has no significant effect on classroom interactions during mathematics lessons.

The frequency of the classroom activities was summed up and converted to a percentage. The results are shown in Table 4.19.

Table 4.19: Comparison of Classroom Activities during Mathematics Lessons in Vectors by Percentage

CATEGORY	GROUP			
	E1	E2	C1	C2
TEACHER ACTIVITY				
	%	%	%	%
Reinforcing statements	6.7	7.0	6.1	6.4
Giving of clear instructions and directions	6.7	7.8	8.2	8.5
Supervision of learning activities	5.7	8.6	6.1	4.3
Asking of oral questions	7.6	7.8	12.2	10.7
Demonstration of mathematical skills	11.4	7.0	10.2	8.5
Explanation of concepts and skills	10.5	7.8	14.3	12.7
SUB-TOTAL	48.6	46.0	57.1	51.1
STUDENTS' ACTIVITY				
Giving responses to questions posed	11.4	6.1	6.1	6.4
Following instructions and directions given	6.7	7.8	6.1	6.4
Participating in classroom talk	4.8	7.0	2.0	2.1
Asking questions	3.8	4.4	2.0	2.1
Writing down examples and notes	3.8	7.0	4.2	6.4
Remembering concepts on previous content	6.7	10.4	4.2	2.1
Having periods of silence and/or inactivity	1.8	1.7	14.3	14.9
Consulting with each other during lesson	7.6	3.5	2.0	2.1
Eager to have class work marked	4.8	6.1	2.0	6.4
SUB-TOTAL	51.4	54.0	42.9	48.9
GRAND TOTAL	100	100	100	100

The results of Table 4.19 show the similarities and differences between the teachers' and students' activities in both the Experimental and Control groups.

From the results, the following can be noted. First, the teachers' activities in both Experimental groups E_1 , E_2 are 48.6% and 46.0% respectively which compares with 57.1% and 51.1% respectively for Control groups C_1 and C_2 . This means that the students in treatment groups (E_1 , E_2) participated more in classroom activities than the Control groups. The students' activities in the Experimental groups E_1 and E_2 were 51.4% and 54% respectively compared to 42.9% and 48.9% for Control groups C_1 and C_2 respectively. Also, the students in the Control groups had more moments of silence/ inactivity during the mathematics lessons at 14.3% and 14.9% for C_1 and C_2 respectively compared with treatment groups E_1 and E_2 , which had 1.8% and 1.7% respectively. This means that students in the Control groups were rather passive learners and this might explain the low achievement witnessed in the MAT.

Worth noting is the fact that there was little co-operative learning for the Control groups (2.0% for C_1 and 2.1% for C_2) unlike in the treatment groups which accounted for 4.8% for E_1 and 7.0% for E_2 . The identified learning activities in the Instructional Plans for students to work on might explain why the Experimental groups performed better than Control groups in both the MAT and the SAQ.

To find out if these interactions had statistical differences, the frequencies (tallies) were converted to a score. The scores for the classroom activities observed were used to find out if the treatment groups taught using instructional plans differed from those taught without use of the same. The results are shown in table 4.20.

Table 4.20: Means and Standard Deviations Obtained by Groups in Classroom Activities on MLOC

Group	E₁	E₂	C₁	C₂
Mean	7.0	7.7	3.3	3.1
S.D	4.11	4.28	2.14	2.21

From the comparison of the mean and standard deviations of the scores in both Experimental and Control groups, it can be seen that the means of E₁ (7.0) and E₂ (7.7) are much higher than those of Control groups C₁ (3.3) and C₂ (3.1). The treatment groups have comparable results, which may be attributed to the same treatment given i.e. use of Instructional Plans. To establish the significance of this difference between the four groups, a one – way ANOVA gave the following results.

Table 4.21: ANOVA Results of the MLOC Scores

SOURCE	dF	SS	MS	F-ratio	P-value
Between groups	3	61.23	20.41	5.41*	0.00
Within groups	15	56.48	3.77		
Total	18	117.71			

*Means significant at 0.05 level of significance. $F_{0.05 [3,15]}=3.29$

The one-way ANOVA results in Table 4.21 show that the F-ratio (5.41) is significant at $p < 0.05$. This indicates that the mean scores obtained by the Experimental groups and Control group in the classroom interactions were significantly different. From this presentation, it can be inferred that the significantly higher mean scores obtained in interactions by the treatment groups as compared to Control groups was due to the

teachers' use of the Instructional Plans. Therefore the null hypothesis that use of Instructional Plans had no significant effect on classroom interactions was rejected.

4.6 Discussions

The discussions presented in this section are based on the research findings aimed at achieving the objectives and hypotheses of the study. The first research objective was to find out the effects of teachers' use of the Instructional Plans on students' achievement in vectors. From the findings, it was established that use of Instructional Plans by the teachers during mathematics lessons resulted in improved understanding of the concepts. The students in the Experimental groups demonstrated more factual, conceptual and procedural knowledge of concepts in vectors as was evident from the higher mean scores and gains attained in the MAT.

The above findings agree with Nyambura (2004) that identified learning tasks provide reasonable opportunity for every student to have some success and provide a means for students to check on their own progress. The findings are also in line with Indimuli (2004) who found that students have better understanding of concepts in mathematics if the class exercises and learning tasks are well structured and planned in advance.

The results also show that with planned learning activities and tasks for the lessons, understanding is enhanced amongst the students. This concurs with the KNEC report (2006) which emphasizes that teachers need to prepare adequately for lessons before exposing students to mathematical concepts and skills. Thus, advance and adequate

lesson preparations are a pre-requisite to improved understanding of concepts and skills by students.

The second objective aimed at finding out the effects of teachers' use of instructional plans on students' attitude and motivation towards mathematics. The data generated revealed that the teachers who used the Instructional Plans created conducive learning environment for students to learn. The Instructional Plans were a rich source of activities that encouraged interactions and sharing of ideas. The data showed that over 70.0% of students in the Experimental groups (Table 4.12) found learning of mathematics easy. This implied that if teachers clearly identify the objectives and learning tasks for the lesson, then an organized learning environment is created thus leading to a positive attitude towards mathematics. The significantly higher mean gains in attitude and motivation in Experimental groups confirm the same. These results are in agreement with earlier findings by Indimuli (2004), Makunja (2003) and Kiragu (2002) that planned learning tasks and clear objectives enhance learning of mathematics concepts by students. From these studies, positive significant relationships were found between lesson preparations, teaching method and students' attitude towards mathematics.

Again, the findings on reasons why students lost interest in mathematics indicated that it is the teachers who contribute towards students' poor attitude and motivation towards mathematics. The reasons cited like only concentrating on bright students, use of few examples, dull and uninteresting presentations are indicative of inadequate lesson preparations by the teachers. The high mean scores in SAQ were indicative of the change of attitude by the students in experimental groups. These

observations are in line with Waithira (2008) and Nyambura (2004) that when teachers create opportunities for learning tasks, where all students participate in the lesson, then, there is a chance for improvement in students' attitude towards the subject.

The third objective of the study was to find out the effects of use of the Instructional Plans on classroom interactions during mathematics lessons. The results of the MLOC showed that the students' activities in the Experimental groups were much higher than those in the Control groups (Table 4.19). The higher percentages in classroom talk (4.8% and 7.0%) for E₁ and E₂ respectively, answering of questions and consultations with each other during the lesson attest to the fact that use of Instructional Plans resulted in more classroom interactions as compared to the Control groups. This finding concurs with Wasike (2003) and Miheso (2002) that meaningful learning often develops best in classroom environments that give students more opportunities for participatory interaction.

Further, the findings that the experimental groups had high classroom interactions agree with Makunja (2003) that teachers' design of learning activities and tasks leads to more interactions in class. This is helpful especially to the low achievers who are encouraged to become active participants in class. The result is that this leads to development of both positive attitude and therefore improved performance in the subject.

The findings are also in agreement with Nyambura, (2005) that classroom interactions are mainly determined by the teacher who ensures that the class is a

conducive place for students to learn. The findings therefore indicate that there is a chance for teachers to encourage friendly atmosphere during lessons. Simpson (2001) notes that well designed learning tasks provide reasonable opportunity for every student to have some success and provide a means for students to check on their progress. This explains the reason why there were a lot of opportunities for classroom interactions and more students' participation (Tables 4.18, 4.19).

Finally, it can be noted from the findings that the teachers who used the Instructional Plans during the mathematics lessons did not dominate the classroom activities. This finding is in line with Orton (2002) that a teacher who tries out learning activities before presentation leads to meaningful learning.

In conclusion, the findings have shown that use of Instructional Plans by the teachers enhanced students' achievement in vectors and improved their attitude towards mathematics. The findings also show that classroom interactions amongst the students, with the teachers and resources were in favor of the Experimental groups.

4.7 Summary

This chapter has presented and discussed the data collected in order to accept or reject the hypotheses developed for testing on effects of Instructional Plans on students' achievement, attitude, and motivation and classroom interactions. The hypotheses were tested at alpha level of 0.05. The pre-test and post-test results have shown that use of the Instructional Plans on the treatment groups had a positive impact on achievement, attitude, motivation and classroom interactions. The findings have shown that use of Instructional Plans encourages interactive and cooperative

learning through the pre-planned activities and promotes more classroom interactions.

The significant learning gains cited give evidence that the Instructional Plans were effective in influencing the classroom interactions during the lessons. Moreover, the students were motivated to ask and answer questions in class.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the study findings in view of objectives that were investigated. It also gives the implications, recommendations and suggestions for further research.

5.2 Summary of Findings

The purpose of the study was to investigate the effects of teachers' use of Instructional Plans on students' achievement, attitude and motivation and classroom interactions. The research involved 155 students in public secondary schools in Makeni district.

Three hypotheses were tested statistically for this study. These were:

Ho₁: Teachers' use of Instructional Plans has no significant effect on students' achievement in mathematics.

Ho₂: There is no significant difference in the attitude and motivation towards mathematics between students taught by teachers using Instructional Plans and those taught by teachers who did not use them.

Ho₃: Use of Instructional Plans has no significant effect on classroom interactions during mathematics lessons.

From the findings on achievement, it was established that the students who were exposed to mathematics content by teachers who used the Instructional Plans gained

more of the needed knowledge, concepts and skills in the topic vectors. This was deduced from the higher mean scores obtained on all the measures taken by students in the Experimental groups as compared to the Control groups. On achievement, the findings show a positive influence on students' knowledge in mathematics as far as the Instructional Plans is concerned. This is an indication that when teachers use prior well prepared instructional plans for their lessons, then the students' understanding of concepts is enhanced.

On attitude and motivation, which were tested using Ho₂, the results indicate that the teachers' use of Instructional Plans improved the students' attitude towards mathematics lessons and on the whole towards the mathematics course. The significant differences in mean scores between the Experimental and Control groups confirm this. Implementation of learning tasks that were outlined in the worksheets provided learners with an opportunity for mastery of the concepts learnt. The tasks also encouraged more classroom interactions amongst the students and with the teacher.

Ho₃ was tested using data collected by use of MLOC. The results of the MLOC indicate that there were more students' activities in the Experimental groups than in the Control groups. Further, the teachers' role in the control groups was more dominant as opposed to the experimental groups. This was an indication that there were more student-centered learning opportunities and this encouraged more classroom interactions. On the whole, the results suggest that teachers' use of instructional plans had positive effect on students' classroom interactions and improved their attitude and motivation towards the mathematics course.

In conclusion, the findings of the study on all the three hypotheses affirmed that teachers' use of Instructional Plans had significant effects on students' achievement, attitude and motivation and classroom interactions. The results of inferential statistics have shown that there were significant differences between the mean scores obtained by the experimental groups (E_1 , E_2) and control groups (C_1 , C_2) in MAT and SAQ tested at 0.05 level of significance. The use of Instructional Plans during mathematics lessons led to higher achievement, better interaction and improved attitude towards mathematics.

5.3 Conclusions

The following conclusions of the study were drawn: First, it was established that students' achievement in mathematics can be improved if teachers make adequate preparations that involve identification of the objectives to be achieved, learning tasks to be done by the students and evaluation procedures to be used during the lesson. It was noted that the planned learning tasks in the Instructional Plans involved considerable learner participation. The control groups, which did not use the Instructional Plans, were denied these tasks and their achievement was lower than the experimental groups.

Second, the study found that without proper lesson preparations, poor attitude continued to dominate students in mathematics. If lesson preparations are well done, then the students have the opportunity to participate in lesson presentations, share amongst themselves and this may result in change of attitude towards mathematics.

Third, analysis of data on comparison of scores obtained by the students in the two groups revealed that the practical learning tasks, interaction with resources as a result of use of worksheets resulted in more classroom interactions by the students in the experimental groups. The study has further revealed that there is a significant relationship between use of the Instructional Plans in mathematics teaching and teaching-learning interactions. Students taught by teachers who used the Instructional Plans had more self-directed learning tasks which enabled them to share and interact more during the mathematics lessons.

Overall, the findings indicate that prior and advance lesson preparations where the objectives are clearly identified, learning tasks well sequenced and main interactions identified, then there is more gain in skills as well as improved attitude and motivation towards mathematics. Interactions also increase and this enables the students to be active participants in the learning process.

5.4 Implications of the Findings

Several implications can be inferred from the findings of this study.

(a) Implications for teachers

It is important that teachers should be encouraged to use Instructional Plans in their lessons to improve performance of students in mathematics. The use of Instructional Plans in this study has shown that when prior adequate preparations are made, i.e. lesson objectives identified, learning tasks and activities identified and evaluation procedures spelt out, then the students gain more in the teaching- learning process. The simple, clear, well-structured worksheets enabled the students in the

experimental groups to have higher mean gains than the control groups. The proposal from KNEC Report (2006) that teachers need to prepare adequately before subjecting learners to concepts gives a basis for teachers to adopt the instructional plans used in this study.

The mathematics teachers need to develop elaborate and well thought out learning activities, which can be implemented individually, in pairs or in groups by the students. Absence of such may result in low mean scores as witnessed by the performance of control groups C_1 and C_2 .

(b) Implications for school administrations

Head teachers have a major role in promoting the teaching- learning process and especially for the benefit of the student. The performance levels of the control groups have demonstrated the inherent weakness of “normal” instructional process. These are the practices where teachers use teaching notes that are not updated, have no programmed learning tasks and exhibit signs of inadequate lesson preparations. They also have a duty to ensure that the mathematics teachers have the necessary professional records and learning resources required for improved achievement by students.

Head teachers also need to carry out regular checks on students work to note what they have covered and how it was covered. This will help improve the teachers’ overall instructional performance and students’ achievement, not only in mathematics but in other subjects.

(c) Implications to Quality Assurance and Standards Officers (QASO)

The QASO have the responsibility of establishing and maintaining quality in education standards. They need to recognize the important role played by professionally prepared instructional products, which should reflect the learning activities and the role of the students in the learning process. These must be regularly used and updated by the teachers in the course of the teaching –learning process. This can be achieved through regular subject inspections in the schools. They therefore need to carry out these inspections to identify the usefulness of instructional products in the instruction process.

There is need for them to acknowledge that teachers need to use instructional plans so as to improve students' achievement. Therefore, they need to visit teachers and see the instructional products they are using, and whether they are flexible and addressing the different levels of learners in the classroom. Failure by teachers to prepare instructional guidelines might result in performance patterns seen in groups C₁ and C₂. This calls for familiarization with skills in instructional design and implementation so as to effectively guide teachers in use of the same.

These findings therefore suggest that the QASO need to regularly visit the practicing teachers for the benefit of the student who is the central player in the learning process.

5.5 Recommendations

Based on the findings and conclusions, the study recommends that:-

(a) The Instructional Plans used in this study be adopted for the teaching and learning of the topic of vectors in mathematics. This is on the basis of significant differences in learning gains obtained by students in the experimental groups. It is important that teachers have well prepared and identified learning activities because these are the component that enables students to create meaning of their learning.

(b) Professional development programs should be strengthened so as to improve teachers' competence in instructional design. Currently, the SMASSE project has a vision of enhancing the potential of teachers in realistic instructional design. Such a project should incorporate the Instructional Plans and use them to improve the teachers' competence in instructional planning. Based on significant effects of the Instructional Plans on students' achievement, attitude and classroom interactions, the plans can be used as a strategy for strengthening teaching and learning of mathematics.

(c) The Instructional Plans had learning tasks which enabled students to be active participants in the learning process and this enabled the students to be responsible for their learning. It is therefore recommended that every mathematics lesson should encompass planned learning activities because they are the tenets of a meaningful lesson.

5.6 Suggestions for Further Research

(a) The study be replicated on basis of an expanded sample of schools in the provincial and national categories of secondary schools.

(b) With onset of information revolution, use of information technology, internet among other innovative teaching- learning approaches to teaching and learning of mathematics to improve students' achievement are encouraged. Hence, more research on the integration of IT to encourage student participation and achievement is recommended. Such include use of computers to teach vectors and other related topics like matrices and 3-dimensional geometry.

(c) There is need to carry out a study on which other topics are deemed difficult and reasons for such.

(d) There is need to carry out research on use of instructional products by newly employed teachers vis-a-vis long-serving teachers so as to determine their usefulness.

REFERENCES

- Allan, C.O. (1990). *Strategies for effective teaching*. New York: Harper and Row.
- Allan, C. and Louis, C. (1988). *Primary education: A source book for teachers*. London: Paul Chapman Publishers.
- Ausubel, D.P. (1978). *Education psychology as a cognitive view* in Cooney et al (1975). *Dynamic of teaching secondary mathematics*. Boston: Houghton Mifflin Publishers.
- Biggs, J. (1999). *Teaching for quality learning at university*. Buckingham: Society for research in higher education and Open University press.
- Biggs, J. and Pollard, A. (2003). *Reflective teaching: Effective and Evidence-informed professional practice*. New York: Continuum Publishers.
- Borg, R.W. (1987). *Educational Research: A practical guide for Teachers*. New York: Macmillan Publishing Company.
- Brow, J.F., Lewis, R.G. and Harceleroad, D.W. (1983). *A- V instruction: Teaching, Media and method*. New York: McGraw Hill Book.
- Bruner, J. S. (1966). *The process of education*. Cambridge, Mass: Harvard university press.
- Cockroft, W.H. (1982). *Mathematics counts. Report of the committee of inquiry into the teaching of mathematics in schools*. Her majesty stationery office, London.
- Cooney, T.J. (1992). *Evaluating teaching of mathematics: The road to progress and reform* (Arithmetic teacher. no. 39).
- Cooper, J.M. (ed.) (1998). *Classroom teaching skills 7th edn*. Boston: Houghton Mifflin company.

- Costello, J. (1991). *Teaching and learning mathematics, 11-16*. London: Routledge, Chapman Italy Inc.
- Cox, M., Webb, M., Abbot, C., Blakeley, B., Beauchamp, T., and Rhodes, V. (2000). *“ICT and pedagogy: A review of research literature.”* ICT in schools research and evaluation series No. 18.
- Dean, G.P. (1982). *Teaching and learning mathematics*. Great Britain: Woburn.
- Di Bentley, W.M. (1992). *Communicating in school science: Group tasks and problem-solving 5 – 16*. London: The Falmer Press.
- District Education Office (2007). List of Secondary Schools, Makueni District.
- Doll, C.R. (1989). *Curriculum improvement: Decision making and process*. Boston: Allyn and Bacon.
- Ebel, R.L. and Frisbie, D.A. (2004). *Essentials of educational measurement*. New Delhi: Prentice- Hall of India.
- Eshiwani, G. (1985). *Education in Kenya since independence*. Nairobi: East African Educational Publishers.
- Eshiwani, G.S. (1993). *Research into methods of teaching mathematics*. Nairobi: Kenyatta University.
- Fennema, E. and Sherman, J.A. (1976). *Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females*. Catalog of selected documents in psychology, 6 (1), 31
- Gachenga, S.K. (2007). *The influence of teaching methods on student’s achievement in mathematics in Kieni divisions, Nyeri district. Kenya*. Unpublished Master of Education project, University of Nairobi.

- Gorard, S. (2001). *Quantitative methods in educational research; The role of numbers made easy*. London: Continuum publishers.
- Harcel- Lerold, D.W. (1983). *Technology, Media and Methods* (6th ed.) New York: MCGraw.
- Indimuli, J. (2004). “*The role of lesson preparation in management of learning challenges in secondary schools, Bungoma District*” An unpublished Master of Philosophy thesis, Moi University.
- Ingule, F., and Gatumu, H. (1996). *Essentials of educational statistics*. Nairobi: East African Educational Publishers.
- Kathuri, N.J. and Pals, G. (1993). *Introduction to Educational Research*. Egerton University: Education Media Centre.
- Kenya Institute of Education (2002). *The secondary school syllabus, Vol. 7*. Nairobi: Government printer.
- Kenya National Examinations Council, KNEC (2002). *Kenya Certificate of Secondary Education, KCSE 2001 report*, Nairobi: KNEC.
- Kenya National Examinations Council, KNEC (2006). *Kenya Certificate of Secondary Education, KCSE 2005 report*, Nairobi: KNEC.
- Kenya National Examinations Council, KNEC (2007). *Kenya Certificate of Secondary Education, KCSE 2006 report*, Nairobi: KNEC.
- Kihara, J.M. (2003). *The extent to which KCPE mathematics results predict performance in mathematics at KCSE. A case of National schools*. Unpublished Master of Education thesis, Kenyatta University.

- Kiragu, F.W. (2002). *A study of factors that affect achievement in mathematics at secondary school level in Kenya*. Basic Education Research Centre, Kenyatta University, Seminar paper No. 79.
- King'oriah, F. (2004). *Fundamentals of applied statistics*. Nairobi: Jomo Kenyatta Foundation.
- Knight, T.P. (2002). *Being a teacher in higher education*. Ballmoore: SRHE Open University
- Koul, L. (1990). *Methodology of educational research*: Bombay: Vikaz publishing House, PVT Ltd.
- Makunja, C. (2003). *Teacher competence in instructional design. A case of Bungoma District*. Unpublished Master of Philosophy thesis, Moi university.
- Merger, M. and Clack, M.(1988) cited by Rowntree 1990: Role of objectives in teaching in Rowntree (1974). *Education Technology in curriculum development*. London: Harper and Row Publishers.
- Miheso, K.M. (2002). “ *Factors affecting mathematics performance among secondary school students in Nairobi province.*” Unpublished Master of Education thesis, Kenyatta University.
- Minutes of meeting between the Japanese evaluation team and the authorities concerned of the Government of the Republic of Kenya and JICA on: *Strengthening of Mathematics and Science Education (SMASE) Project (2003)* Nairobi: Government Printer.
- Ministry of Education (2004). *Careers information* . Nairobi: Government printer.
- Mugenda, O.M. and Mugenda, A.G. (1999). *Research Methods: Quantitative and qualitative approaches*. Nairobi: ACTS Press.

- Mwamwenda, T.S. (2002). *Educational psychology: An African perspective* (3rd ed.) Durban: Heinemann publishers Ltd.
- Nacino- Brow, R.; Oke, F.E. and Brown, D.P. (1992). *Curriculum design and instruction: An introduction to methods of teaching*. Auckland: Macmillan press Ltd.
- National Council of teachers of Mathematics, NCTM. (2000). *Curriculum and Evaluation Standards for School Mathematics*, Reston, V.A: The council.
- Njuguna, S. (1998). *The relationship between attitudes and academic achievement in science subjects of form 4 students in Kigumo division, Kenya*. An unpublished Master of Philosophy thesis, Moi University, Kenya.
- Nyambura, H.N. (2005). “*Students’ perception of teachers’ classroom behaviour and academic performance in English language. A case of secondary school students in Gucha district*”. Unpublished Master of Philosophy thesis, Moi University.
- Nyambura, G. (2004). *Determination of classroom discourses patterns that enhance mathematics learning in selected public schools, Nakuru district, Kenya*. Unpublished Master of Education thesis, Kenyatta University.
- Odundo, P.A. (1999). “*The impact of instructional methods on students’ achievement in Business Education in Kenya’s Secondary Schools*.” Unpublished Doctoral thesis, University of Nairobi.
- O’Hara, M. (2004). *Meeting the standards for initial teacher training and induction*. London: Continuum publishers.
- Orton, A. (1987). *Teaching mathematics: Issues, theory and classroom practice*. London: Casell education Ltd.

- Oyaya, E.O. and Njuguna, B.M.(1999). *Strengthening mathematics and sciences in secondary education: A paper presented to Kenya National Heads' Association conference*. Mombasa, Kenya.
- Perrot, E. (1992). *Effective teaching: A practical guide to improving your teaching*. New York: Longman Group Ltd.
- Piaget, J. (1964). Cognitive development theory in Modgil S. (1974). *Piagetian Research*. NFER (Berks)
- Pollard, A. and Filer, A. (2000). *The social world of pupil assessment*. London: Continuum Publishers.
- Royse, D. (2003). *Research methods in social work*, (4th edition). New York: Thomson Brooks Ltd; USA.
- Sangster, M. and Lyn, O. (2003). *Secondary teacher's handbook*. New York: Continuum Publishers.
- Shulman, L. (1997). *Knowledge and teaching: Foundations of the new reform*. Harvard Educational review., 57: 1-22.
- Simpson, A. (2001). *Teaching and assessing skills in mathematics*. London: Cambridge University Press, U.K.
- Skemp, R.R. (1971). *The psychology of learning mathematics*. London: Penguin Books Inc.
- Sotto, E. (1999). *When teaching becomes learning: a theory and practice of teaching*. London: Continuum Publishers.

Strengthening mathematics and sciences in secondary education (2004).

Evaluating implementation of mathematics teaching strategies. Vol. 2
SMASSE unit Nairobi.

The Kenya National Examinations Council (2005). *The years 2001 – 2005 examinations Report: Nairobi: The Kenya National Examinations Council.*

Too, J.K. (2004). “*Towards effective mathematics instruction: A classroom study of questioning, task supervision and learning activity in secondary schools in North Rift Valley Province, Kenya*” An unpublished Doctor of Philosophy thesis, Moi University.

Totally Integrated Quality Education and Training, TIQET. Report of the commission of inquiry into the education system of Kenya (1999). Nairobi: Government printer.

Tum, C.P. (2006). *Education trends in Kenya: A vocational perspective.* Nairobi: Jomo Kenyatta Foundation.

Waithira, G.A. (2008). *Impact of Quality Assurance and standards on education quality in secondary schools in Nyeri South district, Kenya.* An unpublished Master of Education thesis, University of Nairobi.

Wasike, D.W. (2003). “*Effects of a Socialized Mathematical Language Module on Students’ Understanding of Mathematics and their Perception of Learning Environment: A Case of Form 2 students of Bungoma District , Kenya*”. Unpublished Master of Education thesis, Egerton University.

APPENDIX I
STUDENTS' ATTITUDE QUESTIONNAIRE

Part A: Instructions

This questionnaire is meant to get your views and opinions on learning of the Mathematical concepts and skills. The responses will be used only for research purposes and the findings will be of great importance in improvement of teaching – learning practices.

Please do not write your name anywhere in this questionnaire.

Part B:

1. (i) What is your age?years.

(ii) What is your sex?

2. Please indicate by placing a tick (✓) against either:

SA – Strongly Agree

D – Disagree

A – Agree

SD – Strongly Disagree

U – Undecided

on the following statements on Mathematics and Mathematics lessons.

		SA	A	U	D	SD
I	The Mathematics lessons are interesting					
ii	The Mathematics concepts and skills are not presented systematically.					
iii	The teacher presents the content to be learned in a simple and organized way.					
iv	The students are not given adequate time to answer to oral questions.					
v.	The examples and illustrations given during the lessons are adequate.					
vi.	The teacher teaches at a pace that allows me to understand the concepts.					

3. Below are statements relating to the teaching and learning of the topic vectors.

Please tick the response that closely reflects your opinion.

		SA	A	U	D	SD
I	The topic was presented in a simplified way that enhanced understanding of the concepts.					
Ii	The group activities were a boost to understanding of the topic.					
Iii	Presentation of the sub-topics was well organized and easy to follow.					
Iv	Use of practical/ real-life examples made the topic easy to understand.					
v.	The topic was too difficult to understand.					
vi.	I took shortest time possible to attempt the exercises during the lesson.					
Vii	Attempting similar questions in the exercises after the lesson was easy.					
Viii	I did not enjoy the Mathematics exercises in this topic.					
Ix	I did the Mathematics questions after every sub-topic with ease.					

4. The statements below are intended to get your views on classroom interactions during the Mathematics lessons. Please tick against either SA, A, U, D or SD.

		SA	A	U	D	SD
I	There are no questions asked during the lessons by the teacher.					
Ii	The worksheets and group work activities enabled us to understand the concepts.					
Iii	The class questions are marked and corrected during the lesson.					
Iv	There are no planned exercises to attempt during the lessons.					
v.	Clear instructions and directions on what to do during					

	the lessons are given.					
vi.	The students are guided in working out Mathematical activities.					
Vii	The students are allowed to consult with each other during the lesson.					
Viii	The students are given adequate time to answer the oral questions posed by the teacher.					
Ix	There were periods of inactivity during the Mathematics lessons.					
X	The directions and instructions given for paired activities are clear.					

Part C

1. How are Mathematics textbooks used in your classroom during Mathematics lesson? (Please tick).

- i) Only the teacher has the textbook
- ii) I use the book by myself
- iii) I share with a colleague
- iv) I share with three or more colleagues

2. Which of the following is true about your learning experience in mathematics? (Please tick).

- i) Very interesting
- ii) Interesting
- iii) Boring
- iv) Very boring.

3. Please give a reason for your response in question 2 above.

.....

4. Which of the following is true about how you have found learning of vectors?

- i) Very easy
- ii) Easy

- iii) Difficult
- iv) Very difficult

5. Please give a reason for your response in question 4 above

.....
.....
.....

Thank for your co-operation.

JOSEPH M. WAMBUA

APPENDIX II

INSTRUCTIONAL PLANS

A long journey starts with the first step. However, before the first step is made, adequate preparations need to have been done for the journey, reason for the journey known and requirements for the journey need to have been packaged well in advance. Similarly, planning a lesson is a necessary requirement. Teaching without .3

instructional planning is comparable to starting on a journey without making any preparation.

The following instructional plans will assist you, the mathematics teacher, to identify the lesson objectives, the sequential lesson development, teachers' activities, students' activities, worksheets for group work and subsequent evaluations to be carried out in the teaching of the topic Vectors. However, these plans do not prevent you, the teacher, from incorporating and integrating spontaneous learning activities that are likely to crop up during the lessons.

TOPIC: VECTORS I

LESSON 1.

TOPIC: VECTORS

Sub-topic: Vectors and scalar quantities

Duration: 40 minutes

Rationale: Learners encounter many examples of quantities that can be either vectors or scalars. It is important that they mention some of these – e.g. Speed, acceleration, distance and distinguish between which ones have directions.

Lesson Objectives:

By the end of the lesson, the learner should be able to:-

- i) Define correctly the terms “vector quantity” and scalar quantity.
- ii) State correctly at least 2 examples of each quantity

Pre-requisite skills and knowledge.

- Different quantities in measurement e.g. velocity, speed, volume, areas, height.

Teaching and learning resources:

A table on the chalkboard to be filled.

Stage/Time	Teaching and learning activities	Learning point	Main interactions	Remarks
Introduction. Step 1. 5 minutes	Introducing different quantities eg. speed, velocity, volume, acceleration. Pose a question: What is the difference between speed and velocity? Give other quantities.	Different quantities- Magnitude and direction.	$T \longleftrightarrow S$ $S \longleftrightarrow T$	
Step 2. 30 minutes Minds on activity	Divide students into groups of 6 students Provide a list of examples of vectors and scalar. Let students' classify them.	Vectors Scalars	$S \longleftrightarrow T$ $S \longleftrightarrow T$	
Step 3. Conclusion 5 minutes	Revise definition of vector quantity Illustrate vectors.	Definition between the two	$T \longleftrightarrow S$	

LESSON 2

SUB-TOPIC: Vector notation and displacement vectors

DURATION: 40 minutes

Rationale: There are different conventional ways of expressing variables and quantitative in mathematics. Students need to differentiate between a line segment and a vector. There is also need to know change in position of an object involves some displacement and direction.

Objectives.

- i) Write down vector displacement of a vector AB using vector notation.
- ii) Identify the initial and terminal points of a vector.

Teaching and learning resources.

- A Cartesian grid.
- Manila drawing of vectors AB, PQ, RS.

Stage/Time	Teaching and learning activities	Learning point	Main interaction	Remarks
Step I. Introduction 4 minutes	Review the definition of vector and scalar quantities State the objectives of the lesson	Differentiate between vector and scalar quantities	$T \longleftrightarrow S$	
Step II 15 minutes Demonstration	Draw line AB on the chalkboard Draw line AB and show direction A B	Vector representation	$T \longleftrightarrow S$	
Step III 15 minutes Minds – on – activity	Draw vector diagrams (a triangle; a parallelogram) on the chalkboard. Ask students to add the vectors Mark and make corrections.	Geometrical representation	$S \longleftrightarrow S$ $T \longleftrightarrow S$	
Step IV 5 minutes Summary	Revise on displacement of vectors Give assignment.		$T \longleftrightarrow S$	

LESSON 3.

Sub-topic: Equivalent Vectors

Rationale: There are many things in life that are equivalent. Students need to understand how fractions, quantities, solids etc are equivalent and compare the same with vectors.

- Objectives:** i) Identify correctly equivalent vectors
 ii) Represent geometrically equivalent vectors using arrowed lines.

Pre-requisite knowledge:

Equivalent quantities e.g. a line segment $AB = 5\text{cm}$ and $PQ = 5\text{cm}$.

Teaching and learning resources

- A grid with labeled axes
- Worksheet 1

Stage/Time	Teaching and learning activities	Learning point	Main interactions	Remarks
Step I. Introduction 4 minutes	-Revise on displacement vectors and vector notation -Ask student to explain what is meant by “equivalent”.	-Equivalent	T \longrightarrow S	
Step II. 30 minutes Minds-on activities	-Give paired points to plot in the Cartesian plane. -Join each two points by a straight line Ask questions:- i) What do you notice about the	-Sense of direction -Magnitude	T \longrightarrow S S \longrightarrow S S \longrightarrow R	

	lines. ii) If they have direction, are they equivalent?			
Step III. 6 minutes Summary	-Summarise -Give assignment	-Conditions for equivalence	T \longrightarrow S	

Worksheet 1 / Group Activity 1

- 1 Draw the X and Y axis using the scale: Vertical scale 1:1
Horizontal scale 1:1
- 2 On the Cartesian plane, draw the following pairs of points:
 - i. A (2,1) C (5,4) join A to C.
 - ii. D (7,2) F (11,6) join D to F
 - iii. G (1,6) I (4,9) join G to I
 - iv. J (9,5) L (6,8) join J to L
 - v. M (12,3) P (16,7) join M to P

Questions

- a. What do you notice about the line segments AC, DF, GI, JL and MP? -----
- b. What is the nature of the slope of lines AC, DF?

- c. Give a single word describing line AC, GI and JL

- d. Put an arrow from A to C, D to F and M to P. What can you say about vectors AC, DF and MP? -----

NB: Please keep the worksheet 1 safely.

LESSON 4

Sub-topic: Addition of vectors

Rationale: Learners already know addition of numbers, variables and other quantities.

They now need to know how two or more vectors can be added together to give a single displacement.

Objective: Add correctly two vectors, using tail to head to give a single displacement.

Pre-requisite knowledge and skills

- Tail and head of a vector
- Sense of direction and corresponding magnitude.
- A triangle i.e. 3 sides of a triangle.

Teaching and learning resources

- Floor of the classroom
- Triangles and parallelograms drawn on a manila paper
- Worksheet 2.

Stage/Time	Teaching and learning activities	Learning point	Main interactions	Remarks
Step I. Introduction 5 minutes	-Oral Questions: - What are equivalent vectors -State the conditions necessary for two vectors to be equivalent.	-Conditions for equivalence of vectors.	T \longrightarrow S	
Step II. Minds – on activity 20 minutes	-Use the classroom. Mark the corners as vertices A,B,C,D. -Let students illustrate two routes equivalent to the diagonal AC.	-Single displacement	T \longrightarrow S S \longrightarrow R S \longrightarrow S	
Step III. Hands – on	-Use manila paper with the drawing	-Addition of vectors	S \longrightarrow R	

activities 10 Minutes	of triangle and parallelogram Refer to worksheet I for addition of vectors.		S \longrightarrow S	
Step IV. Summary 5 minutes	-Show the initial point A and terminal point C. -Conc: addition requires use of triangle method or tail to head method.	-Tail; Head; -Triangle method	T \longrightarrow S	

Worksheet 2 / Group Activity 2

Using the graph work of worksheet 1; work out through the following steps.

- i. Drop a perpendicular line from the point C
- ii. Draw a horizontal line from through point A
- iii. Where the vertical and horizontal lines meet, label the point B.
- iv. Similarly, do the same for DF and GI

Questions

- a. Write down the two vectors that can be added together to give the single displacement:-
 - i. AC =
 - ii. DF =
 - iii. GI =
- b. In each of the above single displacements, identify which one is the initial and terminal point.

NB: Keep the worksheet 2 safely.

LESSON 5

Sub-topic: Multiplication of a vector by a scalar

Rationale: Students need to know how to multiply a variable by a scalar e.g $2 \times y = 2y$ and use the same knowledge to multiply a vector by a scalar e.g. $2\mathbf{a} = 2\mathbf{a}$ and illustrate geometrically the same.

Objectives: (i) multiply correctly a given vector by a scalar.

(ii) Identify the different types of scalars i.e. positive, negative and fractional the same.

Pre-requisite knowledge and skills

-Representation of vectors

-Multiplication of variables by different scalars.

Stage/Time	Teaching and learning activities	Learning point	Main interactions	Remarks
Step I. Introduction 5 minutes	-Revise on addition of vectors -let students multiply diff. scalars i.e positive, negative or fractions.	- multiplication by a scalar.	T \longrightarrow S S \longrightarrow T	
Step II. minds on activities (25 mins)	-give paired points as in worksheet 1. Join the points. -show magnitude of each vector e.g. a+a+a -multiply each vector by a scalar	-multiplication -effect of a negative scalar.	T \longrightarrow S S \longrightarrow R	
Step III. (10 mins) hands-on-activities.	-use the Cartesian plane to plot the paired points. -extend each resultant vector by a given vector e.g. 2; -3; $\frac{1}{2}$	-sense of direction	T \longrightarrow S R \longrightarrow S	

Summary.	Multiplication by a scalar changes direction.			

LESSON 6.

Sub-topic: Column vectors

Rationale: Students need to know that the horizontal and vertical displacements are NOT written as co-ordinates but as $x\ y$.

Objectives: (i) Plot correctly paired points in the Cartesian plane.

(ii) Identify the horizontal (x) and vertical (y) displacements.

(iii) Represent correctly column vectors in the form $x\ y$.

Pre-requisite knowledge and skills

- plotting points.

- displacement i.e. $(x-x_1)$; $(y-y_1)$.

Teaching / learning resources

Worksheet 3 / Group Activity 3

Refer to graph work of worksheet 2

Questions

- i. Write down the length of AB ----- units.
- ii. Write down the length of BC ----- units.
- iii. Write down the length of DE ----- units.
- iv. Write down the length of EF ----- units. Hence write down the displacement $AC = \left(\begin{array}{c} \\ \end{array} \right)$
- v. What single word do we give to the displacements written in (iv) above? -----

Stage/time	Teaching and learning activities	Learning point	Main interactions	Remarks
Step I. (5 mins)	-Revise on plotting of points. - join the plotted	- displacement.	T \longrightarrow S	

	points.		S → R	
Step II (30 mins) Minds on activities	- give students paired points to plot. -guide students to draw horizontal and vertical lines through the given points. -identify the horizontal and vertical displacements show as x y	- displacements $\begin{bmatrix} x \\ y \end{bmatrix}$ - column vector	T → S S → R S → S	
Step III (5 mins) recuperation	- give column vector as x y -give assignment.	-column vector	T → S	

Worksheet 3 / Group Activity 3

Refer to graph work of worksheet 2

Questions

- i. Write down the length of AB ----- units.
- ii. Write down the length of BC ----- units.
- iii. Write down the length of DE ----- units.
- iv. Write down the length of EF ----- units.
- v. Using answers of (i) and (ii), write down displacement vector of AC
- vi. Using answers of (iii) and (iv), write down displacement vector of DF
- vii. What single word do we give to the displacements written in (v) and (vi) above? -----

Lesson 7

Sub-topic: Position vector

Rationale: The origin (0,0) is a very important point in the Cartesian plane. It is the reference point for describing the displacement of all points from it, horizontally and vertically.

Objectives: (i) Define correctly the term position vector.

(ii) Find correctly the position vector of points on the Cartesian plane.

Pre-requisite knowledge and skills

- Plotting points
- Displacements as $(x-x_1)$; $(y-y_1)$

Teaching/ learning resources

- Chalkboard grid

Stage/ time	Teaching and learning activities	Learning point	Main interaction	Remarks
Step I. (5mins) introduction	-revise on plotting points -questions: *what is an initial and terminal point? *what are the co-ordinates of origin?	-initial and terminal points. - the origin	T \longrightarrow S S \longleftrightarrow S	
Step II (15mins) minds-on-activities	-draw the Cartesian plane. -plot points: A (2,4); B(-3,1); C(-2,-3); D (2,-4). -join each point to the origin	-the origin	S \longrightarrow R T \longrightarrow S	
Step III	-join each point	-the common	S \longrightarrow	

(15 mins) hands-on- activities	to the origin i.e. OA, OB, OC, OD. -identify the initial and terminal points. -what is the common point in each vector. NB: use the responses to define position vector.	point (origin) -position vector	S S → R	
Step IV. (5 mins) conclusion	-Give a summary of the plotting of the points to the origin. -Identify the origin	-Position vector	T → S	

LESSON 8.

Sub-topic: Mid-point of a vector

Rationale: There is need to identify the midpoint of a line segment. The same idea is needed to find or identify the midpoint of a vector in the Cartesian plane.

Objectives: i) Identify correctly the midpoint of a vector in the Cartesian plane.

ii) Work out correctly the midpoint of vector AB in the Cartesian plane

Pre-requisite knowledge and skills

Plotting points

Division of a line into two equal parts

Teaching and learning resources

- Graph books
- Worksheet 4.

Stage/Time	Teaching and learning activities	Learning point	Main interactions	Remarks
Step I. 5 minutes Introduction	-Give points to students to plot in their graphs - Revise on position vectors -Ask students on:- i) What is meant by position?? ii) How do we find mid-point??	Position vector	T \longrightarrow S S \longrightarrow R	
Step I. 15 minutes Hands-on-activities	-Plot given paired points i) A(2,3) B(4,5) ii) C(6,2) D(8,4) -Identify midpoint of each line/vector	Mid-point by plotting	T \longrightarrow S S \longrightarrow R	
Step III. Summary 5 minutes	-By calculation, find the mid-points of lines/vectors AB and CD -Show idea that midpoint of A (x,y) B(x,y) is given by $M = \left(\frac{x+x_1}{2}, \frac{y+y_1}{2} \right)$	Midpoint by calculation	T \longrightarrow S S \longrightarrow R	

	-Summarize on formula for mid-point -Give assignment	Mid-point formula	T \longrightarrow S	
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Worksheet 4 / Group Activity 4

Refer to graph work of worksheet 1

Questions

- a. Write down co-ordinates of Mid-point of DF and MP. Label them as M_1 and M_2 respectively.

$$M_1 =$$

$$M_2 =$$

- b. Write down the formula for finding the Mid-point of a vector.

$$\text{Mid-point} =$$

LESSON 9

Sub-topic: Magnitude of a vector

Rationale: Finding lengths application of learnt knowledge. There is need for students to calculate length of a line segment in the Cartesian plane and use the same idea to calculate length of a vector using Pythagoras's theorem.

Objectives: Calculate correctly the length of a vector in the Cartesian plane using Pythagoras's theorem.

Pre-requisite knowledge and skills

- Pythagoras theorem
- Horizontal and vertical displacements

Teaching and learning resources

- Worksheet 5
- Chalkboard grid

Stage/Time	Teaching and Learning activities	Learning point	Main interactions	Remarks
Step I. 5 Minutes Introduction	-Ask students to give formula for mid-point -Revise on	- Magnitude	T \longrightarrow S	

	calculation of mid-point -Introduce the word “Magnitude”			
Step II. 15 Minutes Hand-on-activities	-Give students paired points to plot. A(3,4) B(6,8) -Joint the points A and B -Draw the horizontal and vertical lines through points A and B.	-Magnitude of a vector	$S \longrightarrow$ R	
Step III. 15 Minutes Minds – on-activities	-Work out the length of lines AB and CD by calculation. -Show notation as $ AB $ -Show $ AB = \sqrt{(c-a)^2 + (d-b)^2}$	-Magnitude formula	$T \longrightarrow$ S $S \longrightarrow$ S $S \longrightarrow$ R	
Step IV. Conclusion	-Summarize on calculation of length of a vector -Give assignment		$T \longrightarrow$ S	

Worksheet 5 / Group Activity 5

Refer to worksheet 2

Answer the following questions:

Questions

- a. What kind of triangles are the following triangles: ABC, DEF, MNP?

- b. Measure the length of AC ----- units,

DF ----- units

MP ----- units respectively.

c. Work out the length of AC, DF and MP.

\tilde{AC} = ----- units.

\tilde{DF} = ----- units.

\tilde{MP} = ----- units.

d. What do you notice about the answers in (ii) and (iii) above?

e. Write down the formula you have used to find the lengths AC, DF and MP in part (iii) above.

LESSON 10.

Sub-topic: Translation vector

Rationale: Objectives plotted in the Cartesian plane can be “pushed” and this change their positions. There is need to identify how this “push” can be explained mathematically using vector methods.

Objectives: i) Define the term translation

ii) State clearly and correctly the properties of translation.

iii) Use translation vector to find the co-ordinate of final image of an object.

Pre-requisite knowledge and skills.

- Displacements
- Plotting points

Teaching and learning resources

- Worksheet 6
- Chalkboard grid

Stage/Time	Teaching and Learning	Learning point	Main interactions	Remarks
Step I. 5 Minutes Introduction	-Give points to revise -Ask students Questions:- i) What is horizontal displacements??	Displacement	T \longrightarrow S	

	ii) What is vertical displacement??			
Step II. Hands-on-activities	-Plot given points P(2,2) Q(8,2) and R(8,8). -“Push” the triangle along the line $y= 15$ units horizontally.	-Translation		
Step III. Minds-on activities 15 minutes	-What do you notice about PP^1 , QQ^1 , RR^1 ?? -Let students give out the properties they are discovering.	Translation properties		
Step IV. 5 Minutes Conclusion	-Summarize on properties of translation -Give assignment			

Worksheet 6 / Group Activity 6

1. Use a scale of 1:2 on both the X– axis and Y – axis.
2. Plot triangle PQR with co-ordinates P(2,2) Q(8,2) and R(8,8).
3. Cut out the triangle.
4. Using the same scale, draw triangle PQR on a separate sheet and produce line PR to point R' (14,14).
5. Place the cut-out on triangle PQR, then slide it along line PR until point R lies on point R'.

Questions

- a. Write down co-ordinates of P' and Q'
 $P' = (\quad)$
 $Q' = (\quad)$
- b. Write down the horizontal units and vertical units;
 $PP' \text{ ----- units.}$
 $QQ' \text{ '----- units}$
- c. Write down the column vector using the displacements in (b) above.
- d. What do you notice about PP' and QQ' ?

----- x
e. What single name do we give to ()_y

f. Write down any three discoveries made?

APPENDIX III

MATHEMATICS LESSON OBSERVATION CHECKLIST

GROUP: _____ **ROLL:** _____ **DATE:** _____

TIME: _____

CATEGORY	FREQUENCY
TEACHER ACTIVITY	
1. Teachers' reinforcing behavior. 2. Gives instructions and directions clearly. 3. Supervises learning activities. 4. Asks clear questions. 5. demonstrates mathematical skills. 6. Explains concepts and skills.	
STUDENTS' ACTIVITY	
1. Responds to questions asked. 2. Follow directions and instructions. 3. Participation in group activities and discussions. 4. Students ask questions. 5. Students write down examples and notes. 6. Students agree with previous content learnt. 7. Students have periods of silence / inactivity. 8. Students consult each other. 9. Students eager to have class work marked.	

Comments:

APPENDIX IV

MATHEMATICS ACHIEVEMENT TEST (MAT)

INSTRUCTIONS

- i) This test is meant to gauge your understanding of the topic Vectors.
- ii) Do not write your name anywhere in this question paper.
- iii) The responses/ answers are meant for research purposes and will be treated with utmost **CONFIDENTIALITY**.
- iv) You are advised to use 1 hour in this paper.

SECTION A: (15 Marks)

1. a) What is a scalar quantity?
b) Give an example
2. a) What is a vector quantity?
b) Give an example
3. State whether the following are vector (v) or scalar (s) quantities.

a)	Speed of 80km/h due North-East	
b)	A distance of 10km due South of a water tank	
c)	80 litres of milk	
d)	Speed of 870km/h of an aero plane	

4. What are the two conditions necessary for two vectors to be equivalent?
5. What is the net effect of multiplying a vector by a negative scalar
6. What is meant by the term position vector?
7. If $P(a,b)$ and $Q(c,d)$, write down PQ of a translation.
8. State which of the following statements are TRUE, and which ones are FALSE when a figure or object has a translation applied to it.

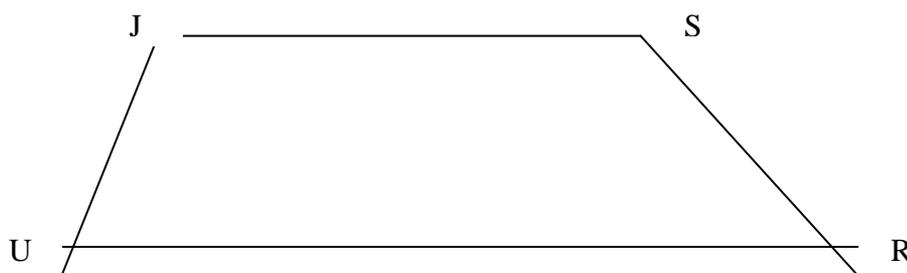
i.	All points move in the same direction	
ii.	Not all points of the figure move in the same direction	
iii.	All lengths in the object remain unchanged	
iv.	A translation can be described by any directed line segments	

	provided each has the same length and direction.	
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9. If $A(a,b)$ and $B(c,d)$, write down IAB

SECTION B (20Marks)

1. Using the figure below, write down a single displacement representing:
- $ST + TU$
 - $TS + ST$
 - $ST + TU + UR$



2. Mutisya walks 10km in the N.E direction and then 4km due north. Draw a vector diagram to show Mutisya's displacement from his starting point. When he stops walking, how far from the starting point will he have walked?
3. Four railway stations L, M, E and R are on a straight line.
Express the following in terms of \mathbf{ME} .



- LM
 - LE
4. If $A(1,4)$ and $B(2,7)$ are points in the Cartesian plane, write down the column vector.
- \mathbf{AB}
 - \mathbf{BA}
5. a) If $a = \begin{pmatrix} 4 \\ 1 \end{pmatrix}$ and $c = \begin{pmatrix} -1 \\ 2 \end{pmatrix}$ evaluate $4(a+2c)$.
b) If a is a vector, solve the equation $2a + \begin{pmatrix} 4 \\ -1 \end{pmatrix} = \begin{pmatrix} 5 \\ 9 \end{pmatrix} - a$
6. If $\mathbf{CF} = \begin{pmatrix} 3 \\ 8 \end{pmatrix}$ and $\mathbf{OG} = \begin{pmatrix} -1 \\ 4 \end{pmatrix}$, Find the column vector for \mathbf{FG} and \mathbf{GF} .

7. Calculate the co-ordinates of the mid-point of the line joining the points A(0, 3) and B(2,7).
8. In the following cases
- Find the column vector of \mathbf{PQ}
 - Hence or otherwise find co-ordinates of the mid-points
- a) P (3,0) Q(5,4)
- b) P (-8,-7) Q(-2,3)
9. a) Calculate the length of the vector $\begin{pmatrix} -3 \\ -4 \end{pmatrix}$
- b) Calculate the distance between the following pairs of points:
A (-1, -1) and B (-5, -6)
10. A triangle RST with co-ordinates R (0,1), S (2,0) and T (3,4) is given a translation $\begin{pmatrix} 2 \\ 4 \end{pmatrix}$. Find the co-ordinates of the final image.

