EFFECTS OF GOWIN'S VEE HEURISTIC TEACHING STRATEGY ON SECONDARY SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING AND METACOGNITION IN THE TOPIC OF MOMENTS IN PHYSICS, IN UASIN GISHU COUNTY, KENYA

DANIEL KIBET MUTAI

A Thesis Submitted to the Graduate School in Partial Fulfillment for the Requirements of the Award of the Masters Degree in Education Science of Egerton University.

Egerton University

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DECLARATION AND RECOMENDATIONS

DECLARATION

This is my original work and has not been presented for a degree or diploma award in this or any other university.

Signature ------------------------------------ Date: ---------------------------------

Daniel Kibet Mutai

EM14/01612/06

RECOMMENDATIONS

This work has been submitted for examination with our approval as university supervisors.

Signature ------------------------------------ Date: ---------------------------------

Professor M.I.O Okere

Department of Curriculum,

Instruction and Educational Management

Egerton University

Signature ------------------------------------ Date: ---------------------------------

Professor J.M Changeiywo

Department of Curriculum,

Instruction and Educational Management

Egerton University

DEDICATION

I dedicate this thesis to my wife Josephine Jepleting our children Lamech Kimaru and Faith Chebichii and in loving memory of my parents Kibiego Mutai and Ruth Mutai.

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ABSTRACT

Physics is a science subject that has contributed immensely to the technological advancement of the world. In the Kenyan 8-4-4 curriculum, it is optional at form three. However, various studies show that physics in Kenya has been faced with poor performance. Consequently, many students drop out of the subject. Educational researchers have partially attributed the cause to be poor instructional methods. This study attempts to change this trend in the topic of moments in physics. Data were collected on the effects of Gowin's Vee heuristic strategy on secondary school students' conceptual understanding and metacognition in the topic of moments in physics in Uasin Gishu County Kenya. Solomon four non equivalent control group design was used. Two experimental groups were taught using Gowin's Vee and two control groups were taught using conventional methods. The target population was 3735 form two students in 83 mixed secondary schools. Purposive sampling was used to select 134 students. The instruments used were Physics Metacognitive Activity Inventory Questionnaire (PMCAIQ) and Physics Conceptual Understanding Achievement Test (PCUAT). Their validities were determined by supervisors and science education experts of Egerton University and physics teachers. Estimations of reliabilities using Chronbach coefficient of alpha gave 0.75 and 0.78 for PCUAT and PMCAIQ respectively. Analysis using means and standard deviations was done. Also sample *t*-test, one way ANOVA and post hoc analysis were done at coefficient of alpha (α) equal to 0.05 level of test of significance using Statistical Packages for Social Sciences. Gowin's Vee had statistically significant improvement on students' conceptual understanding and metacognition in the topic of moments in physics hence it improved students' conceptual understanding and metacognition. Therefore teachers should use it in teaching this topic and other topics in physics. This study is important in enhancing performance and quality of teaching in the topic of moments in physics and sciences in general.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ABREVIATIONS AND ACRONYMS

ACME	Assessment of Cognitive onitoring Effectiveness
ASEI	Activity, Student, Experiment and Improvisation.
CEMASTEA	Centre for Mathematics Science and Technology Education in Africa
GOK	Government Of Kenya
GVTM	Gowin's Vee Teachers Manual.
INSET	In-service Educational Training.
IRA	Index of Reading Awareness
JICA	Japanese International Cooperation Agency
KLB	Kenya Literature Bureau
KIE	Kenya Institute of Education
KLR	Kenya Law Reports
KNEC	Kenya National Examination council
LASSI	Learning and Study Strategies Inventory
MCAI	Metacognitive Activity Inventory
MOEST	Ministry of Education Science and Technology
MOLES-S	Metacognitive Orientation; Learning Environment Scale -Science
MSLQ	Motivated Strategies for Learning Questionnaire
PCUAT	Physics Conceptual Understanding Achievement Test.
PDSI	Plan, Do, See and Improve
PMCAIQ	Physics Metacognitive Activity Inventory Questionnaire
SEMLI-S	Self –Efficacy and Metacognitive Learning Inventory-science
SMASSE	Strengthening of Mathematics and Science in Secondary School Education

CHAPTER ONE

INTRODUCTION

1.1 Background Information to the Study

The learning requirement in the twenty first century is to develop life-long skills for learners to cope with the various emerging challenges being encountered. Physics knowledge and skills are among the most required for one to face these challenges especially in high technological advancements being witnessed today (Musasia, Abacha & Biyoyo, 2012). Physics is made up of experiments, calculations, graphs, symbols, equations as well as conceptual explanations and applications experienced in its topics (Angell et al., 2004). Each topic presents its own level of learning challenges (Waititu, 2004). This has made many students to perceive the subject as difficult leading to low enrolment and poor performance (Menjo, 2013). Consequently most students see physics as made up of memorization of information and problem solving procedures that apply to specified situations and not their life experience (Ornek, Robinson & Haugan, 2008).

Research in teaching methods has proved that these challenges can be addressed by applying the relevant teaching methodology. Effective physics instruction should be able to change students' way of thinking about physics. In an attempt to achieve these, various contemporary researches in education and psychology have come out with epistemologies, theories and pedagogy like constructivism and meaningful learning theories(Ausubel, 1968), metacognition (Flavell, 1979), creativity and process skills (Okere, 1996), advanced organizers (Ausubel, 1968), Gowin's Vee (Gowin, 1981) and concept maps (Novak & Gowin, 1984) among others. These have added to physics education thinking skills and creativity through conceptual understanding. Thus the use of socio constructivist perspective and meaningful learning theory has offered a window of hope in the teaching and learning of various topics in physics and science in general. Students should be made to understand the physics world as made up of coherent structure of concepts which are interlinked together (Ausubel, 1968; Novak & Gowin, 1984).

The other two meaningful learning tools, concept maps and advanced organizers, were developed on conceptual and theoretical framework of the new knowledge that the student must learn. However, they do not address relationships between activities and concepts required in order to acquire the knowledge being sought (Gowin, 1981). Gowin’s Vee offers a solution to this by combining both the theoretical knowledge to be learned with the activities to be performed in one unit of a Vee. Gowin’s Vee is a very useful teaching and learning tool which has been extensively used in many other countries like USA (Novak & Gowin, 1984), Finland (Ahlberg, 1993), Australia (Afamasaga,1998),Venezuela (Ramírez, Aspéen, Sanabria & Tellez, 2008) and South Africa (Ramahlape, 2004) in bringing about meaningful learning.

The Gowin’s Vee heuristic, apart from including the concepts in the left hand side, it includes activities in the right hand side of its V-structure. These enable the learner to understand the nature of scientific knowledge as being both theoretical and practical (Novak & Gowin, 1984). The theoretical side consists of world view, philosophy, theory, principles, constructs and concepts. The methodological side includes records, transformations, knowledge claims and value claims. At the tip of the Gown’s Vee diagram are events or objects to be studied which interact with both sides in order to achieve the answer to the focus question (Novak & Gowin, 1984). Figure 1 shows Gowin’s Vee heuristic with a description of all the twelve epistemological elements.

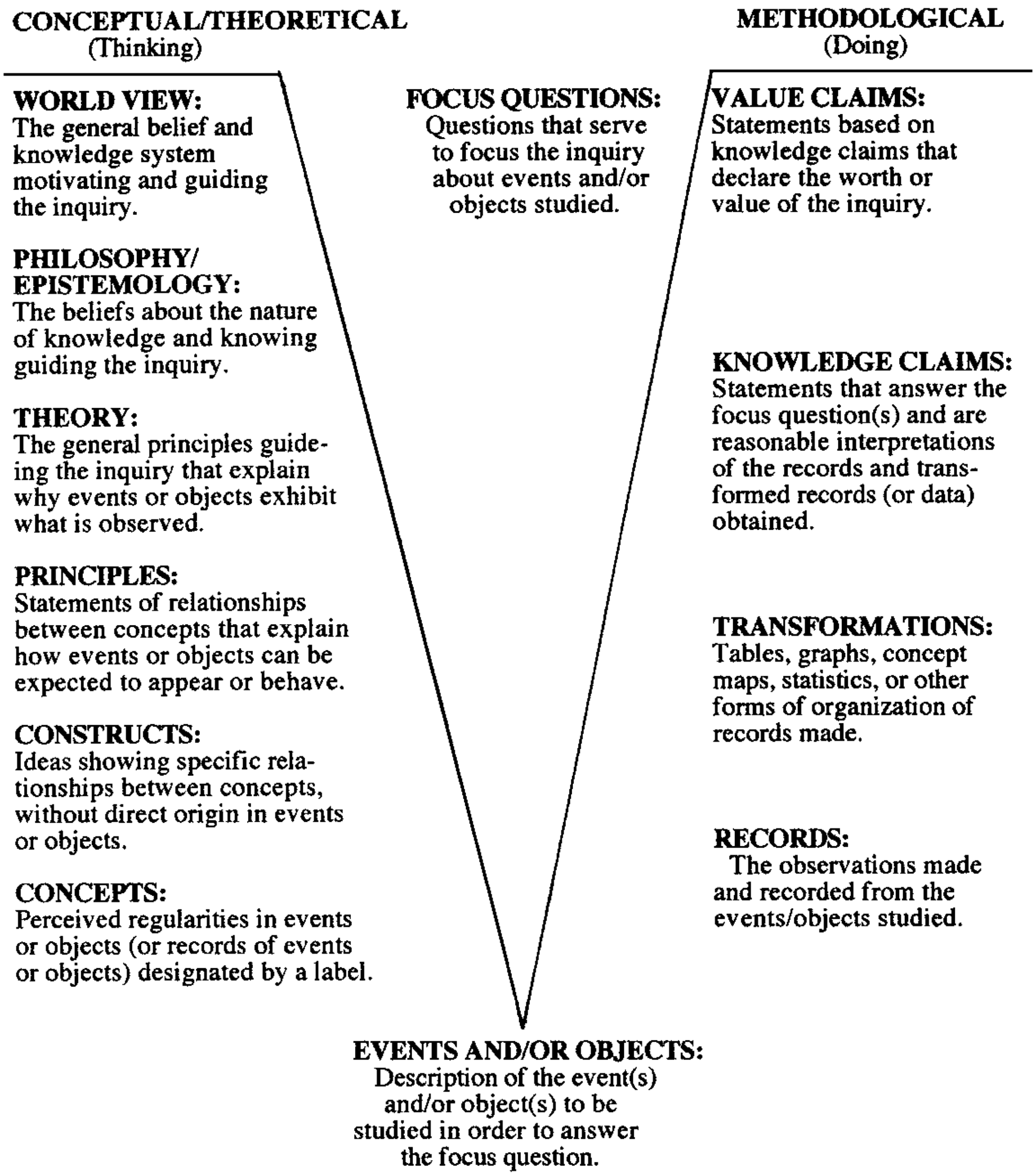


Figure 1

Gowin's Vee heuristic twelve epistemological elements (Gowin & Alvarez, 2005, p.36).

When using the Gowin's Vee in the teaching and learning process it is important that the learner starts by filling in the focus question under investigation at its centre. Then writes down any of the activities, procedures, descriptions, apparatus objects and events needed in order to answer the focus question. In the conceptual side the learner indicates the theories, principles, constructs (formulae) and concepts used in the study (Afamasaga, 1998).

Under records section (in the methodological side) the learner fills in data in tables or audio-visual form. In the transformation section the learner analyzes the data using graphs, calculations and charts. The answer to the focus question is written under the knowledge claims section. Finally, the relevance and importance of the knowledge attained is written under the value claims. After filling in all the sections of the Gowin's Vee, the learner relates both sides which may lead to conceptual understanding of the scientific knowledge sought. Therefore the learners retain the knowledge for a long time and reproduce it at any time using the basic structure of a Gowin's Vee heuristic. These make this learning process meaningful (Novak & Gowin, 1984).

It is of great importance for this teaching tool to be extensively used in teaching science in Kenya which may change the trend of rote learning in science (Namasaka, Mondoh & Keraro, 2013). In Kenya, Physics, Chemistry and Biology science subjects are offered in its 8-4-4 curriculum (KIE, 2002). A student is required to choose at least two sciences upon transition from form two to form three. However, during this transition many students drop out of Physics leading to low enrolment in the subject as shown in Table 1.

Table 1

KCSE Overall Enrolment Compared to Enrolment in Physics, Chemistry and Biology from 2008 to 2014

KCSE Enrolment %	2008	2009	2010	2011	2012	2013	2014
Overall	305015	337404	357488	411738	434121	445800	483,630
Physics	93692	104883	109811	120074	118508	119862	130,752
%	30.71	31.09	30.72	29.16	27.30	26.89	27.03
Chemistry	296937	329730	347364	403070	427303	439941	477,393
%	97.35	97.73	97.17	97.89	98.43	98.69	98.71
Biology	274215	299302	317135	365458	386538	397314	430,583
%	89.90	88.71	88.71	88.76	89.04	89.12	89.03

(KNEC, 2008-2014)

From Table 1 it can be observed that for the seven year period (2008-2014) even though there is increase of the overall number of candidates nationally each year the enrolment in physics has remained at 31% and below. This is a very low number considering that the other two sciences chemistry and biology in the same group have at least 90% and 80% enrolment respectively. Likewise Table 2 shows physics KCSE performance nationally.

Table 2

Overall KCSE Percentage Mean Scores in Physics, Chemistry and Biology from 2008 to 2014

KCSE Enrolment	2008	2009	2010	2011	2012	2013	2014
Physics	36.71	31.33	35.13	36.64	37.87	40.10	38.84
Chemistry	22.71	19.17	24.89	23.66	27.93	24.83	32.16
Biology	30.32	27.17	29.19	32.44	26.21	30.15	31.83

(KNEC, 2008-2014)

The results in Table 2 show that the performances in physics nationally range from 30% to 40% from 2008 to 2014. These give an average mean grade of D+ which is below average. Similarly, in Uasin Gishu County the enrolments in physics range from 30% to 40% as shown in Table 3. Also the performance in the county has mean points ranging from 3.5 to 4.8 in 2008 to 2014. These give an average mean grade of D+ which is still below average as shown in Table 3.

Table 3

Uasin Gishu County KCSE Enrolment and Performance Mean Points in Physics from 2008 to 2014

Year	Overall	Physics	% Enrolment	Mean Points out of 12 scale
2008	3092	1250	40.43	3.92
2009	5530	1738	31.43	4.34
2010	7473	2739	36.65	4.43
2011	7966	2949	37.02	4.51
2012	9341	3220	34.47	4.48
2013	9854	3595	36.48	4.65
2014	10966	3842	35.03	4.81

(MOEST, Uasin Gishu County, 2014).

The low enrolment in physics in Uasin Gishu and also nationally has been attributed to poor performance partly blamed on teaching methods among other factors (Uside, Barchok & Abura, 2013). Many students perceive the subject as difficult as established by Musasia et al. (2012). Consequently, many opt out of the subject despite its importance (Nyakan, 2008). It is against this background that this study joined other studies in Kenya in exploring for the appropriate teaching methods. It undertook the use of the Gowin‘s Vee heuristic strategy in the topic of moments in form two. The topic of moments in physics is among those perceived to be difficult by 40% of teachers (CEMASTEA, 2011). The Gowin’s Vee heuristic has both conceptual and methodological parts and by going through the twelve stages the learner combine the concepts and activities being sought in the problem they are investigating. During the process they create conceptual understanding and metacognitive awareness. Metacognition is the process by which the learner is able to plan, monitor and evaluate their own learning process (Gowin & Alvarez, 2005).

Many teachers in Kenya use expository methods which are teacher dominated learning process (Changeiywo, 2000; Kiboss, 2002). Few attempts are made to develop students’ conceptual understanding and metacognition. There is no relating of new content to the learners environment so as to create meaning to the learner. These reduce learning into rote memorization of facts (Alvarez & Risko, 2007). As Driver (1987) reaffirms, in the expository methods, there are a lot of emphasis on absoluteness of the content where students are supposed to just accept the content given to them. Ausubel (1963, 1968), Alvarez and Risko (2007) and Novak and Gowin (1984) have stressed the need to use meaningful learning strategies so that the already existing knowledge of the learner is related to the new knowledge and wrong conception of the learner is clarified.

The poor performance in sciences and mathematics has led the Ministry of Education Science and Technology (MOEST) to introduce an annual teacher in-service training called Strengthening of Mathematics and Science in Secondary School Education (SMASSE) in 1998 in collaboration with Japan (JICA, 2007). In March 1999, SMASSE project Cycle one carried out a baseline study involving nine districts. In the study, at least 40% of teachers rated the topics of moments, magnetic effect of electric current and waves as difficult (CEMASTEA, 2011). According Menjo (2013) in a study in Baringo county neighboring Uasin Gishu confirmed that secondary school students found the topic of moments to be difficult. Also KNEC (2005, 2011) observed that in questions concerning moment of a force the students were able to state the principle of moments but failed to translate the law in relation to the activities they were doing in the KCSE practical examination which is lack of conceptual understanding. This made them perform poorly in physics.

The SMASSE project emphasized the use of experimental method and improvisation to deal with the problems facing the topics but left out other strategies of learning like the Gowin's Vee heuristic. Furthermore, the topic of moment of forces in Form two is very applicable in the learners' day to day lives. It contains many activities that are used to verify its principles. The topic plays a pivotal role in topics like equilibrium and centre of gravity, states of equilibrium, work energy and machines and floating and sinking. These make it relevant for this study. This study emphasized on the need for the learning process in Kenya to be meaningful through Gowin's Vee conceptual and methodological approach of the physics knowledge.

The many strategies of learning science influence understanding and performance only to a certain limit (Mintrez, Wandersee & Novak, 2005). Therefore, there should be focus on combining them with other important aspects affecting learning like metacognition, attitude, motivation, and self-efficacy. Metacognition is the ability of the learner to plan, monitor and evaluate their own learning process. It has become such an important aspect in education. Furthermore, metacognition has attracted many educators because it has potential for teaching thinking skills and to enhance transfer of knowledge across various subjects, topics, school situation and everyday problems at home and workplace (Wittrock & Baker, 1991).

Learners who have good metacognitive skills learn better by identifying the objective in a problem, choosing the strategies used to achieve the objective, being observant of their own process of knowledge processing and carrying out a quick evaluation to verify whether the objective has been achieved or not. On the other hand, learners who have poor metacognitive skills, have impulsive attention, make premature conclusions, lack reflective thinking and get stuck on one point without progression which lead to poor learning (Brown, 1987).

Consequently, the future characteristic of successful science is attributed to metacognition and conceptual understanding. The methods used by teachers either improve or reduce the metacognitive tendencies of the students. This has called for the use of metacognitive tools like the Gowin's Vee. By using these teaching and learning tools teachers develop creative and reflective persons, with ability to change society (Mintrez, Wandersee & Novak, 2005). When using the Gowin's Vee heuristic the learner goes through the process of metacognition which includes planning, evaluating and monitoring the learning process. Therefore, the Gowin's Vee heuristic goes further to facilitate the development of students' metacognitive skills (Tobias & Everson, 2002).

The elements in the Gowin's Vee diagram can be interpreted to suit any educational level and curriculum content as long as the basic structure remains. Therefore, during this study the Gowin's Vee heuristic was made to suit the level of the learner and Kenyan secondary school curriculum. For instance, in secondary school level the world view and philosophy elements of the Gowin's Vee heuristic can be left out (Afamasaga-Fuata'i, 1998). Novak (1998) predicted that it may take several decades before the Gowin's Vee heuristic is fully utilized in the teaching and learning process. However, many researchers have acknowledged the importance of the Gowin's Vee and emphasized that its use should not take too long before it is utilized. This is because of its power to capture and facilitate the thinking process of the learner (Piyush & Robert, 2006). The role of the Gowin's Vee has not been fully realized in Kenya. This is supported by Namasaka et al. (2013) that there is need to use Gowin's vee heuristic in Kenya since it has potential to improve students' motivation and does not depend on gender.

1.2 Statement of the Problem

Physics subject in Uasin Gishu County secondary schools has been faced with low enrolment. This is because few students choose the subject at the end of form two. This trend has led to few people with technical knowledge applicable in industries and real life. This slows down the technological advancement of the country which is much needed in the 21st century. SMASSE and educational researchers attribute these to poor teaching methods among other factors. Expository teaching methods are widely being used in classroom instruction. They have been found to be unsuitable methods if used entirely in contemporary teaching because they are teacher centered and encourage rote memorization. In the topic of moments and others in physics, excessive uses of expository methods have lead to poor conceptual understanding. Hence the learners cannot relate the concepts, principles and theories with the activities performed in the laboratory. In addition students have low metacognition which should be improved so that they can plan, monitor and evaluate their learning process. These are some of the reasons that have lead to poor performance in this topic. This study intended to bridge this gap by getting an appropriate teaching strategy for the topic of moments in physics. It isolated the topic of moments because it has many learning activities and has been poorly performed. Gowin's Vee heuristic strategy was used as a teaching and learning tool which related theories and principles to the activities being performed. Its twelve epistemological elements enhanced conceptual understanding of scientific concepts. It also influenced learners to plan, monitor and evaluate their own learning which improved their level of metacognition. This study therefore investigated effects of Gowin's Vee heuristic strategy on students' conceptual understanding and metacognition in the topic of moments in form two Physics in Uasin Gishu County Kenya.

1.3 Purpose of the Study

The purpose of this study was to determine the effects of Gowin's Vee heuristic strategy on secondary school students' conceptual understanding and metacognition in the topic of moments in physics, in Uasin Gishu County.

1.4 Research Objectives

i. To investigate the effects of using Gowin's Vee heuristic teaching strategy on secondary school students' conceptual understanding in the topic of moments in physics.
ii. To investigate the effects of using Gowin's Vee heuristic teaching strategy on secondary school students' metacognition in the topic of moments in physics.

1.5 Research Hypotheses

H_O1: There is no statistically significant difference in conceptual understanding between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics.

H_O2: There is no statistically significant difference in the level of metacognition between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics.

1.6 Significance of the Study

Physics is a science subject which has many concepts, principles and theories combined with practical activities which must be well understood for it to be applied and to explain phenomena. This study intended to find the appropriate teaching strategy consistent with nature of scientific knowledge and relevant to the topic of moments in physics. Gowin's Vee heuristic strategy comes in handy since it combines the activities, concepts, principles and theories in one structure. Hence it improved students' conceptual understanding in the topic of moments in physics. They also transfer the knowledge and strategy acquired to other topics. More so physics teachers were introduced to an additional method of teaching the topic. Using this strategy also improved the learners' level of metacognition. Metacognition enabled learners to plan, monitor and evaluate their own learning which is useful not only in physics but also in other sciences making the tool versatile. These eventually improve performance and encourage many students to choose the subject which increases enrolment.

In addition after learning the topic of moments, the learners acquire knowledge and skills which are applicable in solving day to day problems especially making work easier. For instance design of most machines and devices that use lever system apply the concepts of the topic of moments. Students who perform well in physics will be able to per sue courses and join careers in the field of engineering, information and communication technology, computer science among others. Consequently, there will be high enrolment in these courses and careers and an increase in the number of people with technical training applicable in industries. As a result there will be technological advancement of the country which is much needed in the 21st century. Eventually these lead to the attainment of some of the educational objectives and goals. Therefore the stakeholders and educationalists should find the Gowin's Vee heuristic to be a useful teaching tool in secondary school science education in Kenya.

1.7 Scope of the Study

This investigation was confined to mixed district secondary schools in Uasin Gishu County. The target group was secondary school students in form two. This study focused only on the conceptual understanding and metacognition in the topic of moments in physics. Metacognition has many aspects and measuring instruments. Only metacognitive self regulation skills which are related to science and especially physics were considered and measured using self-report inventory questionnaires. The study was carried out in a period of two and half weeks as guided by the syllabus.

1.8 Assumptions of the Study

The following are the assumptions of the study:

i. The respondents under study gave honest answers in the questionnaire. Some of the respondents do give answers without following the instructions.
ii. The extraneous variables were fully controlled and did not have any significant effect on dependent variables.

1.9 Limitations of the Study

The study was faced with the following limitations

i. There is no random selection in Quasi-experimental design since the schools have already arranged the students in classes.
ii. The generalization of the results was limited to Uasin Gishu County.
iii. While there are other categories of secondary schools this study was limited to mixed secondary schools.
iv. Although metacognition is made up of many aspects this study was limited to self regulations skills of metacognition.

1.10 Definition of Terms

Concept: Perceived regularity of events or objects designated by a label (Novak & Gowin, 1984). In this study it was used to mean the physical quantities used in the topic of moments like: force, mass, clockwise and anticlockwise moments and many other basic and derived physical quantities in physics.

Conceptual Understanding: Knowledge about a topic acquired in an integrated and meaningful manner (Novak, 1998). In this study it was used to mean ability of students to connect relationship between concepts, principles and theories in a Gowin's Vee depicted by level of scores attained by a student in Conceptual Understanding Achievement Test (PCUAT) in the topic of moments in Physics.

County: A unit of local government and one of the administrative subdivisions used by some countries (Encarta, 2008). In this study it means a devolution unit in the Kenyan government structure stated in the Kenyan constitution 2010 (KLR, 2010). In this study Uasin Gishu is among the 47 counties in Kenya.

Expository methods: These are traditional teaching methods whereby the teacher dominates the learning process while the learner is passive recipient (Driver 1987). In this study it is used to mean methods which promote rote learning as opposed to conceptual understanding associated with Gowin's Vee heuristic teaching strategy.

Gowin's Vee: This is a name derived from the shape of the diagram and the person who designed it (Gowin, 1981). A Gowin's Vee is a heuristic with twelve epistemological elements arranged in the center, tip, left and right of the V-shaped structure (Novak & Gowin, 1984). In this study it was drawn and filled by the learner during the study in the topic of moments.

Heuristic strategy: Heuristic is a tool, method, or procedures that helps people to recognize relationships and through this process reach higher levels of understanding about complex events, objects, or phenomena (Armstrong, 1902). In this study it was a visually drawn Gowin's Vee meant to focus attention of learners on all the twelve epistemological elements required to solve a physics problem in the topic of moments.

Metacognition: Thinking about the process and approaches used in one's own learning process (Schraw & Dennison, 1994). In this study it was used to mean the awareness of a student on his/her ability to plan, monitor and evaluate one's own thinking towards learning process in a physics class.

Moments: The product of a quantity such as a force multiplied by its perpendicular distance from a given point (Encarta, 2008). In this study it is used to mean a form two physics topic which comprises: Turning effect of a force, principle of moments and sum of upward and downward forces at equilibrium, equal and oppose forces and their applications.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter will be divided into the following subtopics: Kenya Secondary School Curriculum, Physics Curriculum in the World and Africa, The Topic of Moments in Form Two Physics Syllabus in Kenya, Science Teaching Methods and Strategies in Kenya, Expository Methods, Constructivist Learning, Meaningful Learning Methods, Heuristic Teaching Strategies, Gowin's Vee Heuristic Teaching Strategy, Metacognition, Importance of Metacognition, Measurement of Metacognition, Conceptual Understanding, Theoretical Framework and Conceptual Framework.

2.2 Physics Curriculum in the World and Africa

Physics is one of the major sciences that studies matter in relation to energy. It explains the way matter interacts with each other both in subatomic level and in the larger universe (O'keeffe, 2009). It is an experimental science which observes, describes and models the understanding of the natural inanimate world with the aim of identifying the unifying fundamental principles. It is an international subject that is important to the advancement of mankind in the following ways:

i. Provides knowledge about understanding of fundamental issues in nature both in the whole universe and in the earth we live in.
ii. Provides knowledge about future technological advancement that drives economies of the world.
iii. It is an important element in other disciplines like engineering, chemistry, computer science and many others.
iv. It provides trained personnel and technological infrastructure needed to utilize scientific advancement and discoveries.

These make the learning of the subject very important and necessary to the world and proper science and physics education is needed (IUPAP, 1999; French, 1998).

The science education of the world took a new direction after the Second World War. This was as a result of the realization by many nations that the knowledge in science had contributed to a large extend in winning the war. Therefore many nations embarked seriously on developing a good science curriculum (Kojevknikov, 1997). However, certain emerging issues have created the need for consistent reviews to make the curriculum to be in touch with these issues. On the contrary educationalists in the world are always reviewing the achievements and failures of curricula. This is because it has come to be commonly accepted that physics education is not constant but continuous process depending on the societies' changing beliefs, aspirations, advancement in physics knowledge and technology. Hence the curriculum developers have come to adapt to these changes (Lijnse, 1998).

Therefore there are calls from science education experts all over the world to make physics education effective and relevant to the entire student population. This is in order to address the technical issues like climate change, genetic modification, energy supply among others. Also modern economies are highly dependent on technology and require better technical problem solving skills by the citizens. This is not necessarily for occupational purposes but to be able to fit into today's technological system. It is therefore emerging that the science education will benefit society more by focusing not only in producing experts but also to provide basic science education for all students (Perkins & Wieman, 2005).

Amongst the issues needed to achieve these is having an effective physics instruction that changes the way students think about physics and problem solving skills that make them think like experts. These require the traditional strategies to be merged with new approaches that promote conceptual understanding. Conceptual understanding has been extensively studied. It has been found to be relevant to the nature of physics whereby a few fundamental concepts can be used to explain a vast range of phenomena (Perkins & Wieman, 2005)

Many African countries especially in sub-Saharan Africa attained independence in the early sixties to late nineties. They were faced with the challenges of filling the technical gap left by the colonialist through educating their citizens. This called for curriculum change to accommodate their new goals. As the society evolved many of these curricula have been forced to adjust their goals to accommodate contemporary and emerging issues of quality education for all and the enhancement of science and technology for economic development. Some of the emerging curriculum issues are (Maduewesi, 2003):

i. Curriculum relevance to the society.
ii. Continuous expanding curriculum content leading to overload.
iii. Continuous change in the learners’ interests and needs.
iv. Delays in curriculum reviews.
v. Integration of global issues and concerns like gender, HIV/AIDS, global warming, sexuality among others.
vi. Large class sizes.
vii. Possibility of learning without teachers using computers.
viii. Quality of trained teachers.
ix. How to make teachers cope with these changes of curriculum.

The sub Saharan Africa region has come out with initiatives through Science, Technology and Mathematics (STM) and African Forum for Children’s Literacy in Science and Technology (AFCLIST). They identified common goals being shared in most African countries in science and technology. Amongst them, is to identify how science, technology and mathematics relate to personal and social issues (Pillai, 2003). The STM and AFCLIST have put efforts to have science teaching instructional methods that ensure meaningful learning despite limited resources.

An STM meeting was held in University of Zimbabwe in 1997 by African science education experts. They invited their counterparts from the rest of the world especially UK and USA. The rich exchanges of ideas lead to resolutions for the adoption of the following activities relevant to STM (Otuka, 2003):

i. Encourage learners’ involvement in activities like games , role play, discussion techniques, using case studies, picture stories among others.
ii. Developing creativity and thinking through, Think and Do, young scientists’ competitions, problem-solving and decision making.
iii. Using real-world resources such as national tree planting, using local resources, collecting and interpreting information.

They advocated for the use of concept maps and other meaningful learning tools. In this view the science curriculum in Africa are shifting from transmission of knowledge to the use of knowledge to build competences. They encourage the use of student centered methods (Pillai, 2003).

In conclusion the contemporary researches in physics education have clearly indicated that hands on approaches that encourage critical thinking lead to an increase of understanding of physics and should be integrated into its teaching and learning. Research on students' conception of physics has shown that students come to class with their own thoughts and beliefs of the world which are consistent or inconsistent with physics. Therefore, they need to be actively involved to modify and reinforce their views. However, there is still serious concern that many countries in the world are predominantly still using text book based lectures and they under utilize laboratories which is an important part of physics education. Furthermore, there are only few institutions in the world that have integrated active learning techniques to assist the students to visualize and attain qualitative and quantitative understanding of physics concepts. More so, there is great concern that even the laboratory experiments are done using cook book approaches which do not engage the students' mind and cannot impart any procedural and conceptual knowledge about the activity. Thus the students neither attain the psychomotor skills and any understanding of the natural world. They neither realize the validity, reliability and the source of errors of the experiments nor the connection between theories and experiments they are undertaking (IUAP, 2008).

It is against this background that International Union of Pure and Applied Physics (IUPAP) in conjunction with UNESCO and other bodies came out with the following appeal to all countries of the world towards physics education (IUPAP, 2008):

i. To ensure that best practice in physics education acquired from physics education research are implemented at all levels by encouraging teaching methods, including laboratory work, that actively engage the hands and minds of learners.
ii. To avail resources to equip laboratories and develop curricula that emphasize on science process skills.
iii. To develop indigenous low-cost instruments, physics apparatus and equipment. Also avail funds for computer-based data-acquisition systems for real-time measurements at the appropriate level of sophistication for a variety of uses in teaching of physics in the classroom and the laboratory.

iv. To develop appropriate curricula that teach physics with diversity of methods, including hands-on approaches that encourage critical thinking and help students' understand how physics is relevant to their local cultures and to a sustainable future for humankind.
v. Arrange for special sessions on educational aspects of hands on learning, experimentation and appropriate assessment through conferences, multinational collaborations and workshops for design and development of resource material for active learning and laboratory work.
vi. Dissemination of active learning methodologies through professional training of physics educators.
vii. Established electronic resource centers for exchange of ideas about local initiatives, teaching materials, prototypes of hands-on equipment, in particular those that can be locally adapted for construction by the teachers.

This study joins Africa and the rest of the world in improving physics education using Gowin's Vee heuristic strategy in the topic of moments in physics. It is a tool with both conceptual and methodological sides that encourages students and teachers of physics to be actively involved in the learning process. It also engages students' metacognitive abilities in its structure. These improve conceptual understanding of the subject and as a result some educational goals are attained.

2.2.1 Kenya Secondary School Curriculum

Kenya is still faced with the dilemma of curriculum relevance. Its response has always been the appointment of various commissions among them MacKay commission that ushered in the 8-4-4 system. Most of these commissions gave minimal attention to science curriculum and teaching methodologies. However, they play a significant role in making citizens cope with socio economic challenges facing the country and the achievement of some of the educational goals. Henceforth the educational reforms should adjust the science curriculum towards teacher education and teaching methods that will enable learners to be creative thinkers who can solve problems affecting society (Ndirangu, 2004).

The Kenya 8-4-4 education system takes sixteen years. That is 8 years in primary, 4 years in secondary and 4 years in university. In this curriculum the secondary school sciences offered are physics, chemistry and biology. Physics consists of 41 topics which are 9 in form one, 10 in form two and three and finally 11 in form four. These topics should be covered in four academic years. One year has 39 weeks which are divided into three terms namely term one, two and three respectively. Form one and two have 4 physics lessons per week. However in form three and four there are 5 lessons per week. Each lesson takes 40 minutes. The topic of moments is the third topic in form two and is allocated 10 lessons (KIE, 2002).

The curriculum is intended to achieve the specific objectives in each of the topics to be taught, subject objectives, secondary education objectives and finally the general aims of education (KIE, 2006). In the general objectives of physics the learner should be able to:

i. Select and use appropriate instrument to carry out measurements in the physical world.
ii. Apply principles of physics and acquire skills to construct appropriate scientific. devices from the available resources.
iii. Develop the capacity for critical thinking in solving problems in any situation.
iv. Contribute to the technological and industrial development of the nation.
v. Acquire adequate knowledge in physics for further education and training.
vi. Acquire positive attitudes towards physics.

The achievement of the above physics objectives will lead to the achievement of the secondary school objectives which enable the learner to:

i. Acquire knowledge, skills and attitudes for self and national development.
ii. Build a foundation for further education and training.
iii. Develop ability for enquiry, critical thinking and rational judgments.
iv. Build a foundation for technological and industrial development.

The achievement of the above secondary school objectives finally lead to the realization of some of the national goals. Hence the learner will be able to promote technological advancement to meet industrial, social and economic needs among others (KIE, 2006). Therefore there is an interconnection between the objectives and goals. For instance, when the learners attain specific objectives in the topic of moments, they will be able to achieve some of the general objectives of physics, secondary school objectives and finally the national goals (Muriithi & Ringera, 2004). Consequently, the process of teaching and learning in Kenya should aim at assisting students to achieve these objectives and goals set by the curriculum. This can be done by carefully choosing the relevant teaching methodologies. As a result the country will attain the millennium goals and facilitate the process of achieving vision 2030.

2.2.2 The Topic of Moments in Form Two Physics Syllabus in Kenya

The topic of moments (turning effect of a force) is the third topic in the Kenyan form two secondary school physics syllabus. It is allocated ten lessons hence it should take two and a half weeks to teach. The students learn about the principle of moments, sum of upward forces and downward forces, equal parallel force in opposite direction (couple) and various applications of the topic (KIE, 2002). It is a topic full of activities and applications and many apparatus used are easily available. For instance the teacher requires several metre rules, pieces of thread, wooden wedges and small masses. These materials are readily available in many schools (KLB, 2006).

The achievements of the above goals and objectives related to the topic of moments have not been fully realized. Most students performed dismally in the questions related to this topic. For instance in KCSE paper three 2005, students were not able to connect the activities in the experiment with the principle of moments (KNEC, 2005). This shows that students had poor conceptual understanding. This could probably be due to poor teaching methods among other factors. Most teachers still apply expository methods entirely despite having varied methods available depending on the demands of the lessons being taught (Njoroge, Changeiywo & Ndirangu, 2014). This develops poor conceptual understanding which is among the causes of poor performance. Furthermore students develop negative attitude towards the topic. SMASSE baseline studies 1998 (CEMASTEA, 2011) and Menjo (2013) established that teachers and students found the topic of moments to be difficult.

The topic of moments plays a key role in the learning of physics. It lays the foundation of concepts required in other topics to be covered later in the four year of physics syllabus. These are:

i. Equilibrium and centre of gravity in form two
ii. Work Energy and Machines in form three
iii. Floating and sinking in form four

Equilibrium and center of gravity is the fourth topic in form two. It is taught after the topic of moments which involves finding center of gravity of various objects. The principle of moment is applied in the calculation of weight of metre rule which acts at its centre of gravity. Therefore it is not possible to achieve this objective without the knowledge of moment of a force. Also stability of an object is affected by moment of a force whereby the turning effect due to the weight of an object determines its state of equilibrium and as a result its stability (KIE, 2006). Therefore the coverage of the topic of moments precedes this topic.

Work energy and machines is a topic in form three physics. It involves the study of work and energy. These concepts cannot be taught without prior knowledge of forces and distance which are found in the topic of moments. More so the machines being studied in the topic apply the principle of moments (Okere, 1996). Floating and sinking is the third topic in form four and the principle of moments is applied in finding up thrust in solids and liquids using relative density. The topic of moments is tested in physics paper one and mostly in practical paper three in the KCSE national examination.

Understanding the topic of moments will enable students to perform well and attain some of the goals set out by the curriculum. Therefore, it plays a significant role in physics and finding the correct teaching method that promotes its understanding is highly appreciated. This study focused on addressing these by using Gowin’s Vee heuristic teaching strategy. The Gowin’s Vee heuristic has come in handy in promoting conceptual understanding of the topic. In addition metacognitive ability of the learners is improved.

2.3 Science Teaching Methods and Strategies in Kenya

The center of debate in education for many years has been to have well trained teachers who can apply relevant teaching methodology. This is also the objective of every curriculum all over the world (Vanhear & Pace 2008). As result educationalists have been working hard to develop approaches and methods that can maximize the realization of teaching and learning objectives (Mintrez, Wandersee & Novak, 2005).This is due to generation of new concepts necessitated by changing technologies (CEMASTEA, 2011).

Since set curriculum in Kenya has determined the content to be taught with some suggestions on teaching approaches and methods (KIE, 2006), it leaves the teacher with limited control. On the contrary it is always the duty of the teacher to select suitable methods to be used. However, the challenges the teachers have are the many factors affecting learning. These are student ability, the topics to be taught, variety of teaching approaches, required resources and time among others. These make teaching and learning a complex task (Wong, 2009). This is further complicated by personal attributes of both the teacher and the learner like attitude, motivation, self- efficacy and level of metacognition. Despite the above predicaments, the physics teachers should be in the forefront in providing effective and relevant physics education for all students. What should be considered in learning science should not be what the knowledge is about but how it is delivered and experienced (Vanhear & Pace, 2008). This is because the correct selection of the teaching and learning strategies so that meaningful learning occurs determines professional competence of a teacher (Ramahlape, 2004). Therefore any teaching methodology used should add value, be unthreatening, convincing and trustworthy. There will be lack of harmony if the methodology is not in touch with cognitive, emotional and internal study goals. This calls for inspiration of the learner to gain high confidence and motivation (Wong, 2009).

The Kenyan 8-4-4 curriculum advocates for the integration of the teaching methodologies. Therefore the teacher is supposed to identify the convenient teaching methodology depending on the following prevailing circumstances in class (KIE, 2006):

i. Whether the method will contribute to achievement of the objectives.
ii. It should be appropriate to the learner.
iii. It should be an efficient method of teaching.
iv. Availability of resources to teach the topic.
v. Use a variety of teaching strategies to captivate the learner.

The approaches given in the teachers guide are inductive (teaching from specific to general), deductive (teaching from general to specific), expository, heuristic and discovery (KIE, 2006). Some of the methods listed are discovery, discussion, informal lecture, demonstration, project work, field work and experimental. These are categorized into teacher centered methods, learner centered methods and content centered methods (Balaraman, Kariuki & Kanga, 2004).

Alternatively, Novak and Gowin (1984) grouped them into meaningful learning methods and expository methods.

However, the teaching and learning process in Kenya is facing many challenges among them teacher centered approaches that promote rote learning are still predominantly used. This is confirmed by various researches carried out in the country. The Kenyan standard newspaper (Aluanga, 2012) reported about educational reforms and confirmed that one of the reasons for reform is the overemphasis on examination. He further reported frustrations that students are undergoing when they fail to get the required grades whereby some of them committed suicide. It also confirms a report by Uwezo (a regional research organization that covers East Africa) that Kenyan education has failed to be utilitarian but rather a fierce competition among schools to accumulate impressive grades. Education scientist, who was interviewed in the newspaper, emphasized the critical importance of science teacher training in order to achieve Vision 2030. He says that the overemphasis on examination results has driven education off the quest for knowledge and skills. Mwaniga (2014) revisited the same issue adding that the teacher student ratio of 1:43 has affected teaching in Kenya. These high shortage of trained teachers make schools to employ untrained or undergraduate teachers to bridge the gap. Most of these teachers use few teaching and learning methods and they apply expository methods entirely. This study applied Gowin's Vee heuristic teaching strategy to improve students' conceptual understanding and metacognition in the topic of moments in physics.

2.3.1 Expository Methods

Expository methods are categorized into teacher centered methods and content centered methods (Makokha & Ongwae, 1997). The teacher's dominion is highly prominent in teacher-centered methods. The teacher commands the contents as the learners listen and take notes. He/she is the master of the content. The learners' contribution is not necessary since the teacher seems to be already aware of their needs and has organized the content appropriately (Alvarez & Risko, 2007). It is highly transmissive, talk and chalk affair in which the learner is passive (Balaraman, Kariuki & Kanga, 2004). Examples of methods of this kind are lecture method and demonstration method. In addition, the content-focused methods have very fixed content that cannot be manipulated by either the teacher or the learner. The teacher's role is to carefully clarify and analyze the content. Alteration of the content is not allowed. Examples of method which disregards the teacher's and learner's input is the programmed learning e.g. use of charts, video programs, radio programs and question answer books (Makokha & Ongwae, 1997).

Expository methods of learning are direct instructional methods. The learners are told what they should know (Driver, 1987). The teacher presents students with the subject content and provides examples that illustrate the content. The teacher has the responsibility of organizing the content and presenting it in the way he/she deems best for the learner to understand (Alvarez & Risko 2007). The supporters of this method believe that should the student be given a chance to contribute to the content he/she will get confused and distracted and cannot be able to determine what is important. They believe that when the content is organized and laid out before them the learners will be able to learn new concepts and ideas (Makokha & Ongwae, 1997).

Expository methods begin with an introduction with an overview of the topic before providing more specific information and detail. An overview of the content is given and students' attention is intended to be focused on the key points of the subject during the presentation. By moving from the general to the specific (deductive approach), detailed explanations of the information and various links will lead to understanding of the content. The role of the student is to write notes for future reference. Many teachers prefer using this method of teaching because mostly the teachers are in control of the amount of content, the way it is presented and the time to be spent. Anything that needs to be taught practically is done using demonstration. It is believed that when learners repeatedly go through the content over and over they eventually understand the content. Direct memorization is accepted to be understanding of the content. The approach is considered less effective in teaching many science topics (Maheshwari, 2013).

Novak (2011) rejects the process of teaching where the teacher stands in front of class and gives out information for the learners to memorize without the slightest idea that the information meaning is understood. However, he confirms that the expository methods are still dominantly used. Kim and Pak (2001) confirm that the student studying mechanics were able to use expository methods to solve problems but had difficulty in understanding the concepts involved. They called for the integration with other approaches that bring conceptual understanding. After finding out the same issue Ndirangu (2004) commented that the teaching and learning should not be a process of providing learners with information to store but rather as a process where an environment is created for the learners to construct knowledge for themselves. Alvarez et al. (1987) explain that students can learn better on their own without the teacher-directed and student-governed expository methods. This study compared the performance of students taught using expository methods with those taught using Gowin's Vee heuristic strategy in the topic of moments in physics among secondary schools in Uasin Gishu county Kenya.

2.3.2 Constructivist Learning

Many early educational researchers pointed in the direction that learning is a constructed process hence the term constructivism. The term constructivism is used to identify a set of psychological theories that have a common belief of knowing and learning. It is grounded on the epistemological belief that the world does not have inherent meaning but human beings impose meaning on the world itself. It unites all the theories of learning, epistemology of knowledge building, the process of meaningful learning, knowledge construction and conceptual change. These theories are cognitive constructivist and social constructivism (Cahyadi, 2007).

These constructivist theories have a common view that the learner assimilates and accommodates new experiences and knowledge using the prior knowledge (Ausubel, 1963). Therefore learners construct meaning of the world through experience as they interact physically, socially and mentally. They adjust their knowledge structures that constitute interpretation and perception of reality (Swan, 2005). They incorporate new content into the already existing knowledge (Ausubel, 1968). They try to make sense of their environment or knowledge by association (Ausubel, 1963). Accordingly, no matter how one is taught all learning involves mental construction and adjustment of mental structures to accommodate the new knowledge and it is unique to the individual (Redish, 1994). This view discourages direct feeding of information using book reading with rigid instruction and procedures, video watching, worked out laboratory books, repetitive "drill'' and algorithmic approaches to solving science problems(Alvarez et al., 1987). It encourages active participation, intensive interaction and thoughtful reflection during the learning process (Taber, 2011). Thus Learning is an active process that is tied to experience and the context of experience (Gowin, 1981).

Constructivist learning approaches take longer since they require more activities in order for the student to learn meaningfully. This calls for a consideration on the educational goals and teaching methods presented to the learning environment (Mintrez, Wandersee & Novak, 2005). Teachers are also learners and they go about constructing meaning of knowledge content with the learners. Therefore teachers should acknowledge and use constructivist methods. Novak (1998) gave five constructivist elements of education to be the learner, teacher, subject matter, context or social milieu and evaluation. He gave five constructivist's pedagogical elements as shown in Table 4.

Table 4
Summary of Implementation of Constructivism Teaching System

Element	Description
Integrated teaching content	Physics book, topic of moment of a force
Role of pedagogue in teaching process	Innovation, organizer, manager, coach, consultant, motivator, evaluator, researcher, choreographer of small groups, learner helper
Learners role in learning process	Active conscious creator of his knowledge, individual understanding and meaning, responsible for his own learning.
Teaching learning strategies, methods, ways	Problem learning, autonomous learning, vee diagram, concept map, 'rain' of thoughts, discussion
Evaluation system	Evaluation forms, accumulated evaluation, self evaluation, idiographic evaluation, evaluation type

(Baleveciene & Juceviciene, 2005, p.121)

Redish (1994) gave four broad constructivist principles which are useful for teaching physics.

i. Construction Principle, which uses constructivism perspective, that knowledge is a constructed process and students should be given a chance to construct their knowledge.
ii. Assimilation principle, this is the rearrangement of knew knowledge by the learners' minds to fit into their mind structures. Related prior knowledge and experience form mental models into which new knowledge and experience are incorporated.

iii. Accommodation principle, which is the changing and modification of the mental structures to allow knew knowledge to be incorporated.
iv. Individuality principle, each individual student have their own unique way of representing the world.

These four principles are framework for physics and other science teachers to help them plan, monitor and evaluate their instruction, classroom activities, and learning assessments so they can maximize student understanding of science. One of the implications of the individuality principle is that teachers need to think about how students arrive at the same answer but for very different reasons. To determine how students reason, teachers should listen to them as they participate loudly in the learning process (Redish, 1994). Methods which call for active interaction among students as well as between the students and the teacher are constructivist. For instance during experiments in physics, the teacher should allow students to discuss their results in groups while performing the experiments. These consume time and students are sometimes noisy as they argue out their observations which according to constructivists are worth it (Okere, 1996).

Consequently, the constructivist teaching approaches have been preferred to the deductive and transmissive approaches (Ausubel, 1963; Ausubel et al., 1978). Constructivists developed meaningful learning strategies like advanced organizers, concept maps and Gowin's Vee (Novak & Gowin, 1984). This study uses the Gowin's Vee heuristic whose epistemological elements promote constructivist approach. When using Gowin's Vee students use constructivist approach when filling the twelve epistemological elements. In summary constructivist approach is based on the following knowledge considerations (Moe, 2011).

i. Knowledge is made up of interconnected conceptual structures and it is not possible to just transfer it from the teacher to student.
ii. Teaching and learning is not the same thing. Teaching is a social activity and learning is a private activity. It is the duty of the teacher to find out what is in the students mind by inferring. Understanding is not directly observable.
iii. The use of language is insufficient and cannot transfer concepts or conceptual structure from one person to another. It can only conjure the learners experience and interpretations in association with what is being said or written by the teacher.

iv. Learner's misconceptions are very crucial in identifying what the learner imagines of the concepts being taught.

2.3.3 Meaningful Learning Methods

The Ausubel and Novak meaningful learning theory considers meaningful learning as a process where the new knowledge is related substantively and non-arbitrarily to the already existing knowledge. Meaningful learning theory encourages the learner to become an active, not passive participant in the learning process (Ausubel, 1963). Ausubel (1968) gave three conditions for meaningful learning to occur. These are:

i. The learning material should be conceptually clear, the language and example used must relate to the prior knowledge of the learner.
ii. The learners must have a prior knowledge of the information.
iii. The learners should make a choice to learn meaningfully.

Ausubel (1963) emphasizes on the need for the teacher to ascertain what the learner already knows before introducing new knowledge. Novak (1998) confirms that knew knowledge cannot occur in a vacuum but depends on the prior knowledge that already exists in the learner's mind. So educators must build upon this prior knowledge in the mind of the learner hence meaningful learning will occur.

According to Novak (2011), knowledge acquire through meaningful learning is fundamentally stored differently from knowledge learnt through rote learning. The organization of concepts and propositions into the learner's cognitive structure takes place only through meaningful learning. Meaningful learning tools (Novak, 2011) bring some level of interaction during learning creating affective element in the process which helps in empowering the meaning of concepts. This makes the human learning to be construction process and different from the computer data processes. Figure 2 shows rote learning and meaningful learning process. It elaborates how rote learning differs with meaningful learning.

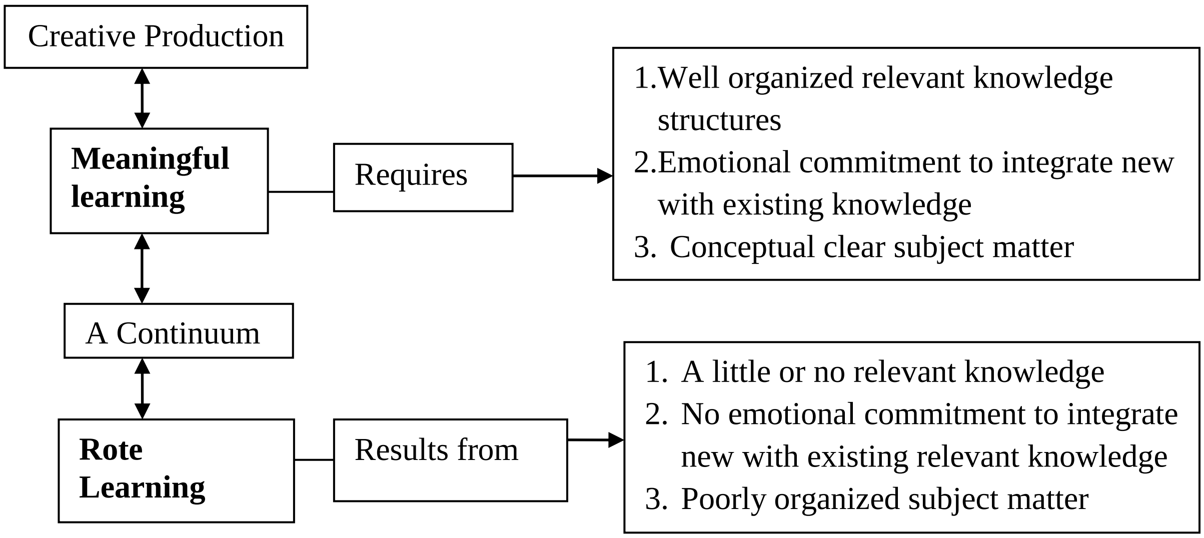


Figure 2
Showing meaningful and rote learning process (Novak, 2011, p.2)

Ausubel (1963), Novak and Gowin (1984) in their extensive research have explained the meaningful learning which brings about the following benefits:

i. Meaningful learning makes the learning process easy. The learners find it easy to learn because it is associated to their own experience. The needs of the learner are met.
ii. The knowledge learnt is long term. Because the knowledge learnt was incorporated into old knowledge. It is stored into long term memory and lasts long. There is deep learning.
iii. The knowledge learnt is easy to retrieve. This is due to the fact that the knowledge is stored in an organized manner through experience.
iv. Learning meaningfully generates more meaning. This is because the learner is able to interlink the known and the unknown knowledge. This enables the learner to subsume knew knowledge into the old knowledge.

Meaningful learning methods can be categorized into learner-centered and interactive/ participatory methods. In the learner centered method the learner plays a major role in the lesson while the teacher role is that of a guide. The teacher motivates and encourages the learner to move in the right direction. The learner and the teachers ask each other questions as they proceed with the lesson (Smith, Lee & Newmann, 2001). The teacher is both a teacher and a learner whereby he/she is able to comprehend how learners can understand the content better (Novak & Gowin, 1984). Each lesson is a new experience to the teacher and the learners (Alvarez & Risko, 2007). Examples of learner-centered methods are discussion method, discovery or inquiry method, field work and experimental method (KIE, 2006).

Interactive/participative methods incorporate elements of all the other methods without over relying on the teacher, learner or content. The class context, availability of resources and time allocated determines the method to be used at the time. This requires a well trained teacher with a wide variety of teaching methods (Newmann et al., 1996). Heuristic strategies like the Gowin's Vee and concept maps are useful in interactive methods.

Learning of science has evolved from the teacher centered where students were considered as only passive recipients to learner centered as explained in the various research. A teacher who applies these methods promotes meaningful learning. Newmann et al. (1996) compared schools use of rich base of teaching methods and those that have a poor base. He established that those with rich base of teaching methods performed highly and were able to organize, synthesize and interpret complex information. Of great consideration was the finding that in classes where teachers used a rich base of teaching methods the gap between low and high achievers reduced considerably.

Smith et al. (2001) did an extensive study in learner centered methods of learning and found that interactive learning produces high performing students. They were able to find that in this method teachers create situations with learners, asked questions, develop strategies to solve problems and communicate with one another. Students explained their answers and explained how they arrived at them. They argue with each other and their teacher. They work on the application and interpretation of their content and how to develop deeper understanding.

Chamizo (2011) confirmed that teachers need to change their teaching from being entirely instruction-oriented to an integrated guidance-oriented role whereby at some point they make use of Gowin's Vee heuristic diagrams. When excessive teacher dominated methods are used rote learning (Gowin & Alvarez, 2005) will take place. The learners consider the information being learnt as irrelevant, non essential and the knowledge is not connected in any way to their experiences. They can only want to memorize the information in order to answer examination questions. Methods that emphasize on the right answer deny the learners the chance to learn meaningfully (Alvarez et al., 1987).

As a result of theory of meaningful learning gaining more attention among educationalists in the world, metacognitive tools like advanced organizers (Ausubel, 1963), Concept maps (Novak & Gowin,1984) and Gowin's Vee (Gowin, 1981) have been developed. Using these strategies in learning subject matter more meaningfully and more effectively has continued to be encouraged and propagated (Mintrez, Novak & Wandersee, 2005). Advanced organizers (Ausubel, 1963) were developed as a teaching tool to promote meaningful learning. It was meant to bring connection of the new knowledge and the already existing knowledge of the learner. These are devices which are introduced prior to the lesson to enable the learner connect knew knowledge to their already existing knowledge (Ausubel, 1963, 1968). Stone (1993) conducted a research on the use of advanced organizers. He concluded that advanced organizers improves the understanding and retention of information at all levels of learning and especially low achievers. Nyabwa (2005) used advanced organizers in mathematics in Nakuru district Kenya and confirmed that advanced organizers are effective in the teaching and learning process and can improve students' attitudes in performance in mathematics.

The Gowin's Vee and concept maps are heuristic meaningful learning methods. According to Edwards (1988) the Gowin's Vee reflects the steps of assimilating knew knowledge to the old knowledge existing in the learners mind. He calls for change of educational methods of teaching in order to embrace the meaningful learning approaches. This study introduced the use of Gowin's Vee heuristic strategy as meaningful learning tool in Uasin Gishu County.

2.3.4 Heuristic Teaching Strategies

Heuristic has a Greek origin which means to discover. Armstrong (1902) introduced the term into teaching and learning methods. It emphasizes on the student centered methods of teaching (Maheshwari, 2013). The student is guided by certain rules to follow in order to realize the knowledge without the teacher. Users of heuristics believe that learners could be trained to discover scientific ideas by using faculties of observation, reasoning and memory. Learners are involved in observation, recording, analyzing, and drawing conclusions (Novak & Gowin, 1984).

The heuristic approaches used in teaching science have been considered important tools of synthesizing problems to be solved (Schoenfeld, 1992). Examples of heuristic tools are among others concept maps and Gowin’s Vee (Mintrez, Novak & Wandersee, 2005).

Concept maps (Novak & Gowin, 1984) are also meaningful learning heuristic tools. They are graphical tools that are used to represent knowledge. The concepts are usually enclosed in circles or boxes whose relationships are indicated by a connecting line. Along the lines are linking words which specify the relationship. The concept maps show knowledge pathways. Apart from being meaningful learning tools they are also metacognitive tools. Concept maps can be used to represent the conceptual side of the Gowin’s Vee (Novak & Canas, 2007). Figure 3 shows an example of a concept map drawn in the topic of motion in Physics.

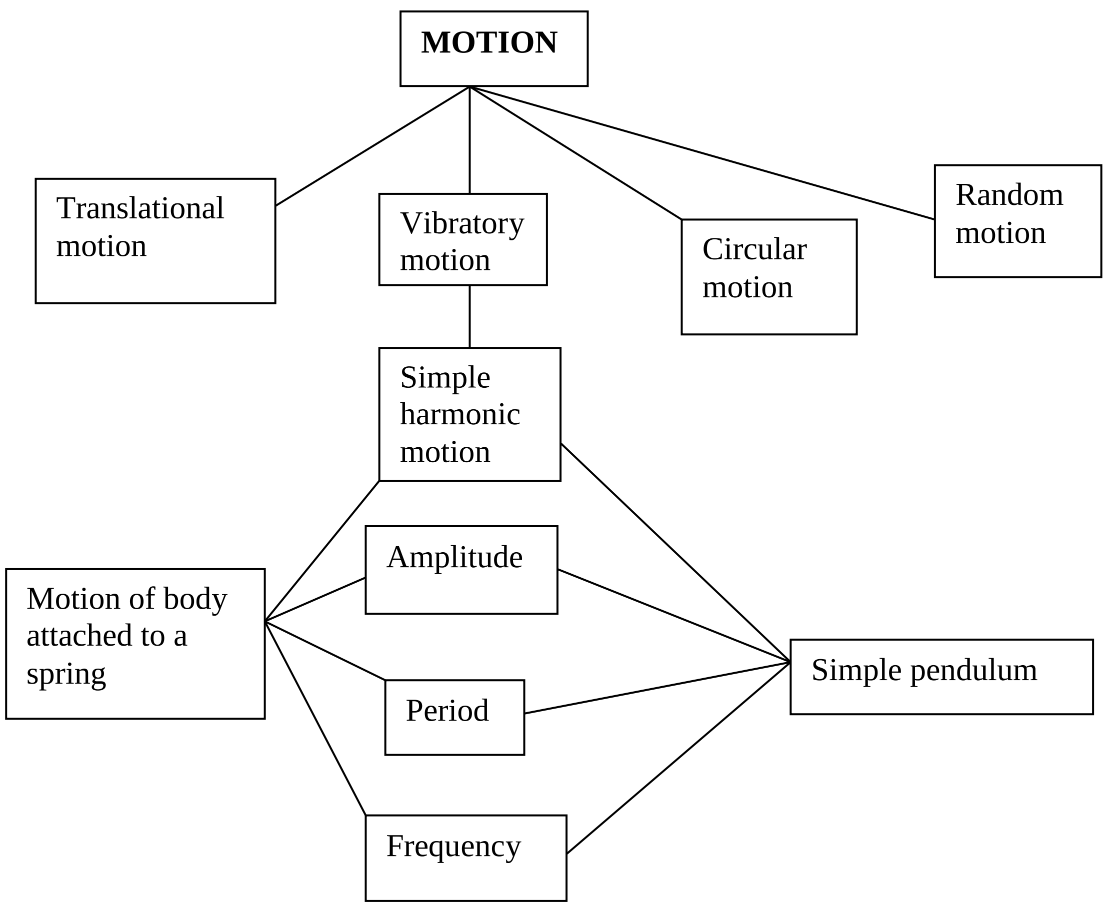


Figure 3
Concept map used in the topic of motion (Safdar, Husein, Shar & Tasnim, 2013, p.56)

Heuristic methods of teaching science have the following merits (Madhavan, 2009):

i. It develops the habit of enquiry and investigation among students.
ii. It develops habit of self learning and self direction.
iii. It develops scientific attitudes among students by making them truthful and honest.
iv. They learn how to arrive at decisions by actual experimentations. It is based on learning by doing.
v. It develops in the student a habit of diligence.
vi. In this method most of the work is done in school and so the teacher has no worry to assign or check home task.
vii. It provides scope for individual attention to be paid by the establishing cordial relations between the teacher and the learner.

Gowin`s Vee in this study is part of heuristic strategies which achieves the objective of knowing the learners interest in relation to teaching (Novak, 1998). It ascertains what is already known by the learner and using its structure extends that knowledge (Mintrez, Wandersee & Novak, 2005). When using heuristic, learning is designed such that the student is made to proceed in the right direction and this makes the learning method student centered. It creates a clear understanding and meaningful learning occurs. In an assumption that heuristic strategies always consume a lot of time (CEMASTEA, 2011) many teachers and educational stakeholders in Kenya do not apply them. However, heuristic tools have been designed as mental shortcuts that allow learners to solve problems and make judgments quickly and efficiently. These rule-of-thumb strategies shorten decision-making time and allow learners to follow a prescribed format that leads to the solution. Gowin's Vee which is a heuristic teaching strategy has been used in this study in the topic of moments in physics.

2.3.5 Gowin's Vee Heuristic Teaching Strategy

The Gowin's Vee heuristic strategy (Gowin, 1981) derives its name from the letter 'V' and the person who developed it in 1977. The shape of Gowin's Vee was chosen by Gowin (1981) because it points at the objects and events which he claims to be the root of production of knowledge. The objects ensure that the knowledge being sought is relevant to the problem. Gowin developed it after realizing that students were not able to connect between theory and activities they were doing in a biology experiment and sought to unite the 'thinking' and 'doing' parts of scientific knowledge (Novak & Gowin,1984).

Gown's Vee helped students to understand the structure of knowledge (such as relation knowledge hierarchies, combinations) and to understand the process of knowledge construction (Alvarez, 2011). Gowin (1981) fundamental assumption is that scientific knowledge is not absolute but is dependent upon the concepts, theories and methodologies by which we view the world. Also it helps student to see interplay of the previous knowledge, knew knowledge and the process of modification over time (Edwards, 1988). Afamasaga (2008) adds that the Gowin's Vee is a tool that has been known to be used for learning, teaching and assessing. It has been known to be effective in promoting learning across many disciplines in many international classrooms. It has twelve epistemological elements to be filled in by the learner as shown in Figure 4.

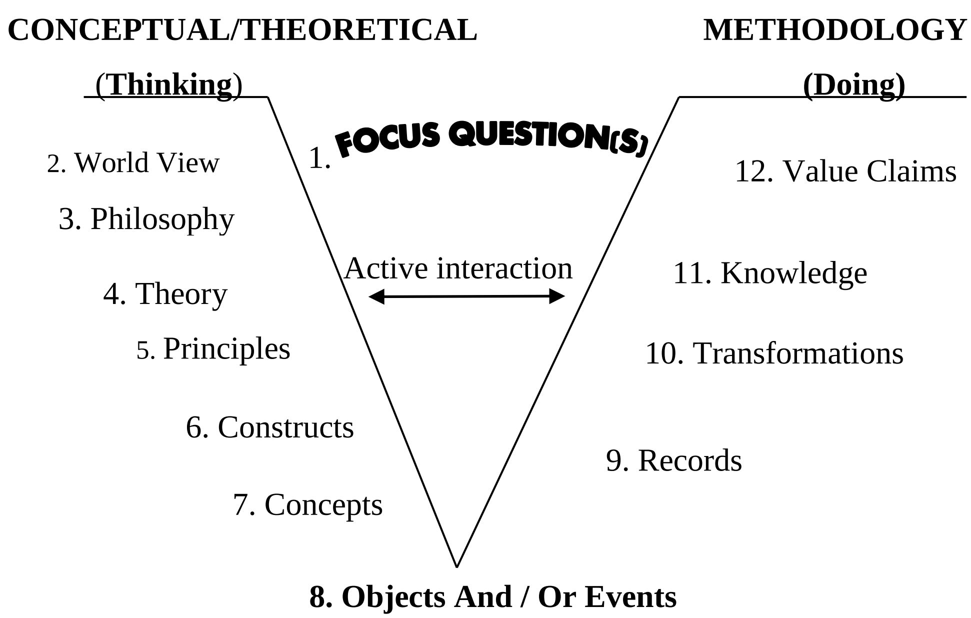


Figure 4
Gowin's Vee twelve epistemological elements (Novak & Gowin, 1984, p. 56)

The twelve epistemological elements in the Gowin's Vee in Figure 4 relate activities performed in the laboratory to the concepts and theoretical ideas that guide the scientific inquiry (Novak & Gowin, 1984). They help the learner to get the interplay between the structural knowledge developed during the laboratory and the conceptual knowledge produced from investigatory process which also improves metacognition (Åhlberg, 1993). These agree with Gowin and

Alvarez (2005) that it is a tool to aid in understanding meaningful relationships, planning, analyzing in research, teaching and learning. They concluded that in using it there is simplification of complex concepts through self educating and sharing the knowledge with others. These processes enable students to have a different experience of learning in education.
Alvarez and Risko (2007) in a study done in America on third graders in learning science concepts in biology, reiterated that students were able to associate concepts, made predictions, raised questions with each other and the teacher, made connections, structured their knowledge and generated their own meaning. It served as an evaluation instrument for both students and the teacher. Students became self empowered thereby correcting their scientific misconceptions and removing uncertainties making the education process meaningful. In conclusion, the students had realized that using the tool, textbook information could be used to create meaning by combining facts and ideas using the Gowin's Vee heuristic.

The Gowin's Vee heuristic is a symbol of knowledge that is constructed. It is a heuristic device meant to analyze the knowledge claims of science. It unpacks information that stimulates the mind to think and critically examine the structure of a given scientific investigation so that there is connection between the known knowledge and the new knowledge to be learnt (Gowin & Alvarez, 2005). Studies using Gowin's Vee heuristic in the laboratory indicated that the students improve in the quality of thinking, quality of lab reports especially in creating meaningful and concrete interpretation of laboratory test scores. This makes the laboratory report to be represented in one structure (Roth & Verechaka, 1993). As a metacognitive strategy, it allows the learner to organize their cognitive structures into more powerful integrated patterns and learners examine the conceptual, rational and hierarchical nature of the knowledge which they are actively learning (Novak & Gowin,1984).

While using it students analyze the processes used in solving problems, validating and looking for relationships among concepts and activities. So it guides the thinking process of the teacher and that of the student in the problem solving situations and various other applications. It gives useful knowledge to teachers about their students thinking and values hence improves the teaching and learning process (Thiessen, 1993). Åhlberg and Ahoranta (2002) established that Gowin's Vee heuristic promote meaningful, deep, creative geographical learning and metacognition. A Typical Gowin's Vee heuristic used in the topic of linear motion in physics is as shown in Figure 5. Similarly, this research used it in the study to teach the topic of moments in physics.

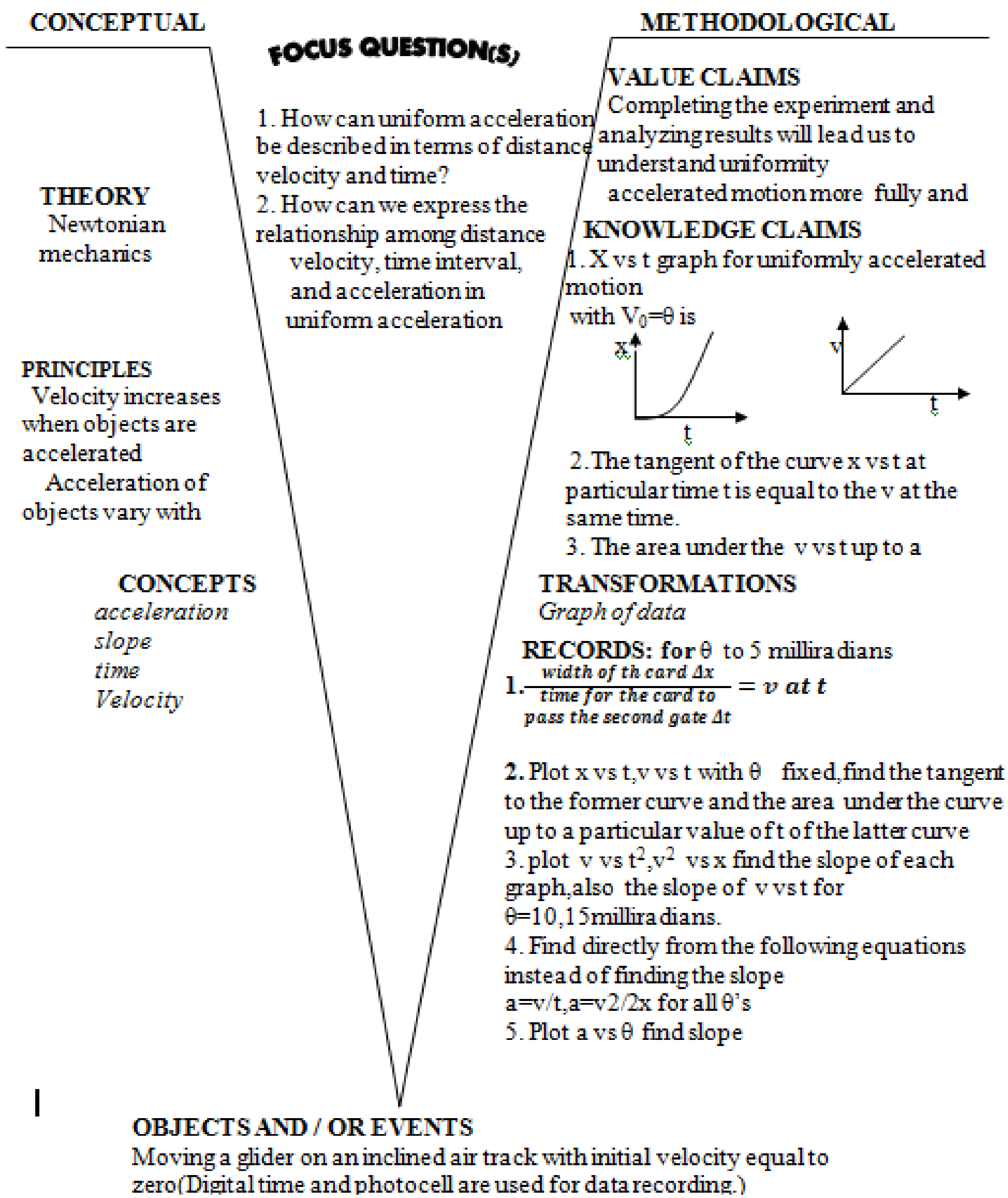


Figure 5

Gowin's Vee diagram on the topic of linear motion (Novak & Gowin, 1984, p. 96)

Ramírez, et al. (2008), in Venezuela, explained the use of Gowin's Vee as a tool that enables the students to build their own knowledge of mathematics. Through the use of Gowin's Vee heuristic, students verify and justify mathematical knowledge which promotes the students metacognition. Morgil, Secken and Karacuha (2005) found the use of Gowin's Vee heuristic in chemistry experiment useful in motivating the student whereby the theoretical knowledge turned to be more meaningful in the students' minds.

According to Roth and Bowen (1993) students working with the Gowin's Vee heuristic can penetrate the structure and the meaning of any branch of knowledge. Students' improve on investigation, are able to organize their thinking and guide themselves in the learning processes. In higher education Sillitoe and Webb (2007) stated the usefulness of the Gowin's Vee heuristic in boosting the students self confidence, making the concepts clearer, deepening their research understanding and locating a suitable theory to their situation. Apart from the Gowin's Vee enabling students to construct knowledge and move away from rote learning to meaningful learning, the student might learn alone without the teacher (Novak, 1990). The usefulness of Gowin's Vee heuristic to the students, teachers and researchers is highly acknowledged and various improvements have been made to suit many educational situations and levels (Ahlberg, 1993, 2005).

Muscat (2012) confirmed that when students use Gowin's Vee heuristic they are able to observe, question, reflect, criticize, evaluate and discuss various issues. Students obtain a holistic science experience which focuses on feelings, emotions and attitudes together with cognitive development. It gives students a way to express their biology knowledge in a direct, concise way, linking knowledge from different topics and academic subjects together without limiting themselves to knowledge alone. It is able to represent valuable skills for future generations.

Afamasaga-Fuata'i, (1998, 2007, 2009) extensively researched on the use of the Gowin's Vee heuristic and concept maps in mathematics. She reiterated that the Gowin's Vee heuristic mapped the students' understanding and they developed deep understanding of structure of mathematics. She emphasized that it is an effective tool in guiding the critical thinking and it is a systematic approach for the analysis of the structure of knowledge in a mathematics problem. Furthermore, she stated that students found the Vee to be much easier than concept maps to draw and it makes the learners self driven when learning. Mostly in her classes in secondary school, students were not required to include world view and philosophy as shown in the Figure 6:

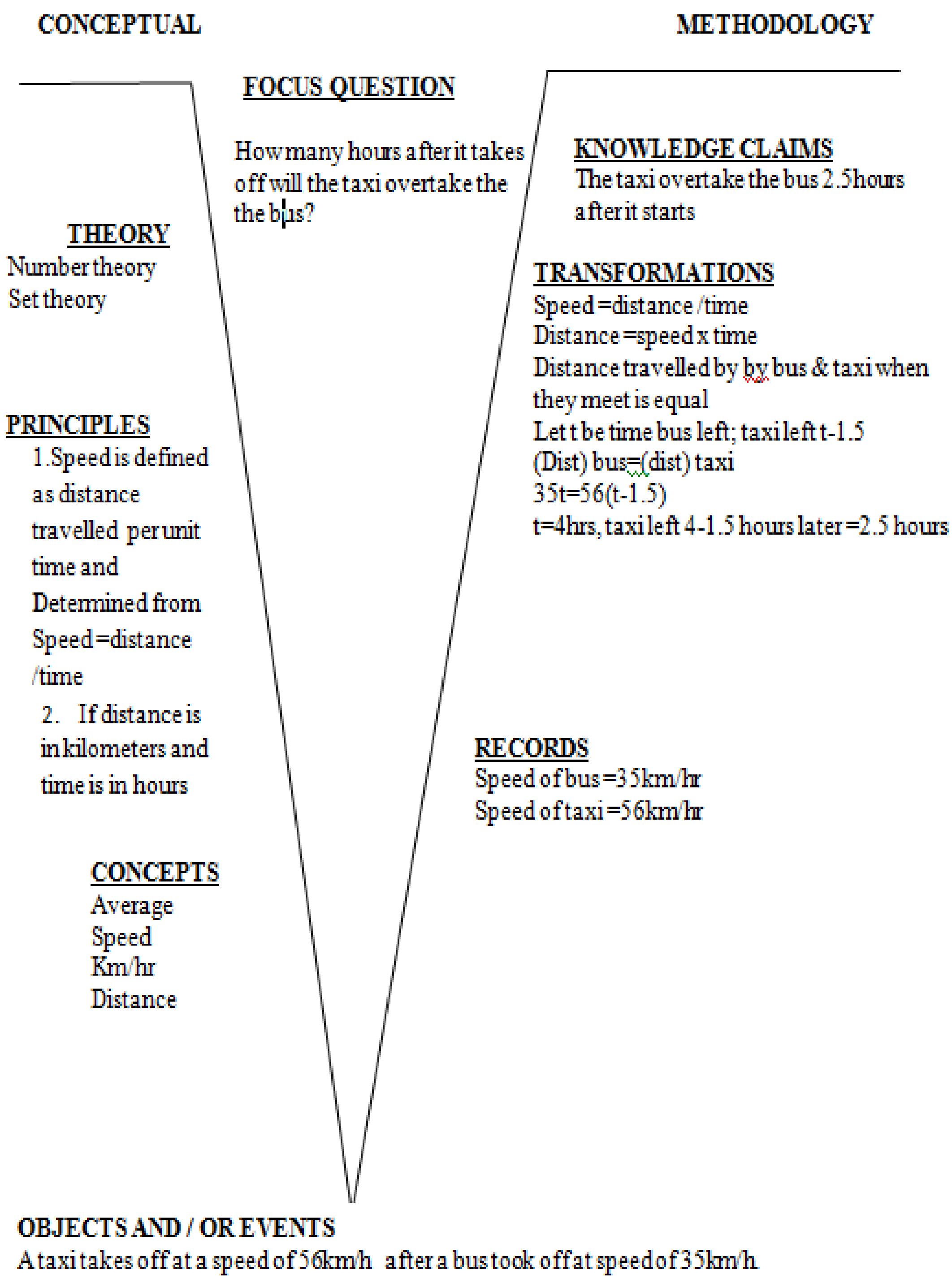


Figure 6

Gowin's Vee drawn by a secondary school student in mathematics (Afamasaga Fuata'i, 1998, p. 69).

Vanhear and Pace (2008) found in their research that when using the Gowin's Vee the learners were able to construct knew meaning especially when the learning process actively involve learners in ways that are familiar to them. They added that the Gowin's Vee is able to meet metacognitive conditions by capturing all the mental process involved like thinking, acting and feeling. They gave more explanation that affective domain improves when the learners become considerate of each other based on mutual understanding of their knowledge processing. It ensures the process of learners' reflection and action, giving a vivid picture of the learners' mental process and how they can develop their thinking.

When using the Gowin's Vee the teacher gets the picture on the way the learner is responding to the incoming information by identifying the child's internal environment. The learner is trained on decision making, reflecting and problem solving skills. It shifts the control of learning from the teacher to the learner making the learners the argents of their own learning. The learner demonstrate how he/she intends to learn more giving the teacher relevant information on how to plan for the next lesson. Hence the lesson becomes sensitive, relevant, motivating and meaningful. These motivate the learner and improve performance (Vanhear, 2012).

Gowin's Vee helps students connect concepts and methods encouraging them to think as scientists when doing experiments rather than followers of readymade procedures. In addition it helps students to learn about the knowledge structure and the process of knowledge construction. Students were able to learn concepts in relation to experiments in the laboratory. It improves learners' understanding of scientific knowledge in the laboratory. The Vee also served as an evaluation tool for both the teacher and the learners in assessing the extent to which ideas were represented in the left part of the Gowin's Vee. In the laboratory, confusion, doubts and misconceptions were corrected using the Gowin's Vee and hence meaningful learning took place (Safdar et al., 2013).

Thoron (2011) stated that the Gowin's Vee is not a tool that requires recall of experiments but students will formulate focus questions, identify the concepts, give procedure, create graphic organizers, include data tables and draw conclusions. He concluded that the Gowin's Vee was effective in agriscience laboratory report than the usual reports. It is not affected by gender ethnicity or grade difference. He called on the teachers and curriculum developers to accept

Gowin’s Vee as a laboratory assessment tool. He concurs with other researchers that educators should steer away from rote learning methods and follow those that foster conceptual understanding like the Gowin’s Vee.

Calais (2009) concurs that the students who pursue their own questions feel responsible and take ownership of the solutions. He reiterates that even the most ideal environment will be useless if the students fail to understand what they are learning. He proposes that apart from the many common uses of Gowin’s Vee in science and mathematics it is versatile and can be used in arts painting work, English in grammar, history topics like world war biopsychology on drug addiction, sociology for census data survey, in music on musical notes. It can be used by teachers as pedagogical tool to improve their teaching skills. It can be used in any level of educational since students are able to come out with ways of using this tool to fit their context.

The use of this tool enhances students understanding. It is an interactive tool that promotes high level thinking skills. The learners are able to conceptualize their learning in a better way because they can see how the scientific knowledge is developed in the Gowin’s Vee (Thoron & Myers, 2011). It compliments Novak (1998) that Gowin’s Vee has been confirmed to be a powerful tool in unpacking knowledge in the text, laboratory and even lectures and improves the learners.

Lee (1997) acknowledges that the students who use Gowin’s Vee in music were able to attain higher scores than the others and reaffirms that the Gowin’s Vee can be used to assess knowledge outcomes. Smith (2012) says that the Gowin’s Vee has been confirmed over time to be able to promote successful science learning. Roth and Roychoudhury (1993) give a similar conclusion that the students get better understanding in laboratory science concepts. They purported that it helps students organize and construct new knowledge giving them better understanding.

Roehrig, Luft and Edwards (2001) stated that the Gowin’s Vee heuristic provides students with a blue print of learning science. The teacher can easily identify the student knowledge already existing in their minds. In their study in biology various students managed to draw a Gowin’s Vee heuristic which substitutes the items in the left side of the original Gowin’s Vee heuristic with a concept map. Ramahlape (2004) also did the study of using Gowin’s Vee in the topic of electricity in South Africa. A Vee map was used which substituted the left side of Gowin's Vee with a concept map as shown in Figure 7.

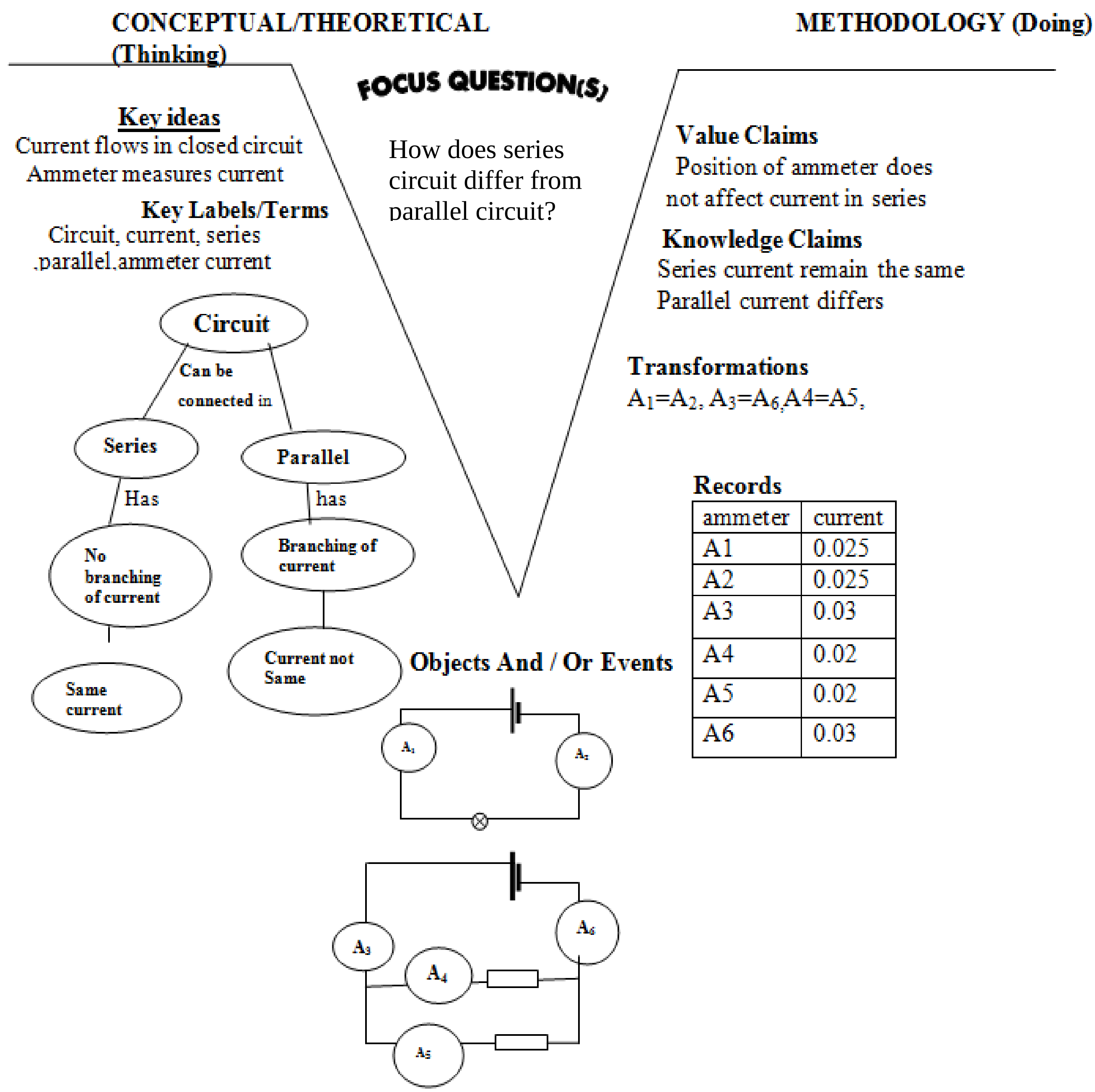


Figure 7

Gowin's Vee with a concept map in current electricity (Ramahlape, 2004, p. 37)

Fox (2007) after using the Gowin's Vee heuristic in Geography in South Africa confirmed that it can create high level of understanding and he encouraged other Geographers to use the tool. He attributed the success of the heuristic to its integration of both methodology and philosophy combined in one cohesive structure hence bringing about meaningful learning. The interaction of all the elements of the Gowin’s Vee in an investigation enables the learner to connect knew information with the already existing knowledge (Ramahlape, 2004).

In summery the following are benefits of Gowin’s Vee (Novak & Gowin, 1984):

i. It enables students to penetrate a given structure of knowledge. By filling the twelve epistemological elements the learner can relate the two sides.
ii. It improves students’ metacognition. When filling the Gowin’s Vee the students’ mind goes through planning, monitoring and evaluation of the knowledge being studied.
iii. It enables the teacher to understand the thinking process of the learner hence can teach accordingly.
iv. Gowin’s Vee brings about conceptual understanding. Students taught using the Gowin’s Vee enables the learner to relate the concepts, principles, laws and theories with the activities they are performing. This brings about conceptual understanding.
v. Students improve in problem solving skills and hence perform better in their test.
vi. Gowin’s Vee can reverse students misconceptions
vii. It enables the learner to transfer knowledge from one subject to the other(Wittrock,1994)
viii. It is versatile. It can be used for research, as laboratory report, lesson plan, planning an investigation.
ix. Asset for revision. It can be used during study to highlight all the elements of the study.
x. It can be used as an evaluation tool. By examining the students using Gowin’s Vee, the teacher can know the level of conceptual understanding.

Namasaka, Mondoh and Keraro (2013) in Kenya performed a research on the combination of concept maps and Gowin’s Vee concluded that their use promotes student’s motivation in biology and improves their performance. They were also able to find out that the use of the Gowin’s Vee and concept maps does not affect gender. This study will encourage the use Gowin’s Vee in the Kenyan 8-4-4 curriculum and more so to teach the topic of moments in form two physics.

2.4 Conceptual Understanding

Concept means perceived regular measurable scientific objects or events. It is a general idea or thought that constituting a set of objects and events that have common properties. It is an abstraction which pulls together a number of facts. It can be expressed as a single word or a combination of words. Concepts help learners to arrange new information by organizing facts into patterns of similarity and difference. Concepts serve as structures for developing scientific knowledge. They include objects like photon, fluids, solids and events like forces, moments, and turning effect just to mention a few (Novak & Gowin, 1984; Chadwick, 2009). In a Kenyan physics syllabus most concepts are mentioned as basic and derived physical quantities.

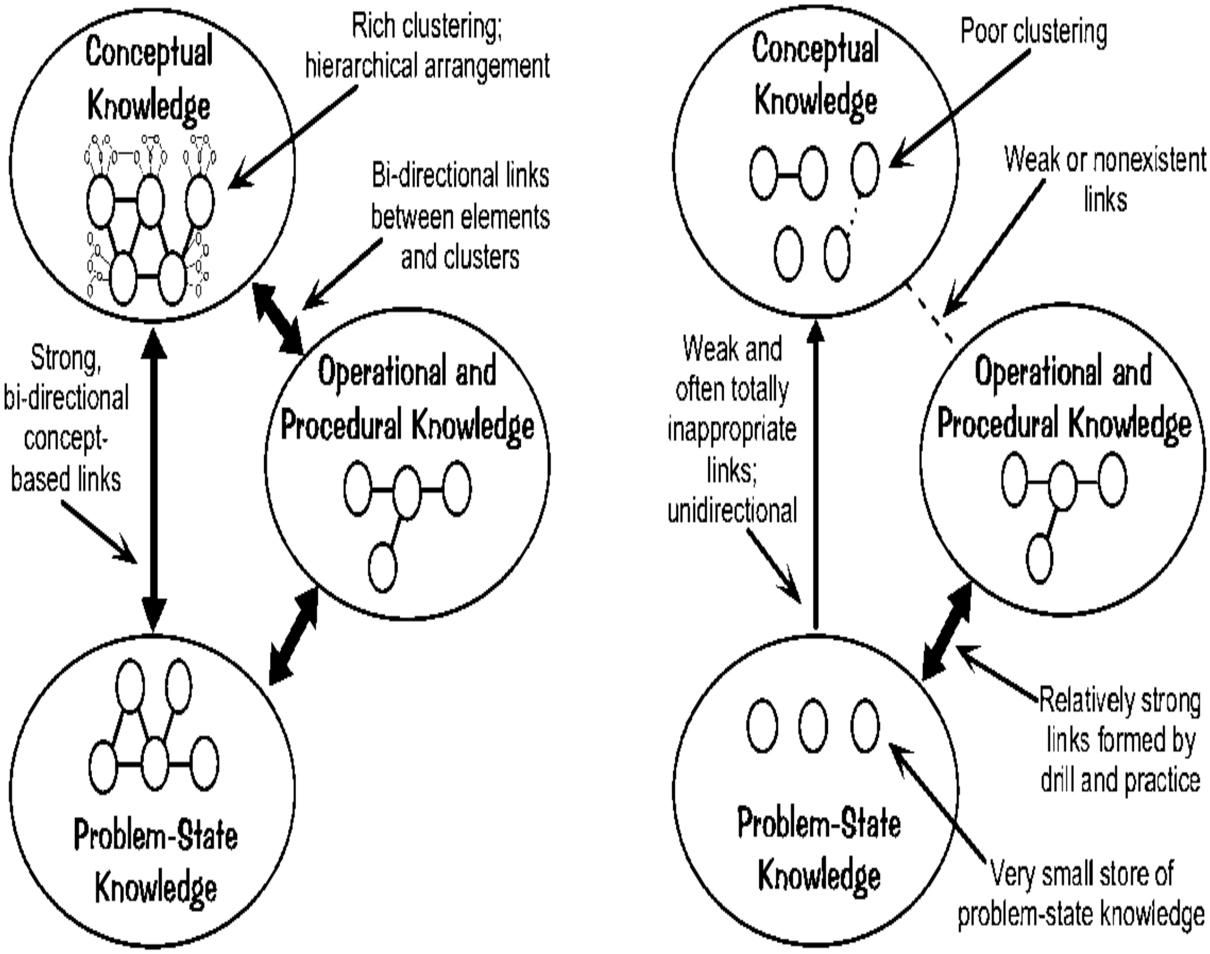
Conception of the learner means the learners' communicated beliefs and feelings about a concept. Understanding is acquiring beliefs of knowledge that are consistent with already existing and acceptable knowledge (Kestberg, 2002). National Research Council (2001) defines conceptual understanding to mean comprehension of concepts, operations and relationships. Students with conceptual understanding know more than isolated facts and methods hence they can recognize, label, and produce examples of concepts. They can use and interrelate varied representations of concepts then identify and apply principles. They should know and apply facts and definitions. They compare, contrast, and integrate related concepts and principles. They recognize, interpret, and apply the signs, symbols, and terms used to represent concepts. It makes students to make connections between concepts, understand the similarities and differences of each concept in detail. They can explain why some concepts are as a result of others. In this case facts are no longer isolated but become organized in coherent structures based on relationships, generalizations and patterns. Their knowledge become generalized and can be applied in many other problems (Wong & Evans, 2007).

Therefore, teaching for conceptual understanding should be the driving force behind every science teacher. Mostly students perform poorly on conceptual problems hence a need to design a teaching strategy that could facilitate students' conceptual understanding. Part of the nature of scientific knowledge is to make empirical observation of the natural world. As a result questions, investigations and interpretation of data are generated. Finally they are filtered through the prism of current scientific concepts, principles, theories and laws. This makes the science knowledge to be subjective and progressive. Since scientific knowledge is made of theories that are progressive and not absolute truths, students who memorize the knowledge are disadvantaged. However, conceptual understanding gives room for these changes and conflicting theories which is part of the nature of science. Table 5 shows the difference between conceptual understanding and rote memorization.

Table 5
Difference between Conceptual Understanding and Rote Memorization

Conceptual Understanding	**Rote Memorization**
Concepts are interlinked meaningfully	Concepts are discrete and no relationship exist
The students modify knowledge to suit their experience	The students take content the way it is without change.
Knowledge stays in long term memory	Knowledge stays in short term memory
Promoted by meaningful learning methods like Gowin's Vee	Promoted by expository methods
Content is meaningful	Content is abstract

When concepts are taught by considering the linkage with already existing conception of the student they easily get the knowledge (Baraz, 2012). Garace (2001) accept the importance of learning with understanding. A student who has developed conceptual understanding behaves like an expert in connecting various concepts. In comparing the experts and novices in various fields, he concurred that experts and novices represent their knowledge differently. The experts have very well connected knowledge of concepts principles and inquiry procedures hence they demonstrate high level of conceptual understanding. This can be shown in Figure 8.



Expert knowledge store **Novice knowledge store**

Figure 8
Expert novice knowledge representation (Garace, 2001, p.1)

Therefore in order for learners to become knowledgeable and competent they should not only have a large content of factual knowledge (Driver, 1987) but also have an organized conceptual framework of concepts and ideas that lead to conceptual understanding. They should be able to transform facts into usable knowledge (Novak &Gowin, 1984). The knowledge learnt through rote memorization is rarely transferable (Driver, 1987). Transfer will only occur when there is deep understanding of concepts and principles which gives the ability to manipulate the variables in order to solve other problems (Branford, Brown & Cocking, 2000). Bottoms, Pressons and Johnson (1992) gave four principles that determine teaching for understanding. These are:

i. Challenging curriculum. It should bring out critical thinking, solve many problems in community by applying their knowledge and should generate new meaning and understanding in their experience.
ii. Teaching for understanding. This should create rich environment for creativity that thoroughly synthesize knowledge being learnt.
iii. Teaching meaningfully. Students should be able to see the connection of content with their experiences and apply their knowledge in many contexts.
iv. Setting clear performance standard. There should be well established standards of assessment that require the learners to demonstrate their understanding of knew knowledge and skills.

Conceptual understanding teaching strategies can promote students' interest, curiosity and understanding by showing that science is a human enterprise. Teachers and writers of textbooks can endeavor to facilitate the understanding that scientific progress requires going beyond the regurgitation of experimental details (Niaz, 2005). Bossé and Bahr (2008) established in their survey that conceptual understanding, involves the knowledge that is adjustable, transferable, and applicable to other situations. They gave the following benefits of conceptual understanding:

i. It makes subject (and the world) more sensible or meaningful.
ii. It is a flexible foundation for long-term retention and understanding.
iii. It assists the reconstruction of the idea if details are forgotten.
iv. It does not rely entirely on memory.
v. It links facts and procedures.
vi. It leads to new learning.
vii. It is continually growing and developing.

In their study Stigler and Hiebert (1999) compared Japan, Germany and U.S.A approaches to learning mathematics. They established that good performance is as a result of teaching for meaning and understanding. Teaching especially in Japan emphasizes conceptual understanding at the expense of content. Weiss et al. (2003) in their analysis of science and mathematics classes in the USA have come to the conclusion that successful learning only occurred in the classrooms where students learnt how to make sense of the mathematics and science principles by getting to know the concepts needed and apply them to new situations.

Marzano, Pickering and Pollock (2001) did an extensive study of various instructional methods of teaching. They established that effective strategies are the ones which make the learners to be able to identify similarities and differences, use non linguistic methods like heuristics, graphic organizers, charts models etc. They enable students to generate and test hypotheses and ask students to explain their thinking. These methods make students establish connections, create, conceptual understanding and explain and apply knowledge to new situations.

For science instruction to be effective it should be able to develop lifelong learning skills so that they can be used in learning high level science knowledge. It should allow them to construct their conceptual knowledge and procedural strategies at any time they require it. In addition it should create awareness to the learners about their scientific beliefs that affect their science learning process and the teachers' choices of teaching methods (Okere, 1996).

For instance, in the Kenyan secondary schools expository methods based on textbooks and past examination papers are mostly used (Kiboss, 2002; Changeiywo, 2000). Furthermore, Okere (1986) elaborated that creativity in physics was lacking because the students lacked basic physics concepts. He confirms that students who had already gone through A-level did not have the necessary knowledge of physics and cannot communicate the same knowledge to those who need it due to poor conceptual understanding.

The poor performance in physics, partly due to lack of conceptual understanding, has been a challenge to all educational stakeholders. As a result of these the government of Kenya (GOK) through Ministry of Education Science and Technology (MOEST) in collaboration with Japanese International Cooperation Agency (JICA) decided to put measures in place in order to reverse this trend. Consequently, they established teacher in-service training (INSET) in 1998 called Strengthening of Mathematics and Science in Secondary Education (SMASSE) project. This study used Gowin's Vee heuristic strategy to improve conceptual understanding in the topic of moments in physics.

2.5 Metacognition

This term originated from developmental psychologist Flavell (1979) of Stanford University. He used the term to mean knowing about one's own cognitive processes and any other related aspects like monitoring and regulation using set goals or objective like checking, planning, selecting and inferring, self interrogation and introspection (Flavell & Wellman, 1977). Other aspects have been added like meta-memory, meta-learning. Metacognitive aspects of memory and learning describe metacognition as what we know about knowledge and how we regulate it (Brown, 1987). Cooper and Sandi-Arena (2009) defined metacognition as knowing why and when things should be done. Metacognition is considered by many scholars as 'control centre' (Flavell, 1979; Schraw, 1998).

Metacognition in education is in two areas, these are the general domain of studying from text and the problem solving (Schoenfeld, 1987). Metacognition has been defined in science education as a composite comprising of knowledge, its control and awareness (Baird, 1990). Blank (2000) added that the students thoughts of science entails some aspects of metacognition. Thomas, Anderson and Nashon (2008) while looking for metacognition instrument for science pointed out that the learner's relationship of metacognition like planning, monitoring and evaluation, self- efficacy, learning risk awareness and controls of concentration that are closely related to metacognition are considered in science learning. This is because metacognition does not exist alone but it is related to the above elements. As a result, metacognition may vary with context and subject area and over time. Thus it is important to look at metacognition in the general context as well as in subject area like science. This is because students learning science will see themselves as science learners and their learning activities will be related to science.

Cognition and metacognition differ in function and content. Cognition solves problems while metacognition regulates the person's cognitive processes in solving the problem. For instance the realization that one has not understood an issue makes one to deliberately increase the level of concentration in order to understand (Hacker, 1998). The contents of metacognition are knowledge, skills and information about cognition and the contents of cognition are objects, persons, events, physical phenomena, signs, etc., skills to handle these entities, and information on the tasks. Therefore they should be differentiated using the above tasks (Livingstone, 1997)

Metacognition is a composite term (Schraw, Krippen & Hartley, 2006) meaning thinking about our knowledge, how we think and their regulation. It is divided into metacognitive knowledge and self regulation. Metacognitive knowledge is what one knows about cognition. It is the knowledge about our own thinking and other peoples thinking. It involves the knowledge that (Livingstone, 1997):

i. Planning and organizing content makes understanding better.
ii. Being aware that a noisy class reduces concentration than a quiet place.
iii. Realization of existence individual variation in thinking and remembering (some can remember names faster than faces).
iv. Knowing limitations of one's memory.

Metacognitive knowledge is divided into declarative, conditional and procedural knowledge. Declarative knowledge is being aware that one is a learner and the factors influencing their learning. It is being aware of one's own learning process and the strategies that one can use to teach (Baird, 1999). Procedural knowledge is about learning strategies and procedures (Pressley, Borkowski & Schneider, 1987). It involves being able to choose the right strategy to use in the learning process and how to use each strategy. For instance, making short notes, slowing down to check for important information and then summarizing main ideas. Conditional knowledge is having knowledge of when to apply the learning strategy. It involves assessing demand for a particular learning situation and hence choosing the right strategy (Reynolds, 1992). Figure 9 shows the various branches of metacognition.

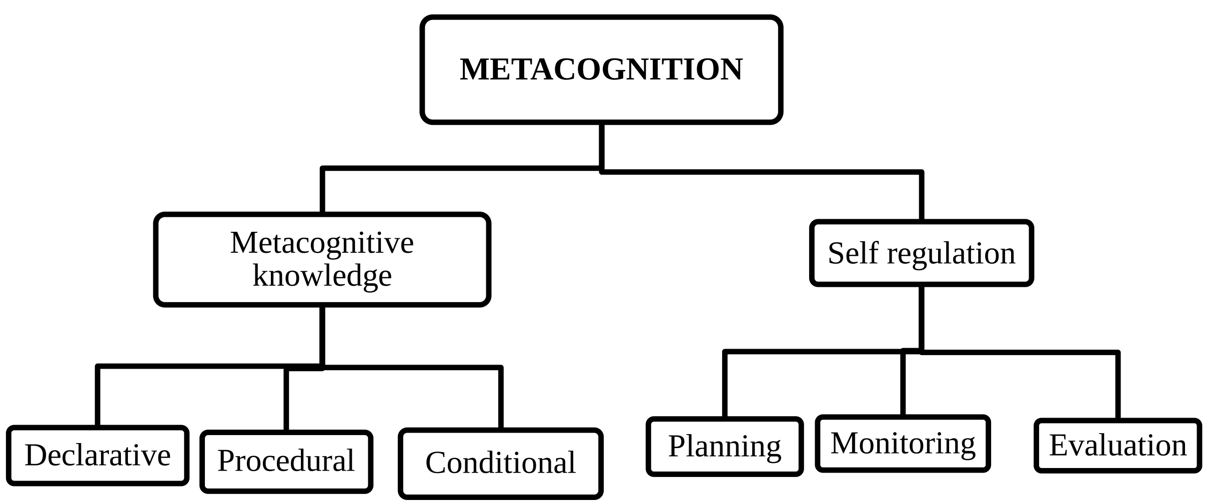


Figure 9
Branches of metacognition (Jordan, 2011, p.8)

Subsequently, self-regulation refers to the activities that help learners control their learning. Metacognitive self regulation helps the learner to be aware of where to direct learning attention appropriately, efficiently use learning strategies and to be aware of understanding challenges being encountered during learning. The three self regulation metacognitive skills are planning, monitoring and evaluation (Baird, 1999). Planning metacognitive skill, involves preparing the ways to tackle a given task. It involves laying out the strategies to be used, putting together the various materials required for learning and selecting the appropriate time to undertake the task. It comprises activating the relevant background knowledge. When planning the learner should ask the following self test questions:

i. What do I already know that can assist me in this task?
ii. How do I direct my thinking?
iii. What are my priorities?
iv. Why am I doing this task?
v. What amount of time is required to complete this task?

As a result the learner will make predictions, be aware of what is already known so that appropriate strategies can be selected, sequencing those strategies, and finally allocating time and attention that affect performance. Planning makes the difference between experts and novices (Garace, 2001). Planning is very useful to the teaching process. This is because the teacher is required to plan the lesson very well before going to class. It is also important to the learner since the learner’s preparedness makes teaching and learning easy and efficient. Okere (1996) emphasizes planning an investigation as part of creativity and sciences process skill. This puts it as a precondition for a scientific investigation. This involves checking the suitability of experimental design, the use of the data and finally the evaluation process (Shraw, 1998).

Monitoring skill means the learners surveillance of the level of progress, the level of understanding and the general performance in the learning task being undertaken. The learner should be able to test oneself and confirm whether understanding is taking place by asking the following self test questions:

i. What is my progress?
ii. Am I moving in the right direction?
iii. What is the next step?

iv. What should I continue to remember?
v. Should I change my direction?
vi. Is the current pace sufficient or it needs change?
vii. What steps should I take if my understanding is poor?

As a result the learner should be able to identifying the task, checking one's awareness of comprehension and task performance, decide whether in light of new information a path already taken should be abandoned. Thus the learner should find anything that can be salvaged from an abandoned attempt by looking for previously overlooked information. Then identify ways to combine information, predicting the eventual outcome and finally engaging in periodic self-testing. Monitoring is a slow process to occur and can be improved by training (Jacobs & Paris, 1987). Tobias and Everson (2002) in their twenty three study series extensively studied monitoring. They established that monitoring is a pre requisite metacognitive skill which comes before the evaluation and planning. This is so because the learners cannot plan or evaluate any knowledge effectively if they cannot separate between what they already know and what they need to know. In their model monitoring comes first followed by evaluation and finally planning.

Evaluation is the analysis of the final outcomes in order to determine the quality and efficiency of the whole process of learning. It involves taking account of all the issues that were well performed and those that were not and hence cross check on ones strengths and weaknesses (Schraw, 1999). It is the process where the learner determines the efficacy of his/her efforts; make self-reflective thinking about experiences and situations to determine if knowledge is adequate. Finally determine what goals are to be set in light of one's self-efficacy. This can be done by asking the following self test questions (Erskine, 2009):

i. What is the level of my success?
ii. Was my thinking able to produce enough results?
iii. Was there anything I could have improved?

Evaluation is a science process skill (Okere, 1996), which in a physics classroom, requires that the learners criticizes experimental procedures and suggesting improvement to be made, it involves making judgments on the reliability of results considering the influencing factors apart from careless mistakes, being able to identify a fallacy statement or a false step in the scientific investigating and finally the learners should be able to explain their answers. This study focused on Gowin's Vee heuristic teaching strategy to improve students' metacognive self regulation skills in the topic of moments in physics in Uasin Gishu county.

2.5.1 Importance of Metacognition

The importance of metacognition is emphasized in educational requirement for students in Europe, North America and Latin America and is considered as the most actively investigated construct in the current research in developmental and instructional psychology (Tobias et al., 1999). Furthermore most of research conducted about metacognition focuses on students thinking and learning.

Baird and White (1984) carried out a study designed to improve metacognition in ninth grade students learning science and eleventh graders learning biology where students tried out concept mapping, self-questioning and think- aloud processes as effective strategies to promote scientific thinking. They concluded that effective metacognitive learners have increased understanding, enhanced awareness of their learning styles, have greater awareness of tasks purposes and their nature, have more control over learning through better decision-making and more positive attitudes toward learning. In addition they develop higher standards for understanding and performance which they set on their own. They acquire more precise self-evaluation in their achievements. Consequently, they develop greater effectiveness as independent learners by planning thoughtfully, diagnosing learning difficulties and overcoming them. As a result they use time more productively.

Gowin's Vee is a strategy that has been known to improve students self -regulation and control of their learning process especially when they are confronted with new knowledge. This is done by going through the twelve epistemological elements of the Gowin's Vee (Alvarez & Risko, 2007; Novak & Gowin, 1984). Åhlberg (1993) maintains that the Gowin's Vee heuristic is a tool to monitor and promote metalearning and metacognition. Vanhear (2012) reinforces that the twelve epistemological elements of the Gowin's Vee heuristic enables the learners to go through a metacognitive process which finally leads to meaningful learning and for this purpose the learners will be equipped in decision making, reflective and problem solving skills.

Aka, Tekkaya and Çakiroglu (2011) stated that students with high metacognition awareness tend to see scientific knowledge with confidence and hence view science learning as simple and attainable. Metacognition improves performance and educators should develop activities of metacognition into the teaching process. Coutinho (2006), Schraw and Dennison (1994) in most of their research in high school through college confirmed the relationship between metacognitive awareness of the learners and intellectual ability which they concluded that metacognition is not affected by intellectual ability. Metacognitive awareness allows individuals to plan, sequence, and monitor their learning in a way that directly improves performance.

Most science teachers consider the content coverage as more important than their metacognition (Thomas et al., 2008). Borkowski, Carr and Pressley (1987) said that in contrast to poor learners the good metacognitive learners have many strategies and creativity during problem solving. Delvecchio (2011) investigated the use of metacognitive skills in solving high school chemistry. During the study using metacognitive framework students were required to use their previous knowledge as well as drawing heuristics in solving a new problem. Fazalur, Jumani, Satti and Malik (2010) considered that apart from the concentration on students metacognition there is need for teacher to be in touch of their own metacognition. Also meaningful learning occurs with metacognition and hence there should be focus on the need for the learner to use their cognitive resources strategically through metacognition.

Metacognitive knowledge is important to the learners because their self awareness and self-regulating their own learning, influences their learning outcomes (Tobias & Everson, 2002). Most curriculum developers rarely include the teaching of metacognitive process in the curriculum. They assume that the learners automatically acquire these skills during learning (Kriewaldt, 2001). However, the importance of metacognition to the learner should not be ignored since it has long-term ramifications in the future ability of the learner to tackle day to day problems (Schraw, 1998). Metacognition gives the students power to control their own learning process rather than being just recipients of the teacher’s content (Alvarez & Risko, 2007).

Metacognitive self-regulation skills enable the learner to put together their learning resources, follow up on their level of progress and understanding and finally make an overall judgment on their learning. This reduces the negative beliefs common among students that learning is due to high intelligence and good luck. It demonstrates to the learner that learning requires their active input and effort. The skills make the learners to be self reflective and makes the learning process to be perceived by the learner beyond the acquisition of good grades (Schraw, 1998).

The nature of metacognitive learners is explained by (Briggs, 1987) that they should be aware of their metacognitive resources and be able to relate them to the task at hand so that they can plan, monitor and control them. Ritchhart, Turner and Hadar (2009) put learning at the centre point of metacognition. Learning according to them should be developed from the related constructs like self regulated learning, conceptual understanding and approach. Learners metacognitive awareness is characterized by thinking awareness that facilitate learning, problem solving, decision making and judgment.

Osborne (1998) says that metacognition is an important aspect in education. This is because it enables the learner to know when and where to apply the acquired knowledge, the learner is able to know their learning limitations and difficulties by having knowledge about their own thinking capacities. It gives the learner a remedial option; it is an alternative method that moves away from the traditional teaching strategies. Schraw and Moshman (1995) confirm that metacognition improves with age and can be taught. Time and effort is required in gaining these metacognitive skills.

Brown (1987) adds that metacognitive strategies are very important because as students become more skilled at using metacognitive strategies, they gain confidence and become more independent as learners. Lodico et al. (1983) showed in their study that the children who were taught to monitor their learning strategy performance better on tasks. In addition metacognitive strategies provide students to find and reflect the ways to understand the target content deeply (Schraw, 1994).

Self-regulated metacognitive strategies improve recall and retention of science knowledge (Spiegel & Barufaldi, 1994). Also, using several strategies rather than a single strategy and being taught within the context of specific subject matter are more effective for metacognitive training

(Mayer & Wittrock, 1996) and developing new metacognitive knowledge (Veenman & Wolters, 2006).

According to Baraz (2012) the metacognitive strategies are techniques which improve the learners thought process while implementing a task. He gave examples of Gowin's Vee and concept maps as known metacognitive tools. Schraw and Dennison (1994) give main types of strategic knowledge that can make a student to think in a metacognitive manner. These are planning which enables the learner to define the problem and select the appropriate strategy, monitoring the progress and effectiveness of the strategy, self regulation in order to overcome obstacles and evaluation of the end results.

Successive science teaching should use metacognitive skills to plan monitor and evaluate their teaching in order to meet the needs of their learners. As a result the teachers can teach these skills to their students so that they can reflect on their own learning process. Metacognition is crucial to the science teaching in thinking about how they manage curriculum, instruction and assessment, as well as systematically reflect on what they teach, why and how. Metacognition plays a pivotal role in the memory processing and makes the memory content to be easily processed and stored in the long-term memory as shown in Figure 10.

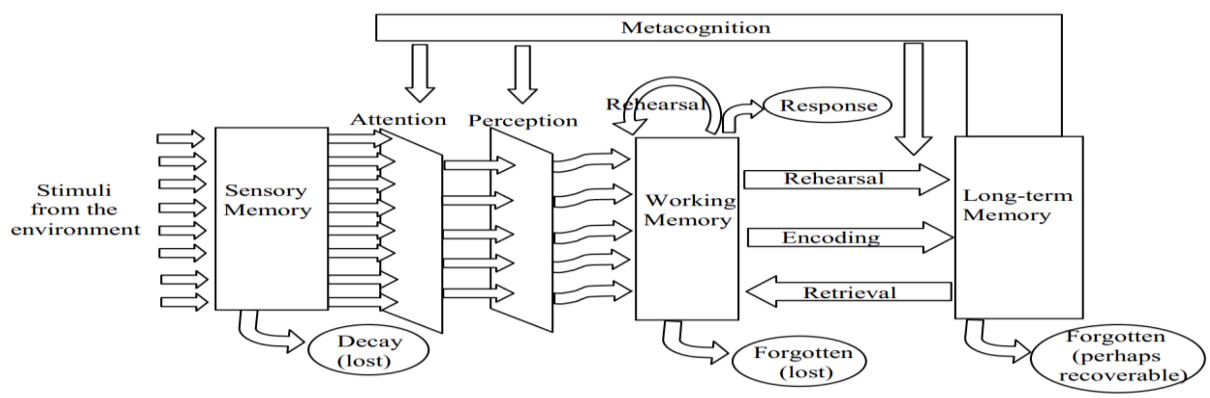


Figure 10
Model of information processing and metacognition (Eggen & Kouchak, 2004, p. 239).

Metacognition helps science learners develop and use effective and efficient strategies for acquiring, understanding, applying and retaining extensive and difficult concepts and skills. Good science teaching requires the application of both the teachers and the learners' metacognition (Hartman, 2001). Ramahlape (2004) in South Africa also did the same and confirmed that one should go through the four self regulation skills of planning, monitoring and evolution and ask self questions. This study joined the above studies in emphasizing the importance of metacognition in teaching and learning by using Gowin's Vee heuristic teaching strategy to improve students' metacognition in the topic of moments in physics.

2.5.2 Measurement of Metacognition

Jimenez et al. (2009) gave three issues that are still controversial to assessment of metacognition. The first is the importance that the researchers attach to each component of metacognition, secondly, the degree of awareness demonstrated by the subject studied before its metacognition is analyzed and finally measurement procedures or techniques employed in relation to each domain. Most of the research done on metacognition has been to identify and validate instruments for measuring metacognition. Metacognition can be measured using the various approaches. Gunstone (1994), Thomas and McRobbie (2001) also agreed that it is important to consider the nature of metacognition in the science context. As a result of this an instrument be developed that will consider the subject being taught and learned as well as metacognition related to it. This will require the learners to be informed that the information being looked for will be related only to their experiences in the science classroom.

Schraw (2000), gives the various metacognitive tools developed which consist of some self report such as empirical self-report instruments that explore students' learning and metacognition. These are, Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & Garcia, 1993), the Learning and Study Strategies Inventory (LASSI) (Weinstein, Schulte and Palmer, 1987), the Assessment of Cognitive Monitoring Effectiveness (ACME) (Osborne, 1998) and the Learning Processes Questionnaire (LPQ) (Biggs, 1987). However the above instruments have not considered metacognition in their subject area such as science and they are very general. They have other unknown issues and properties designed only for specific studies not related to learning science. Therefore, there is need to explore instruments that are less time consuming and domain specific (Annemieke & Egbert, 2012). Table 6 shows various categories of the assessment tools used to measure metacognition. This study will use self-report inventory questionnaire measuring students' level of metacognition in the topic of moments in physics. This is one of the methods recognized for measuring metacognition as categorized in Table 6.

Table 6
Common Methods Applied in Assessing Metacognition

Method	Description	Advantages	Sources of errors and Limitation
Concurrent think aloud	Learners say out loud everything that occurs while performing a task.	Rich data about invisible processes to other methods	• Automated process remains inaccessible • Do not suit young children
Post performance interviews	Provides data from responses to specific and direct probes.	Avail data from responses to specific direction	• Not automated • Affected by poor memory and expression • The investigator need to be careful listener
Cross-age tutorial	Young children tutors are observed on strategies and behaviors they will encourage	Avoid non verbal guessing of data.	• Used in investigating specific strategies
Self report inventory	Likert scale questionnaire	Convenient, structured and easy to use	• Answers may be given to please • Difficult to answer about the least partial automated process

(Gama, 2004, p.18)

Schraw and Dennison (1994) developed a 52 item Metacognitive Awareness Inventory (MAI) instrument used to measure Metacognition. They used it for assessing undergraduate students. According to them, metacognition consists of metacognitive knowledge and regulation of cognition. Cooper and Sandi-Urena (2009) developed Metacognitive Activity Inventory (MCAI). It is a 27 item Likert scale used in chemistry and can be relevant in many other fields. Subsequent research by Weimer (2011) confirms that the MAI and MCAI instruments were carefully developed and their reliability and validity verified. They do not consume time and easy to use. This research adapted and modified Metacognitive Activity Inventory (MCAI) developed by Cooper and Sandi-Urena (2009) whose reliability had been verified as shown in Table 7. A summary of the metacognition measuring instrument, their validity and reliability is as shown in Table 7.

Table 7
A Summary of Instruments used to Measure Metacognition, their Validities and Reliabilities.

Researcher	**Name of Instrument**	**Reliability (Chronbach Coefficient of Alpha)**
Cooper and Sandi-Urena (2009)	Metacognitive Activity inventory(MCAI)	α =0.70-0.85
Jimenez et al.(2009)	Reading awareness scale (Escala de conciencia Lectora) ESCOLA age 12-13.	α =0.86
Tosun & Irak (2008)	Turkish version of metacognitive questionnaire -30(MCQ-30)	α =0.73
Thomas, Anderson and Nashon (2008)	Self –efficacy, metacognitive learning inventory science SEMLI-S.	α=0.77-0.85,
Panaoura and Philippou (2003)	Young pupil’s metacognitive abilities in mathematics.	α =0.8298
Gregory Thomas (2003)	Metacognitive orientation of science class room learning environment Scale –science (MOLES-S)	α =0.70
Mokhtari and Reichard (2002)	Metacognitive awareness of reading strategy	α =0.89-0.93
Cetinkaya and Erktin(2002)	Assessment of metacognition and its relation with reading comprehension, Achievement and aptitude	α =0.87
O’Neil and Abedi (1996)	State metacognitive inventory for alternative assessment	α =0.70
Schraw and Dennison(1994)	Metacognive awareness inventory (MAI)	α =0.95
McLain,Gridley andMcIntosh (1991)	Assessment of scale used to measure metacognitive reading awareness age 10	α =0.15-0.32

2.6 Theoretical Framework

This study focuses on the Ausubel (1963) meaningful learning and Novak theory of education (Novak, 2011). Both were based on meaningful learning and constructivist epistemology. According to the Ausubel’s meaningful learning theory, learning is a process where the student chooses to relate new knowledge to the already existing knowledge (Ausubel, 1963, 1968).While in agreement with Ausubel, Novak in 1977 proposed that learning has five elements. These are teacher, learner, subject matter, context and evaluation. Each must interact constructively in a process of meaningful learning (Novak, 2011). These meaningful learning processes may be facilitated by using tools like Gowin’s Vee heuristic (Gowin, 1981), concept maps (Novak, 1984) and advanced organizers (Ausubel, 1963). The basic assumption in this study is that people think in concepts and that knowledge has structure (Novak &Gowin, 1984).

In the physics classroom the learner uses Gowin’s Vee to construct meaning of concepts by relating prior knowledge to the new knowledge being learnt. This involves filling all the conceptual and methodological side of the Gowin’s Vee and being able to relate them. The teacher should consider what the learner already knows in the topic of moments before introducing the information to be learnt. This creates meaningful learning which occurs through conceptual understanding. Also meaningful learning occurs during social interactions and sharing of ideas. The Gowin’s Vee heuristic also encourages the learner to be aware of their own thinking process as they go through the twelve epistemological elements. This makes them to be able to control their own thinking towards the learning process. This process is called metacognition. This is contrary to rote learning which denies learners the opportunity to direct their own thinking and learning process.

2.7 Conceptual Framework

The conceptual framework in Figure 11 shows how Gowin’s Vee twelve epistemological elements interact during the teaching and learning process in physics topic. The Gowin’s Vee heuristic strategy will help learners develop conceptual understanding. It also makes students be aware and control their own thinking process towards the learning process which is metacognition. The independent variables are Gowin’s Vee strategy and conventional methods. Dependent variables are conceptual understanding and metacognition. This study selected mixed district schools' to overcome the gender effect. Teacher characteristic were controlled by using teachers with minimum qualification of a diploma and at least two years teaching experience. Schools' characteristics were controlled by selecting schools with similar characteristics. In the study students used Gowin's Vee heuristic in writing brief notes, performing experiments and problem solving. The interaction of these variables is as shown in Figure 11.

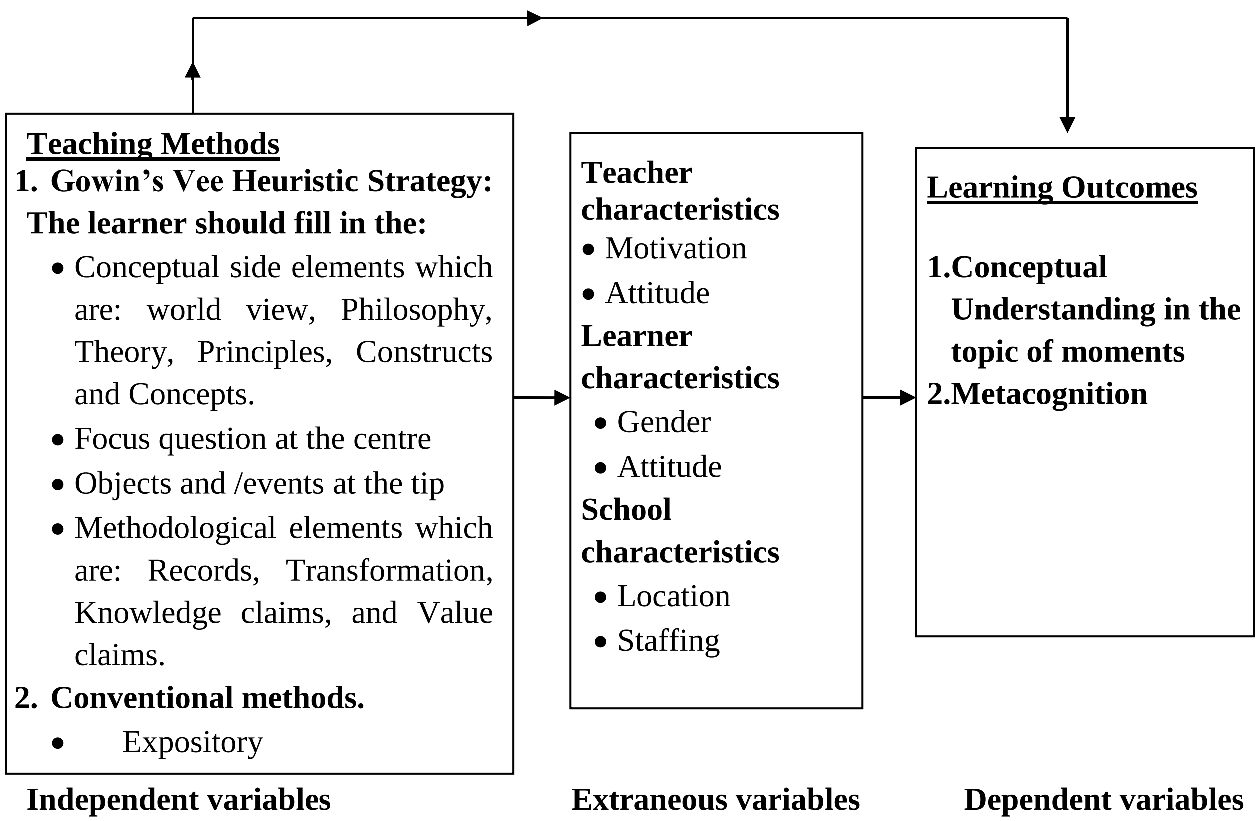


Figure 11
The relationships of the variables of the study

During the learning in the topic of moments in physics the learners construct the Gown's Vee heuristic with a focus question at the center and the objects and activities at the tip. They fill in six conceptual and four methodological epistemological elements. These brought about conceptual understanding and metacognition as shown in Figure 11. Consequently, any effects of extraneous variables were minimized during the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discussed the research design and its strengths, population of the study and location of the study. In addition the method of sampling procedure and the sample size selected for the study were discussed. More so details of the instruments that were used, their validities and reliabilities were included. Finally the data collection procedures and data analysis used was elaborated.

3.2 Research Design

In this study Solomon four non- equivalent control group design was used as shown in Figure 12. This design which is Quasi-experimental, according to Frankel and Wallen (1990), is suitable because it can control all the threats to internal validity. Quasi-Experimental design is adopted because under school arrangement the students have already been assigned classes and cannot be randomly constituted during the study. This cannot be authorized in the schools since it will affect the laid down criteria for which they were initially constituted. Figure 12 shows structure of Solomon four non-equivalent control group design.

1st Experimental group (E_1)	O_1	X	O_2
1st Control group (C_1)	O_3		O_4
2nd Experimental group (E_2)		X	O_5
2nd Control group (C_2)			O_6

Key

------ = No randomization is done

X =treatment results

O_1 & O_3 =pretest results

O_2, O_4, O_5 & O_6=Post tests results

Figure 12

Solomon four non-equivalent control group design (Cohen & Manion, 1990)

There are two experimental groups E_1 and E_2 and two control group C_1 and C_2. One of the experimental group E_1 and control group C_1 received the pretest while the other experimental group E_2 and control group C_2 were not pretested. At the end of the study, all the groups were post-tested simultaneously. Most of the threats to internal and external validity were addressed by this design. Sensitization was addressed by having one of the experimental and control group pretested. The reactive effect was controlled by ensuring that the subjects under the study were not made aware that they are in an experimental situation. The schools that acted as control groups were selected at a far distance from the experimental group in order to prevent any contamination during inter-school activities.

3.3 Population of the Study

The population in this study is form two secondary students. This is because the topic of moments is taught in form two according to the 8-4-4 secondary school syllabus. Also at the end of form two students shall be required to choose any two science subjects and hence the use of Gowin's Vee teaching strategy in the study encouraged them to select physics. The target population in this case was 3735 form two students in mixed district secondary schools in Uasin Gishu County.

3.4 Location of the Study

Uasin Gishu County is among 47 counties in Kenya. It is located in central west of the Rift Valley. It has an area of 3,345.21 square kilometers and population of 894,179, (KNBS, 2009). There are six counties bordering it these are, Nandi to the South West, Elgeyo Marakwet to the East, Trans- Nzoia to the North, Kakamega to the West, Kericho to the South and Baringo to the South East. The largest town in Uasin Gishu is Eldoret whose coordinates are (0.52N, 35.28E) hence it is around the Equator. It has 158 secondary schools of which 113 are public and the remaining ones are private. Majority of the secondary schools are mixed day schools. (Softkenya, 2012; Guide2kenya, 2012). It is divided into three sub counties which are Eldoret East, Eldoret West and Wareng to the south.

3.5 Sample Size and Sampling Procedures

In Uasin Gishu County there were 83 mixed county secondary schools and one National school. Out of these only four were selected purposively to ensure that there was equivalence in terms of resources, performance in national examination and boys and girls well represented. This was done by checking their background performance including KCPE entry marks. To get the sample size the research considers that out of four mixed district schools one class is used. Each class has at most 45 students. However, in the study four classes were selected randomly in each of the four schools. The classes were grouped into E_1=31 students, E_2=31, C_1=42, C_2=30, giving a total 134 students. There were 83 boys and 51 girls in the selected sample.

3.6 Instrumentation

A physics conceptual understanding achievement test (PCUAT) was used to measure students' conceptual understanding in the topic of moments. This is an achievement test constructed by the researcher under close monitoring by the supervisors. It consists of two structure questions with subsections. First question covers the principle of moments and the second question covers sum of upward and downward forces under equilibrium as well as moment of couple of forces. Therefore it covers the entire topic exhaustively. Each question was answered by filling in the twelve epistemological elements of the Gowin's Vee. The students incorporated the applications of the topic under value claims which is the last element of the Gowin's Vee. Gowin's Vee has twelve epistemological elements each earning marks according to Gowin's Vee scoring criteria (Gowin & Novak, 1984) the marks were converted into percentage.

Physics Metacognition Activity Inventory questionnaire (PMCAIQ), a 27 item 5-likert scale questionnaire adopted from Cooper and Sandi-Urena (2009) was slightly modified and administered to measure student's metacognition in physics. The instrument was originally tested using problem solving in chemistry. It was found to have Cronbach alpha of 0.70 and therefore it was reliable. This study used it in the topic of moments and obtained a Cronbach alpha of 0.78.

For instance one of the question is 'I use graphic organizers (diagrams, flow-charts, concept maps and Vee heuristics etc) to better understand physics problems'. The respondent was supposed to respond in five ways by circling the following numbers: 1 (*Never or only rarely*), 2(*Sometimes*), 3(*Half of the time*), 4 (*Frequently*) and 5(*Always or almost always*). The values indicated are commensurate with the marks given to the answer with ‘positive’ connotation questions. However in questions with ‘negative’ connotation the marks are reversed e.g., ‘I do not check that the answer makes sense’ 5(*Never or only Rarely*) 4(*Sometimes*), 3(*Half of the time*), 2(*Frequently*) and 1(*Always or Almost always*). There are eight ‘negative’ questions in the questionnaire. The questionnaire tested students on planning, monitoring and evaluation which are elements of metacognition. Evaluation has 12, monitoring 10, and evaluation 5 questions. The overall total score was 135. Thus the scores of each student were done out of 135 and made into percentage.

3.6.1 Validity of the Instruments

Validity refers to the ability of an instrument to measure what it intends to measure (Kothari, 2004; Frankel & Wallen, 1990). The content in the Physics Conceptual Understanding Achievement Test (PCUAT) addressed the concepts and principles and activities of the topic. It was presented to two physics experts of Egerton University and two physics teachers to check their validity.

The questions in the Physics Metacognitive Activity Inventory Questionnaire tested the required self regulation skills of metacognition which are planning, monitoring and evaluating ability of the learners towards their own learning process. After the researcher gave the instruments to two physics teachers and experts of Egerton University, their recommendations and suggestions were used to improve on the instruments. Further validation of two instruments was done in the field study to eliminate any ambiguity that existed.

3.6.2 Reliability of the Instruments

Reliability refers to the consistency of results produced by an instrument in different settings (Kothari, 2004; Frankel & Wallen, 1990). This was done in the pilot study. The pilot study was carried out in Matunda secondary school. The school was chosen purposively by considering characteristics that were similar to those of Uasin Gishu County. Calculation of Cronbach Alpha(α) for Physics Conceptual Understanding Achievement Test (PCUAT) and Physics Metacognitive Activity Inventory Questionnaire (PMCAIQ) was done in the pilot study. This is a suitable measure of reliability of tests which are scored using a range of values. PCUAT gave reliability of 0.75 and PMCAIQ produced a Chronbach alpha of 0.78. A reliable test has a coefficient of alpha of at least 0.70 (Frankel & Wallen, 1990). They research was carefully monitored to prevent any external threat to reliability.

3.7 Data Collection Procedures

This study received authorization letter to carry out this research from Egerton University Faculty of Education in Njoro through Graduate school. This allowed the researcher to seek permission from National Commission for Science, Technology and Innovation (NACSTI) in the ministry of education to carry out research. The permit was presented to Uasin Gishu county director of education who gave authorization letter to carry out research in Uasin Gishu County. The letter was then presented to the principals of the four schools to seek their permission to carry out research in their respective schools.

The researcher gave pretest to students in the experimental group E_1 and control group C_1. Training of physics teacher(s) on the use of Gowin's Vee took one week. These were teachers who taught in the experimental group E_1 and E_2.They were provided with Gowin's Vee Teacher's Manual (GVTM). The teachers used two weeks to train students using Gowin's Vee heuristic in the topic of measurements II which precedes the topic of moments. This ensured that the students familiarized themselves with the Gowin's Vee before using it in the topic of moments. Teaching using Gowin's Vee heuristic strategy in the topic of moments proceeded for another two weeks. Finally, post testing was done using PCUAT by all the four groups. Care was taken to ensure that the control and experimental groups do not meet to prevent contamination. The students were required to write their admission numbers on the Physics Conceptual Understanding Achievement Test (PCUAT) and Physics Metacognitive Activity Inventory Questionnaire (PMCAIQ) for purpose of identification.

3.8 Data Analysis

This study uses Solomon four non-equivalent control group design. It contains four groups which required careful process of data analysis. Mostly, the data analysis combines various analyses in order to verify the effect of treatment. Therefore, this study first computed standard deviations and means of each score. One way ANOVA were used to test the hypotheses at 0.05 significance α-level respectively. ANOVA gives indication of existence of significant difference among the groups in the Solomon four. However, it does not indicate the pattern of difference between the means. In order to analyze the patterns of difference between means, ANOVA analysis was followed by post hoc analysis which involved comparing a pair of means at a time. The easiest and frequently used comparison technique is Turkey's Honest Significant Difference (THSD). This gives the significant difference of the means using student distribution called *q* values at α=0.05 significance level. Alternatively *t* tests were carried out to test whether the means of the pretests were statistically significant at α=0.05 significance level. Table 8 shows a summary of all the hypotheses, independent and dependent variables and the statistical tests that were used in the study.

Table 8
Summary of Data Analysis used in the Study.

Hypotheses	**Independent Variables**	**Dependent Variable**	**Statistical Test**
H_O1: There is no statistically significant difference in conceptual understanding between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics among secondary schools in Uasin Gishu County.	Gowin's Vee and Expository methods	Conceptual understanding	• Mean • Standard deviation • *t*-test • ANOVA • Post-hoc analysis
H_02: There is no statistically significant difference in the level of metacognition between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics among secondary schools in Uasin Gishu County.	Gowin's Vee and Expository methods	Metacognition	• Mean • Standard deviation • *t*-test • ANOVA • Post-hoc • analysis

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This study investigated the effects of Gowin's Vee heuristic strategy on secondary school students' conceptual understanding and metacognition in the topic of moments in physics in Uasin Gishu County. An examination test and questionnaire were issued at the end of the topic to test their conceptual understanding and metacognition respectively. The data collected was analyzed using descriptive statistics like means and standard deviation. Inferential statistics sample *t* test, one way ANOVA and post hoc analysis were also used. Then they were presented, interpreted and discussed accordingly.

4.2 Effects of using Gowin's Vee Heuristic Strategy on Secondary School Students' Conceptual Understanding in the Topic of Moments in Physics

The first objective of this study was to determine the effect of using Gowin's Vee heuristic strategy on students' conceptual understanding in the topic of moments in form two physics. In order to achieve this objective, Solomon four non equivalent control group design was used. Four schools were selected purposively. The first, second, third and fourth schools were grouped into first experimental group (E_1), second experimental (E_2), first control group (C_1) and second control group (C_2) respectively. E_1 and C_1 were pretested while C_2 and E_2 were not pretested. The teaching of the topic of moments using Gowin's Vee heuristic strategy was done in the experimental groups $E_1$and E_2.

Regular expository teaching methods were used in control groups C_1 and C_2. Physics Conceptual Understanding Achievement Test (PCUAT) was administered at the end of the topic. The examinations were marked and analyzed against the hypothesis that there is no statistically significant difference in conceptual understanding between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics. The pretest results are summarized in Table 9.

Table 9

Comparison of Pretests and Posttests Mean Scores and Standard Deviations Obtained by the Students in PCUAT Examination

Examination	Overall N=207	E_1(n=31)	C_1(n=42)	E_2(n=31)	C_2(n=30)
Pretest Means		38.39	39.05		
SD		9.06	8.90		
Posttest Means	44.94	60.43	40.00	56.77	38.66
SD	12.88	9.26	9.31	9.40	9.96

From Table 9, the pretest examination means scores for the control group (C_1) and experimental group (E_1) are 39.05 and 38.39 respectively. Their standard deviations (SD) are 8.90 and 9.06 respectively. It can also be observed that the posttest mean scores after introduction of Gowin's Vee heuristic strategy for the experimental groups E_1 and E_2 are 60.43 and 56.77 respectively. These scores are higher than those scored by the control groups $C_1$and C_2 which are 40.00 and 38.66 respectively. These results show that the two groups are similar prior to the introduction of the PCUAT. It also gives an early indicator that the groups who received treatment E_1 and E_2 improved in their performance by attaining higher mean scores. To test whether the means of the pretest of experimental group E_1 and control groups C_1 were statistically significant, *t* test was done as shown in Figure 10.

Table 10

Independent Samples *t*-test of Pretests C_1 and E_1 Mean Scores in PCUAT Examination

Variable	Group	Number	*t* value	*df*	*p* value
PCUAT	PretestC_1	42	0.31	71	0.757
	pretestE_1	31			

df=71 Critical values t_c =1.67 $p \leq 0.05$ Calculated values t =0.31 p =0.757

The independent *t*-test value t (71) =0.31 p=0.757, is less than the critical value which is 1.67 $p \leq 0.05$. This shows that the means of the two groups E_1 and C_1 are not statistically significant and were similar before treatment. Therefore the two groups of students E_1 and C_1 can be compared using inferential statistics. As a result of these an ANOVA test was carried out to test whether the change in scores is significantly different at 0.05 α-level as shown in Table 11.

Table 11

Summary of One Way ANOVA of Posttests Mean Scores obtained by the Students in PCUAT

Source	Sum of Squares	*df*	Mean Square	*F*	*p* value
Between Groups	12465.06	3	4155.02	46.31	0.000
Within Groups	11662.75	130	89.71		
Total	61824.88	133			

Critical values F_c (3,130) =2.67, $p \leq 0.05$ Calculated values F (3,130) =46.31, p=0.000

One way ANOVA analysis of PCUAT in Table 11 produce an *F*-ratio of F (3,130) =46.31, p=0.000 this value is greater than the critical values F_c (3,130) =2.67 $p \leq 0.05$ showing that the results of students who used Gowin's Vee heuristic strategy were higher and statistically significant at 0.05 level. The results show that the students who were taught using Gowin's vee improved their conceptual understanding by performing highly than those who were taught using expository methods. To confirm this further, Tukey's honest significant difference was carried out to determine the actual difference between each group as shown in Table 12.

Table 12

Tukey's Honest Significant Difference Post Hoc Analysis for PCUAT Examination

Compared Groups		Mean Difference	*p*-value
Posttest E_1	Posttest E_2	3.66	0.429
	PosttestC_1	20.43*	0.000
	Posttest C_2	21.76*	0.000
Posttest E_2	PosttestC_1	16.77*	0.000
	Posttest C_2	18.11*	0.000
PosttestC_1	Posttest C_2	1.33	0.935

*significant at $p \leq 0.05$

Tukey's honest significant difference (post hoc analysis) confirms that the mean difference between the experimental groups' posttests E_1 and E_2 is 3.66 hence they are not statistically significant at alpha level of 0.05 implying that they are similar. However, there is statistically significant difference between the experimental posttests' scores E_1 and E_2 compared to the control groups' posttest scores C_1 and C_2 :(E_1 -C_1=20.43*, E_1-C_2=21.76*, E_2-C_1=16.77*, E_2-C_2=18.11*). This confirms that the students E_1 and E_2 who were taught using Gowin's Vee had higher performance than control groups C_1 and C_2 who were taught using expository methods in the PCUAT examination.

It is can be concluded at this point that the Gowin's Vee heuristic strategy was effective and students attained higher results on using it. Owing to the above results and analyses, it is safe at this juncture to reject the null hypothesis and confirm that there is statistically significant difference in conceptual understanding between students taught using Gowin's Vee heuristic strategy and those not exposed to it, in the topic of moments in physics in Uasin Gishu County.

4.3 Effects of using Gowin's Vee Heuristic Strategy on Secondary School Students' Metacognition in the Topic of Moments in Physics

In addition, the study investigated the students' level of metacognition after being exposed to the Gowin's Vee heuristic strategy measured by Physics Metacognitive Activity Inventory Questionnaire (PMCAIQ). Table 13 compares students' pretests and posttests mean scores and standard deviations in PMCAIQ.

Table 13
Comparison of Pretests and Posttests Mean Scores and Standard Deviations obtained by the Students in PMCAIQ Examination

Examination	Overall (N=207)	E_1(n=31)	C_1(n=42)	E_2(n=31)	C_2(n=30
Pretest Means		66.24	63.97		
SD		5.43	8.53		
Posttest Means	68.19	76.25	65.66	73.86	65.50
SD	9.49	7.65	9.37	9.68	8.59

The results in Table 13 show that the group that received treatment have high posttest mean scores of E_1=76.25 and E_2=73.86. Also pretest examinations gave mean scores of E_1=66.24 and E_2=63.97. These indicate that the students in control groups have similar characteristics with those in experimental groups. The high pretest results show that students had some metacognitive abilities even before using Gowin's Vee. Independent *t* test was carried out to determine if the mean scores of the pretests E_1 and C_1 are statistically significant at alpha level of 0.05. Table 14 shows independent sample *t* test of pretest and post tests.

Table 14

Independent Samples *t*-test of Pretests E_1 and C_1 Mean Scores in PMCAIQ Examination

Variable	Group	Number	*t* value	*df*	*p* value
PMCAIQ	pretestE_1	31	1.30	71	0.199
	pretestC_1	42			

df=71 Critical values t_c =1.67, $p \leq 0.05$ Calculated values t (71) =1.30, p=0.199

The *t* test value in table 14 is t (71) =1.30, p=0.199 is less than the critical value t_c (71) =1.67 $p \leq 0.05$. The means of E_1 and C_1 were not statistically significant at 0.05 α-level. This indicates that the groups were similar initially before the treatment was administered. The results of sample *t* tests give an assurance that actually the experimental students group E_1 and control groups C_1 had the same level of metacognition before treatment. Although the mean scores appear to suggest that the Gowin's Vee heuristic strategy improved students' metacognition, ANOVA test was carried out to determine whether the mean difference were statistically significant at alpha level of 0.05, see Table 15.

Table 15

Summary of One Way ANOVA of Pretests and Posttests Mean Scores obtained by the Students in PMCAIQ

Source	Sum of Squares	*df*	Mean Square	*F*	*p* value
Between Groups	3068.34	3	1022.78	12.90	0.000
Within Groups	10310.71	130	79.31		
Total	13379.05	133			

Critical values F_c (3,130) =2.67, $p \leq 0.05$. Calculated values F (3,130) =12.90, p=0.000

The one way ANOVA test results in Table 15 has *F*- ratio of F (3,130) =12.90, p=0.000 which is higher than the critical value F_c (3,130) =2.67, $p \leq 0.05$. This implies that the effect of the Gowin's Vee heuristic strategy was statistically significant at 0.05 α-level. Therefore, the Gowin's Vee heuristic strategy was effective in improving the students' level of metacognition. However, post hoc analysis was done to have an actual comparison of the mean scores as shown in Table 16.

Table 16
Tukey's Honest Significant Difference Post Hoc Analysis for PMCAIQ Examination

Compared groups		Mean difference	*p*-value
Posttest E_1	Posttest E_2	2.39	0.870
	Posttest C_1	10.59*	0.000
	Posttest C_2	10.74*	0.000
Posttest E_2	Posttest C_1	8.20*	0.001
	Posttest C_2	8.35*	0.002
Posttest C_1	Posttest C_2	0.16	1.000

*significant at $p \leq 0.05$

The post hoc analysis results of the Tukey's honest significant difference in Table 16 shows that the mean differences between posttest experimental group E_1 and all the other groups except Posttest E_2 were statistically significant at 0.05 α-level. Also there was statistically significant difference between the mean differences between posttest E_2 and all the other groups except postestE_1. However it can be noted that the mean differences between the two experimental groups E_1 and E_2 were not statistically significant. This makes it possible to conclude that the improvement was due to exposure to Gowin's Vee heuristic strategy and therefore the null hypothesis can be rejected. The metacognition constitutes planning, monitoring and evaluation skills. Planning involves actions of setting goals, budgeting and time allocation. Monitoring entails understanding of the task and self-testing. Evaluation means appraisal, checking over goals and conclusions involved in the task. Thus Metacognition enables the students to self control their own learning by being able to plan organize and evaluate themselves on their own learning process.

4.4 Discussion of the Results

The above analyzed and presented results were discussed in the following order. First, the results of the pretest and how the pretest results contributed to the study were done. Secondly, the results of the tests of hypotheses of PCUAT examination and PMCAIQ questionnaire in relation to the objectives of the study were done. Finally the literature review compared with the existing context in the field was done.

4.4.1 Results of the Pretests

The pretest was done to ensure that the control groups and experimental groups have similar characteristics before treatment is administered. Consequently, PCUAT mean scores were pretest E_1= 38.39 and pretestC_1=39.05 which have a slight variation. Similarly PMCAIQ mean scores were pretestE_1=66.24 and pretestC_1=63.97. The mean scores of the PCUAT posttest C_1=40.00 and PMCAIQ postestC_1=65.66. The 1st control groupC_1 did not receive treatment therefore the results of pretest and posttest were expected to be equal. The small increase in posttestC_1 results were due to sensitization of pretesting. The comparison of means using *t*-test gave PCUAT calculated value t (71) =0.31 p=0.757 and PMCAIQ calculated value t (71) =1.30, p=0.199 against Critical Value t_c (71) =1.67 $p \leq 0.05$ which showed that E_1 and C_1 in both PCUAT and PMCAIQ were not statistically significant at 0.05 α-level. These made the control and experimental groups similar before commencement of the study and hence they were suitable for the study.

These results indicate that prior to introduction of treatment the level of metacognition was over 60% an indication that the students already possessed some metacognitive ability. This agrees with other findings that learners have some form of metacognition which is inherent for survival. However, the goal of teachers should be to enhance the level of metacognition (Gunstone, 1994)

4.4.2 Results of PCUAT

The first objective of this study was to investigate the effects of using Gowin's Vee heuristic strategy on secondary school students' conceptual understanding in the topic of moments in physics. Gowin's Vee heuristic strategy is a V-shaped diagram which has 12 epistemological elements. The students stated the theories, the principles, the constructs and the concepts at the left hand side in view of the scientific question at the centre and objects/activities at the tip. The records, transformations, knowledge claims and value claims are filled in the right hand side (Gowin & Novak, 1984). The performance of the students was analyzed using one way ANOVA. The F-ratio F (3,130) =46.31, p=0.000 is greater than the critical value F_c (3,130) =2.67, $p \leq 0.05$. Also the post hoc analysis using (Tukey's honest significant difference) indicated positive and significant increment in performance after treatment. These lead to the rejection of the hypothesis and hence Gowin's Vee heuristic was found to be effective in improving students conceptual understanding.

The finding is in agreement with Gowin (1981) who designed it to enable students relate the activities in the laboratory and the scientific concepts, principles, laws and theories and hence conceptual understanding. More so Novak and Gowin (1984) added that the interplay of the methodological and conceptual side promote conceptual understanding of knew content being learnt. It allows the learner to organize their cognitive structures into discernible, more powerful integrated patterns whereby learners examine the conceptual, rational and hierarchical nature of the knowledge.

Rote memorization which is a problem in expository methods (Driver, 1987) can be avoided. When using the tool the learners construct knowledge on their own making the learning process meaningful. Owing to these the learners uncover the structure of a given scientific investigation by planning and analyzing experiments so that there is connection between unknown and the known knowledge (Novak & Gowin, 1984). These stimulate the mind to think critically (Gowin & Alvarez, 2005). In addition to these Alvarez and Risko (2007) found that the tool improves conceptual understanding. In their undertaking in biology studies the learners assimilate, predict, question, connect, and structure knowledge generating their own meaning.

The results also concur with Gowin and Alvarez (2005) that it is a tool to aid in understanding meaningful relationships, planning and analyzing in experiments during learning. It unpacks information that stimulates the mind to think critically and examine the structure of a given scientific investigation so that there is connection between the known knowledge and the new knowledge to be learnt. The influence of the tool in conceptual understanding was also established by Åhlberg and Ahoranta (2002) whereby it promotes deep, meaningful and creative learning. Its success in creating high level of understanding according to Fox (2007) is due to its cohesive structure.

Gowin's Vee improves conceptual understanding in the laboratory experiments. This is clarified by Roth and Verechaka (1993) who made use of Gowin's Vee in the laboratory whereby the quality of laboratory reports improve and hence they generated meaningful and concrete interpretation of the results obtained. Also Safdar et al. (2013) used it in the laboratory and confirmed that learners' connect concepts and methods making them think as scientists when doing experiments. They learn about the knowledge structure and the process of knowledge construction. Confusion, doubts and misconceptions are eliminated. Thus Gowin's Vee makes laboratory experiments to be scientifically written and interpreted according to existing principles laws and theories.

Conceptual understanding enables the learners to build and justify their own knowledge (Ramírez et al., 2008). Morgil et al. (2005) in chemistry add to the same by confirming that the tool makes theoretical knowledge to be more meaningful in the learners mind. As a result their minds question, reflect, criticize, evaluate and discuss scientific observation generating feelings, emotions and attitudes in their learning process. They express their knowledge in a direct, concise way, linking knowledge from different topics and subjects. Therefore they develop holistic science experience promoting cognitive development. This brings conceptual understanding (Muscat, 2012).

The results resonate with Roth and Bowen (1993) that students' conceptual understanding improve when working with the Gowin's Vee heuristic since they can penetrate the structure and the meaning of any branch of knowledge. Students' improve on investigation, are able to organize their thinking and guide themselves in the learning processes. In agreement Sillitoe and Webb (2007) established that the Gowin's Vee heuristic makes concepts clearer, deepen their understanding and student can locate a suitable theory in their study. Student who use Gowin's Vee attain high scores than those who don't even in subjects like music. The teacher can use it to assess knowledge outcomes (Lee, 1997).

Afamasaga-Fuata'i (1998) in her very extensive research using mathematics produced similar results that Gowin's Vee heuristic mapped the students' understanding and they developed deep understanding of structure of mathematics. She emphasized that it is an effective tools in guiding the critical thinking and it is a systematic approach for the analysis of the structure of knowledge in a mathematics problem.

By mapping the learning it becomes science learning blue print which can be used to identify the progress of conceptual understanding in the mind of the student (Roehrig et al., 2001). Its ability to actively involve the student in familiar situations in assimilating knew knowledge to the learner's existing knowledge has made the process of conceptual understanding to be possible (Vanhear & Pace, 2008; Edwards, 1988).

As students use the Gowin's Vee they witness how scientific knowledge is constructed hence the tool becomes a strong scientific foundation where complex theoretical concepts are connected to practical work hence conceptual understanding. These promote high level thinking skills. The students are able to conceptualize their learning in a better way because they can see how the scientific knowledge is developed in the Gowin's Vee (Thoron & Myers, 2010).

The tool's success in learning science in a deep and meaningful way is confirmed by Smith (2012). In the topic of current electricity in South Africa Ramahlape (2004) did a research and made the same conclusion that Gowin's Vee improves students' conceptual understanding. By using a Vee mapping in biology (a combination concept map and Gowin's Vee) Namasaka, Mondoh and Keraro (2013) have made the same conclusion that the Vee map improves students' motivation which lead to conceptual understanding. This study has joined this rich background of literature that though the Gowin's Vee promote conceptual understanding it is versatile tool in learning. Time has come for it to be utilized in the education sector in Kenya.

4.4.3 Results of PMCAIQ

The second objective was to determine the effects of Gowin's Vee heuristic strategy on students' level of metacognition in the topic of moments in physics. PMCAIQ 27 item 5-Likert scale questionnaire was used. The test of the null hypothesis produced an F-ratio of $F(3,130)=12.90$, $p=0.000$ which is greater than the critical value $F_c(3,130)=2.67$, $p\leq 0.05$ indicating that the effect of treatment was statistically significant at 0.05 α-level. Also post hoc analysis showed higher means in experimental groups' posttest mean scores. The treatment was deemed effective and the null hypothesis was rejected. Then the Gowin's Vee heuristic strategy improved students' level of metacognition.

The finding of this study agrees with Novak and Gowin (1984) who were the first to use the tool. They attribute the metacognitive ability of the tool to the structure and hierarchical nature of the tool. By going through the twelve epistemological elements of the tool the learner improves in planning, monitoring and evaluating the knowledge they are undertaking. It allows the learner to organize their cognitive structures into more powerful integrated patterns and learners examine the conceptual and rational nature of the knowledge which they are actively learning. Thiessen (1993) and Young (1992) concur that Gowin's Vee guides the thinking process of the teacher and that of the student in the problem solving situations. It gives useful knowledge to teachers about their students thinking and values.

The result of this study is in accordance with Alvarez and Risko (2007) and Åhlberg and Ahoranta (2002) who have also established that Gowin's Vee heuristic promotes metacognition. It improves students' self-regulation and control of learning process especially when they are confronted with new knowledge. This is done by going through the twelve epistemological elements of the Gowin's Vee.

When learners build their knowledge using Gowin's Vee they develop metacognitive skills (Ramírez et al., 2008). This is also echoed by Roth and Bowen (1993) that during laboratory experiments students organize their thinking and guide themselves in their learning process. In addition Vanhear and Pace (2008) agree that Gowin's Vee captures all the mental process involved in their thinking, acting and feelings. These motivate the learners and their performance improves. More so it makes the learner to identify their internal thinking environment. The teacher can understand what is taking place in the learners' minds. They develop ideas on how they respond to various situations.

Gowin's Vee heuristic is a tool to monitor and promote metalearning and metacognition (Åhlberg, 1993). In going through the twelve epistemological elements (Vanhear, 2012) the learners become reflective and are equipped in decision making and problem solving skills. On top of these Ritchhart et al. (2009) implied the use of Gowin’s Vee by putting learning at the centre point of metacognition whereby learning should be developed from the related constructs like self regulation and conceptual understanding.

Metacognition is an important aspect in education. This is because when learners develop metacognitive skills, they know when and where to apply the acquired knowledge. They can identify learning limitations and difficulties by having knowledge about their own thinking capacities. In the process they can arrange for remedial process. To achieve these alternative methods (such as Gowin’s Vee) that move away from traditional teaching strategies should be used (Hobson, 2008). Brown et al. (1983) adds that metacognitive strategies are very important because as students become more skilled at using metacognitive strategies, they gain confidence and become more independent as learners.

Lodico et al. (1983) showed the same in their study that the children who were taught to monitor their learning by use of effective strategy like Gowin’s Vee did better performance on their tasks. Also Shraw (1994) added that metacognitive strategies provide students to reflect the ways to understand the content deeply. In contribution, Baraz (2012) established that metacognitive strategies are techniques which improve the learners thought process while implementing a task.

Baird and White (1984) encouraged the use of metacognitive tools like Gowin’s Vee since metacognition has many benefits which cut across many subject. The constituents of metacognition confirm the important role metacognition plays in the learning process. In summery Vanhear and Pace (2008) also established that the Gowin’s Vee has the following metacognitive benefits:

i. It ensures the process of learners’ reflection and action, giving a vivid picture of the learners’ mental process and how they can develop their thinking.
ii. It also provides the teachers with picture on the way the learner is responding to the incoming information.
iii. It shifts the control of learning from the teacher to the learner making the learners the argents of their own learning.

iv. It helps in training on decision making, reflecting and problem solving skills. It identifies the child’s internal environment.

v. It motivates the learner and improves performance.

vi. The learner demonstrate how he/she intends to learn more giving the teacher relevant information on how to plan for the next lesson which is sensitive, relevant, motivating and meaningful.

vii. Affective domain occurs by learners being considerate of each other based on mutual understanding of their knowledge processing.

Since metacognition is not domain specific(e.g., does not rely on induvidual characteristics like intelligence and can be applied across subjects and even outisde the classroom) it is important for it to be enhanced. This study joins other similar studies in capturing all these numerous metacognitive benefits of Gowin’s Vee in the teaching and learning especially in the topic of moments. Therefore the teachers and other stakeholders in education should exploit its potential.

CHAPTER FIVE

SUMMARY, CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives a summary of results and compares them with previous findings. Reasoned judgments of the issues raised by the study are concluded. Subsequent implications of the study to the educational stakeholders are presented. Recommendations on the possible action in the area of study are hereby stated. Finally, the propagation of this study is provided in the recommendations for of further research.

5.2 Summary

The study investigated the effects of Gowin's Vee heuristic strategy on secondary school students' conceptual understanding and metacognition in the topic of moments in physics. This was in relation to poor performance partly associated to lack of conceptual understanding. As a result, few students choose physics in form two providing less numbers of individuals with technical knowhow. The study specifically sought to verify the general hypothesis that there is no statistically significant difference in conceptual understanding and metacognition between students taught using Gowin's Vee and those not exposed to it, in the topic of moments in physics. The findings of this study rejected the null hypotheses and thus the Gowin's Vee heuristic strategy actually improves students' conceptual understanding and metacognition. These findings are in agreement with previous research supporting the importance of Gowin's Vee heuristic strategy in the teaching and learning of science. Not only does it improve students' conceptual understanding and academic achievement but also promotes metacognition. Conceptual understanding makes the concepts become clear to the learner, enable the learner relate the concepts, builds a more complex interrelationship of the science knowledge, reduce excessive use of rote memorization and improves performance. The knowledge is organized meaningfully in the mind of the learner.

Also metacognition enables the learner to manage their own thinking, learn some content on their own, easily study and improve their performance. The teachers can monitor how students are learning. All these benefits are brought about by the use of the Gowin's Vee heuristic strategy. Hence it is clear that the study joins other studies in calling for the use of the tool in teaching and learning of science.

5.3 Conclusions

This study sought to investigate the effect of using Gowin's Vee heuristic strategy on secondary school students' conceptual understanding in the topic of moments in physics. The study concluded that the Gowin's Vee heuristic strategy significantly improved the students' conceptual understanding in the topic of moments in physics. The study also sought to find out the effect of using Gowin's Vee heuristic strategy on secondary school students' level metacognition. The analysis showed that there was statistically significant improvement on students' level of metacognition after using the Gowin's Vee heuristic strategy in the topic of moments.

5.4 Implication of the Study

This study has given rise to some important findings which are very useful to the teaching and learning in the secondary school sciences. The study established that Gowin's Vee statistically improved students' conceptual understanding and metacognition in the topic of moments which have been supported by other related studies. These make it a very useful teaching tool which should be utilized in the teaching and learning in Kenya.

Therefore it has implications on the educational stakeholders, teachers and students in the secondary schools. It enriches the teachers in their teaching methodologies. In physics lessons the students should be able to use Gowin's Vee heuristic to learn the topic of moments. This tool assists learners to understand the structure of scientific knowledge by giving a summary of the scientific knowledge using theories, principles and concepts together with the activities being used hence they achieve high conceptual understanding. Conceptual understanding enables the learner to retain the knowledge for a long time hence it leads to the achievement of some of the educational goals.

Also in the study Gowin's Vee heuristic strategy statistically improved students' level of metacognition. Therefore the students are able to plan, monitor and evaluate their own learning process. These make learners to be good managers of their own learning. It is a very useful teaching tool not only in improving the learning of physics but also other science subjects in general. Therefore this is a teaching tool whose time has come. Thus the science teachers and curriculum developers should consider Gowin's Vee heuristic teaching strategy as a useful tool in the teaching and learning of sciences in secondary schools in Kenya.

5.5 Recommendations

The study has established that the Gowin's Vee heuristic strategy improves students' conceptual understanding and metacognition in the topic of moments. This tool has significantly proved that when it is used in classroom situation it can make the learners improve the understanding of scientific concepts principles, laws and theories and henceforth promote meaningful learning (Gowin & Novak, 1984). It is against this background that the following recommendations are made:

i. Science teachers should promote conceptual understanding using Gowin's Vee heuristic teaching strategy.
ii. The in-service teachers training like SMASSE in Kenya secondary schools should include and promote the use of Gowin's Vee heuristic teaching strategy.
iii. Science teachers should promote metacognition as an important aspect of learning in secondary schools.
iv. All science lessons should be double lessons since Gowin's Vee heuristic teaching strategy requires sufficient time.

5.5.1 Recommendations for Further Research

Suffice is to say that the finding of this study are not exhaustive and should serve as a trigger of more research in the following related areas.

i. Research on teachers' attitude towards Gowin's Vee heuristic teaching strategy on secondary school students' conceptual understanding and metacognition in physics in Kenya.
ii. Research on the effects of using Gowin's Vee heuristic strategy in teaching any other difficult topic in science.
iii. Extensive researches in other available methods that can be used to improve the level of metacognition in the Kenyan secondary school students.
iv. This study used a questionnaire to measure metacognition; other researchers should test the use of post performance interviews, concurrent think aloud and cross age tutorials in testing secondary school students' level of metacognition in Kenya.

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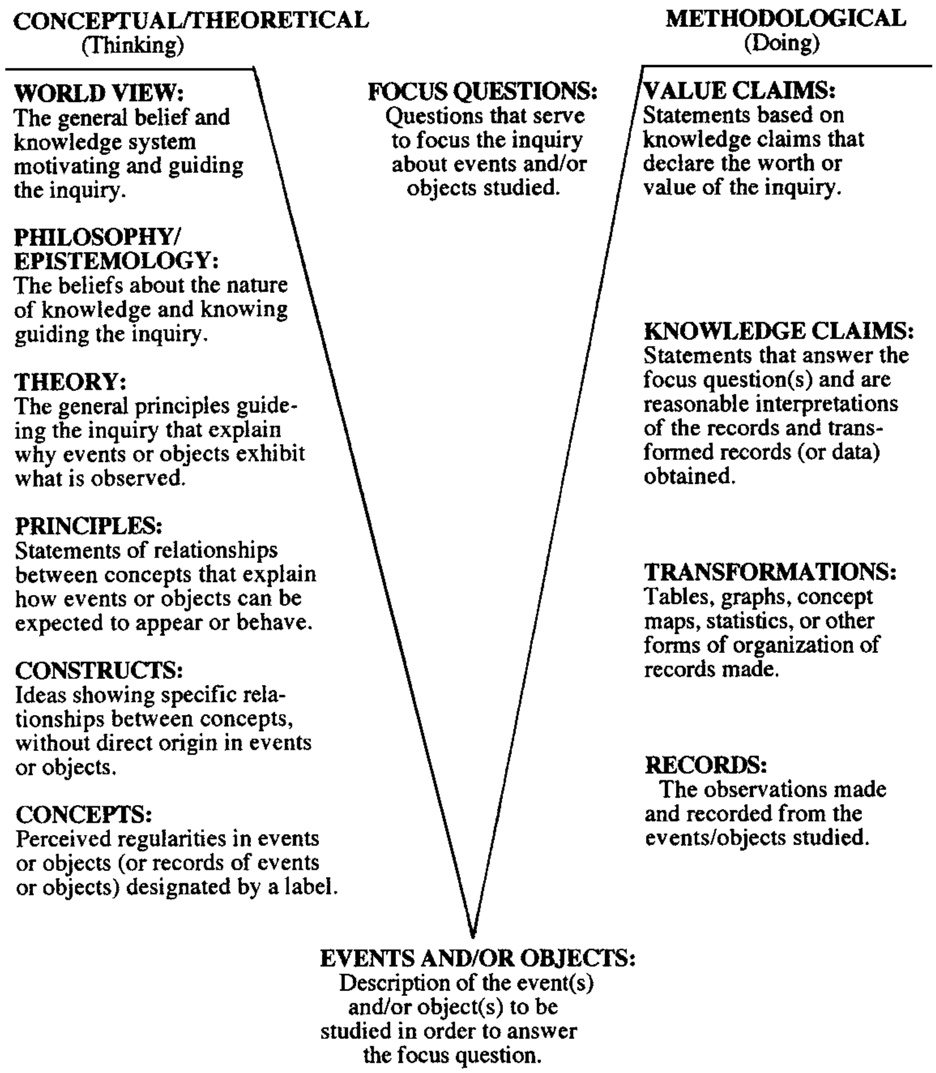
APPENDIX A: Gowin's Vee Teacher's Training Manual

Introduction

Physics is science subject and it involves experimenting. During the experiment you have apparatus, procedure, observation then conclusion. Again you realize that these experiments do not exist alone but they are supported by concepts like density, force, pressure, matter etc which are measurable physical quantities. When these concepts are combined together they form physics principles for example heating causes expansion, an increase in volume causes decrease in density, matter is made up of tiny particles, particles move in continuous random motion etc .but this is not the end. A combination of principles gives a theory for example kinetic theory of matter-Matter is made up of tiny particles which are in continuous random motion etc these theories are well known and written clearly so that they are used to explain phenomena. Is it possible to put all these content in one diagram that can be easily understood? What kind of diagram is this? How will it look like?

The Gowin's Vee is a Vee shaped diagram which has 12 elements. In the left side of the Gowin's Vee are the conceptual elements namely, worldview, philosophy, theory, principles, constructs, concepts. At the centre of the Gowin's Vee is the focus question and at the tip are objects/events. At the right hand side is called methodological side. These are the activities the learner must do in order to answer the focus question. The elements in the methodological side are record, transformations, knowledge claims and finally value claims see figure 1 below.



Use of Gowin's Vee in the classroom.

The Gowin's Vee may appear very complex but if well translated it is easy and versatile to use. However, due to the level of students the world view and the philosophy elements can be omitted. The twelve epistemological elements are translated as follows.

The focus question- it is at the centre of the Gowin's Vee and focuses the learner towards what is to be learnt. For instance, the learner may ask the following pertinent question.

What does the learner want to know?

What do I want to find out?

Theories-these are the theories needed in order to answer the focus question in the topic being studied for example kinetic theory of matter, domain theory of magnetism etc.

P**rinciples** –these are principles that are being applied in order to answer the focus question for example the principle of moments, Archimedes, Principle. It is also possible for learners to combine various concepts to form a principle e.g. heat causes expansion.

Constructs-these are equations being used in the study for example $\rho=m/v$

Concepts –these are physical quantities in physics for example mass, density etc

Objects /events –these are apparatus, procedures and even description in a question.

Records –these tabulation of results, or other record like t=20, s=5 etc

Transformations-these are data analysis methods like graphs, charts, and calculations

Knowledge claims –these is the answer to the question or conclusion of the experiments

Value claims-this is the significance or importance of the knowledge acquired .it can also be applications of the knowledge

CONCEPTUAL/THEORETICAL (Thinking)

METHODOLOGY (Doing)

FOCUS QUESTION(S)

Calculate clockwise moments and anticlockwise moments in the table.

What is the relationship between Clockwise and anticlockwise moments at equilibrium?

WORL VIEW

-

PHILOSOPHY

-

THEORY

Newtonian mechanics

PRINCIPLES

- Principle of moments
- Turning effect of a force depends on its distance from the pivot

CONSTRUCTS

$F_1d_1=F_2d_2$

CONCEPTS

- Force
- Moment
- Mass
- Weight
- Distance

VALUE CLAIMS(applications and importance of the study)

The knowledge of moments enable us to lift heavy objects thus making machines that make work easier

KNOWLEDGE CLAIMS (answers obtained)

F1d1=F_2d_2

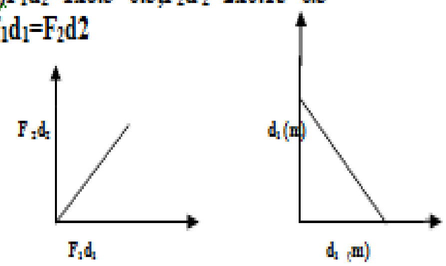
Clockwise moments is equal to anticlockwise moment

TRANSFORMATIONS (analysis which can be calculations, graphs)

i)F_1d_1=0.2x1=0.2,F_2d_2=2x0.2=0.2

ii)F_1d_2=1xo.3=0.3,F_2d_2=2x0.15=0.3

F_1d_1=F_2d2

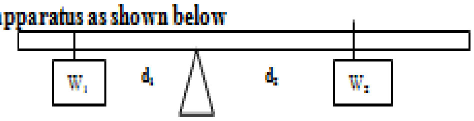


RECORDS (values given which can be in a table)

	w_1	d_1	w_2	d_2
i)	1	0.2	2	0.1
ii)	1	0.3	2	0.15
iii)	1	0.4	2	0.2
iv)	1	0.5	2	0.25

OBJECTS AND / OR EVENTS (Procedure and apparatus or description of a question)

Arrange the apparatus as shown below



Place the weight w_1=1N at 20cm from the pivot adust the weight w_2=2 N until it at equilibrium.Note the distance d_2. Repeat the experiment by adjusting d_1=30cm,40cm,50cm and find corresponding values of d_2.

CONCEPTUAL/THEORETICAL (Thinking)

FOCUS QUESTION(S)

METHODOLOGY (Doing)

WORL VIEW

-

PHILOSOPHY

-

THEORY

Kinetic theory of matter

PRINCIPLES

The volume of an oil drop is equal to the volume of the oil patch it forms

CONSTRUCTS (Equations)

$\frac{4}{3}\pi r^3 = \pi R^2 h$

CONCEPTS

Volume
Surface tension
Force
Molecule
Sphere

Calculate the thickness of the oil molecule.

VALUE CLAIMS (applications and importance of the study)

The knowledge of the oil molecule helps us to understand the size of the atom and particulate nature of matter

KNOWLEDGE CLAIMS (answers obtained)

Thickness of the 0il molecule=3.73 x10^{-10}m

TRANSFORMATIONS (analysis which can be calculations graphs)

.volume of sphere=volume of the patch

$\frac{4}{3}\pi r^3 = \pi R^2 h$

$\frac{4}{3}\pi(7\times10^{-5})^3 = \pi(3.5\times10^{-2})^2 h$

$h = 3.73\times10^{-10}$m

RECORDS (values given which can be in a table)

Radius of sphere r=0.07mm
Radius of patch R=3.5cm

OBJECTS AND / OR EVENTS (Procedure and apparatus or description of a question)

An oil of radius 0.07mm spreads on the surface of water to form a patch of diameter 7cm in a tray spread with lycopodium powder.

APPENDIX B: Physics Metacognitive Activity Inventory Questionnaire.

This questionnaire asks you to describe HOW OFTEN you do each of the following practices when you learn Physics. There is no right or wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future physics classes.

How to Answer each Question

On the next few pages you will find 27 sentences. For each sentence, circle only one number corresponding to your answer. For example: on a question or problem if your answer is frequently then cycle the corresponding number like this 1 2 3 ④ 5

SCALE:

= Never or only Rarely

2= Sometimes

3= Half of the time

4 = Frequently

5 = Always or Almost Always

1. I read the statement of a problem carefully to fully understand it and determine what the goal is.	1 2 3 4 5
2. When I am assigned physics problems, I try to learn more about the concepts so that I can apply this knowledge to the problems.	1 2 3 4 5
3. I sort the information in the statement and determine what is relevant.	1 2 3 4 5
4. Once a result is obtained, I check to see that it agrees with what I expected.	1 2 3 4 5
5. I try to relate unfamiliar physics problems with previous situations or problems solved.	1 2 3 4 5

6. I try to determine the form in which the answer or product will be expressed.	1 2 3 4 5
7. If a physics problem involves several calculations, I make those calculations separately and check the intermediate results.	1 2 3 4 5
8. I clearly identify the goal of a physics problem (the unknown variable to solve for or the concept to be defined) before attempting a solution.	1 2 3 4 5
9. I consider what information needed might not be given in the statement of the problem.	1 2 3 4 5
10. I try to double-check everything: my understanding of the physics problem, calculations, units, etc.	1 2 3 4 5
11. I use graphic organizers (diagrams, flow-charts, concept maps and Vee heuristics etc) to better understand physics problems.	1 2 3 4 5
12. I experience moments of insight or creativity while solving physics problems.	1 2 3 4 5
13. I jot doing things I know that might help me solve a physics problem, before attempting a solution.	1 2 3 4 5
14. I find important relations amongst the quantities, factors or concepts involved before trying a solution.	1 2 3 4 5
15. I make sure that my solution actually answers the question.	1 2 3 4 5
16. I plan how to solve a physics problem before I actually start solving it (even if it is a brief mental plan).	1 2 3 4 5
17. I reflect upon things I know that are relevant to a physics problem.	1 2 3 4 5
18. I analyze the steps of my plan and the appropriateness of each step.	1 2 3 4 5

19. I attempt to break down the physics problem to find the starting point.	1 2 3 4 5
20. I spend little time on physics problems for which I do not already have a set of solving rules or that I have not been taught before.	1 2 3 4 5
21. When I solve problems, I omit thinking of concepts before attempting a solution.	1 2 3 4 5
22. Once I know how to solve a type of problem, I put no more time in understanding the concepts involved.	1 2 3 4 5
23. I do not check that the answer makes sense.	1 2 3 4 5
24. If I do not know exactly how to solve a physics problem, I immediately try to guess the answer.	1 2 3 4 5
25. I start solving problems without having to read all the details of the statement.	1 2 3 4 5
26. I spend little time on problems I am not sure I can solve.	1 2 3 4 5
27. When practicing, if a physics problem takes several attempts and I cannot get it right, I get someone to do it for me and I try to memorize the procedure.	1 2 3 4 5

APPENDIX C: Physics Conceptual Understanding Achievement Test.

Name ……………………………………………………………………………Adm No …….

INSTRUCTIONS

- **Answer the questions below by drawing the Gowin's Vee and filling in the conceptual side (left side) and the methodological (right side).**

QUESTION ONE

1. Form two physics Students and their teacher were studying the topic of moments /turning effect of a force. They increased the forces $\mathbf{F_1}$ and $\mathbf{F_2}$ and measured their respective distance $\mathbf{d_1}$ and $\mathbf{d_2}$ at equilibrium and recorded values as shown in table 1.0.

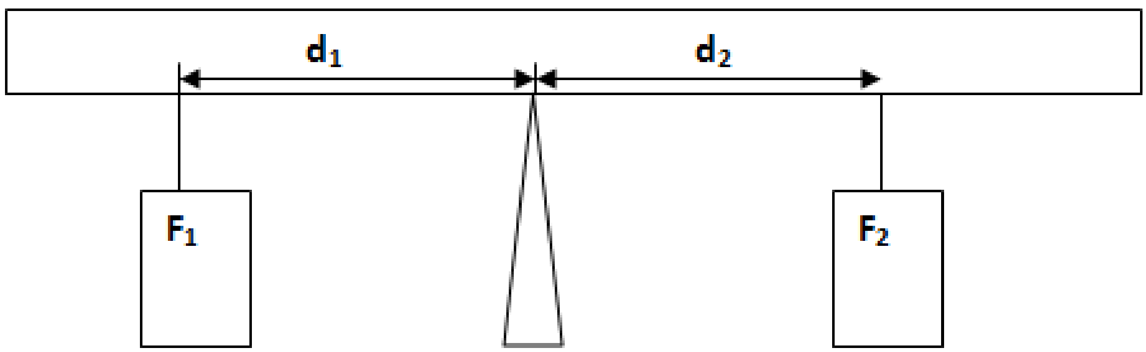


Figure 1.0

Using Gowin's Vee twelve epistemological elements:

a) Calculate and fill in the missing values in the table 1 below
b) From the table 1 below establish the relationship of the two moments.1m

Table 1

Force F_1	**Distance d_1**	**Anticlockwise moments(F_1d_1)**	**Force F_2**	**Distance d_2**	**Clockwise moments (F_2d_2)**
10			**20**	**0.1**	
15				**0.2**	**8**
24			**60**		**18**
40			**80**	**0.4**	

7mks

2. **Figure 2** represents a system at equilibrium. Using Gowin's Vee twelve epistemological elements:

   a) Calculate the value of the force F_5. 5mks

   b) Which two forces in the diagram form a couple? 1mk

   c) Calculate the moment due to the couple. 2mks

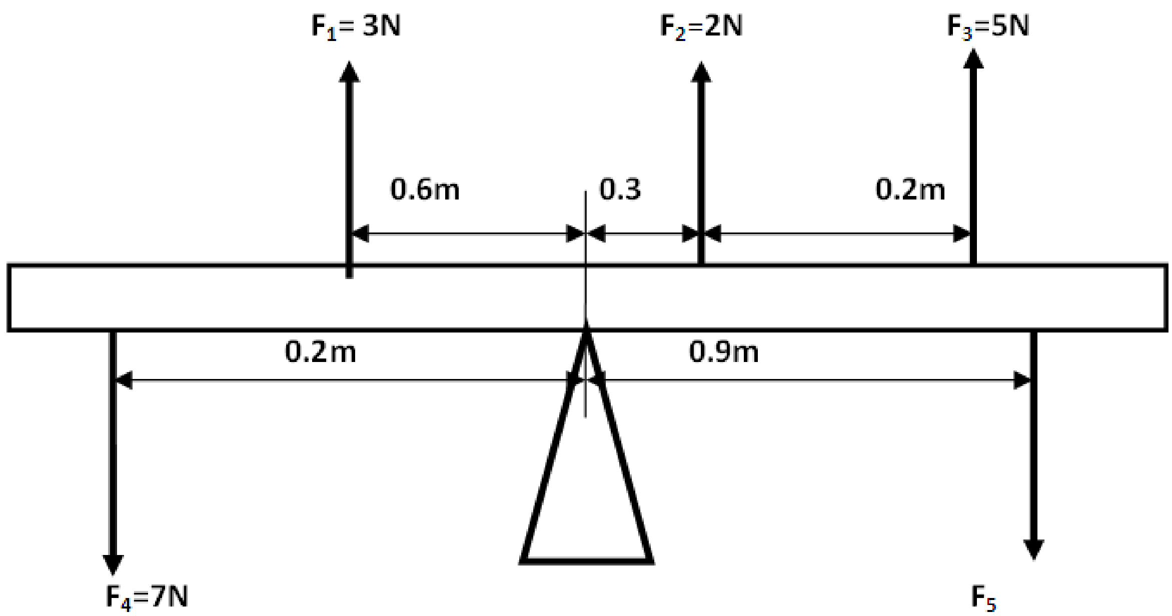


Figure 2.0

APPENDIX D: Physics Conceptual Understanding Achievement Test Marking Schemes.

CONCEPTUAL/THEORETICAL (Thinking)

METHODOLOGY (Doing)

FOCUS QUESTION(S)

a. Calculate and fill in the missing Values in table 1

WORL VIEW

PHILOSOPHY

THEORY

Newtonian mechanics

PRINCIPLES

At equilibrium clockwise moments is equal to anticlockwise moments at the same point

Sum of upward forces equals to sum of downward forces

(1mark)

CONSTRUCTS(Equations

F1d1=F2d2 ***(1mark)***

CONCEPTS

- Moments
- couple
- Clockwise
- turning effect
- Anticlockwise
- Distance
- pivot
- Force
- Equilibrium

(1mark)

VALUE CLAIMS(applications and importance of the study

The knowledge of moments can be applied in lifting heavy objects and making moving parts in machines

KNOWLEDGE CLAIMS (answers obtained)

i)0.2,2,2,(ii)0.53,8,40;(iii)0.75,18,0.3(iv)40,0.8,32 0

TRANSFORMATIONS (analysis which can be calculations, graphs)

F1d1=F2d2 10xd1=2 ⇨ d1=0.2:F2d2=0.1x20=2

F1d1=20x0.4=8 :0.2xF2=8 ⇨F2=40:30x0.6=18;60xd2=18 ⇨d2=0.3

F1x0.8=32 ⇨F2=40;80x0.4=32

	F_1	d_1	$F_1d_1)$	F_2	d_2	(F_2d_2)
i	10	**0.2**	**2**	20	0.1	**2**
ii	15	**0.53**	**8**	**40**	0.2	8
iii	24	**0.75**	**18**	60	**0.3**	18
iv	**40**	**0.8**	**32**	80	0.4	**32**

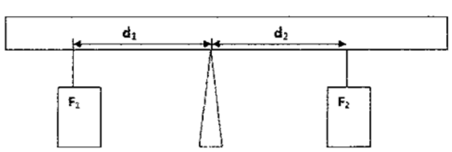
½(half) a mark for each correct answer

RECORDS (values given which can be in a table)

F_1	d_1	$F_1d_1)$	F_2	d_2	(F_2d_2)
10			20	0.1	
15				0.2	8
24			60		18
40			80	0.4	

OBJECTS AND / OR EVENTS (Procedure and apparatus or description of a question)

Form two physics Students and their teacher were studying the topic of moments /turning effect of a force. They increased the forces $\mathbf{F_1}$ and $\mathbf{F_2}$ and measured their respective distance $\mathbf{d_1}$ and $\mathbf{d_2}$ at equilibrium and recorded values as shown in table 1.0.



CONCEPTUAL/THEORETICAL (Thinking)

METHODOLOGY (Doing)

FOCUS QUESTION(S)

a. Calculate the value of the force F5

b. Which two forces form a couple?

c. Calculate moment due to Couple.

WORL VIEW

PHILOSOPHY

THEORY

Newtonian mechanics

PRINCIPLES

At equilibrium clockwise moments is equal to anticlockwise moments at the same point

Sum of upward forces equals to sum of downward forces

(1mark)

CONSTRUCTS(Equations

F1d1=F2d2 ***(1mark)***

CONCEPTS

- Moments couple
- Clockwise turning effect
- Anticlockwise
- Distance
- pivot
- Force
- equilibrium

(1mark)

VALUE CLAIMS(applications and importance of the study

The knowledge of moments can be applied in lifting heavy objects and making moving parts in machines and steering wheel

KNOWLEDGE CLAIMS (answers obtained)

a. 3N
b. F1 and F5
c. 3.3N
d. Sum of upward forces equals to sum of downward forces

TRANSFORMATIONS (analysis which can be calculations, graphs)

a) 7+F5=3+2+5: F5=3N ***(3marks)***

b) F1 and F5 ***(1mark)***

c) 3x1.1=3.3Nm ***(2mark)***

RECORDS (values given which can be in a table)

F1=3N

F2=2N

F3=5N

F4=7

F5=7

OBJECTS AND / OR EVENTS (Procedure and apparatus or description of a question)

Figure 2 represents a system of forces a tequilibrium.

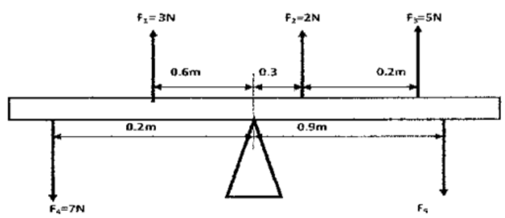
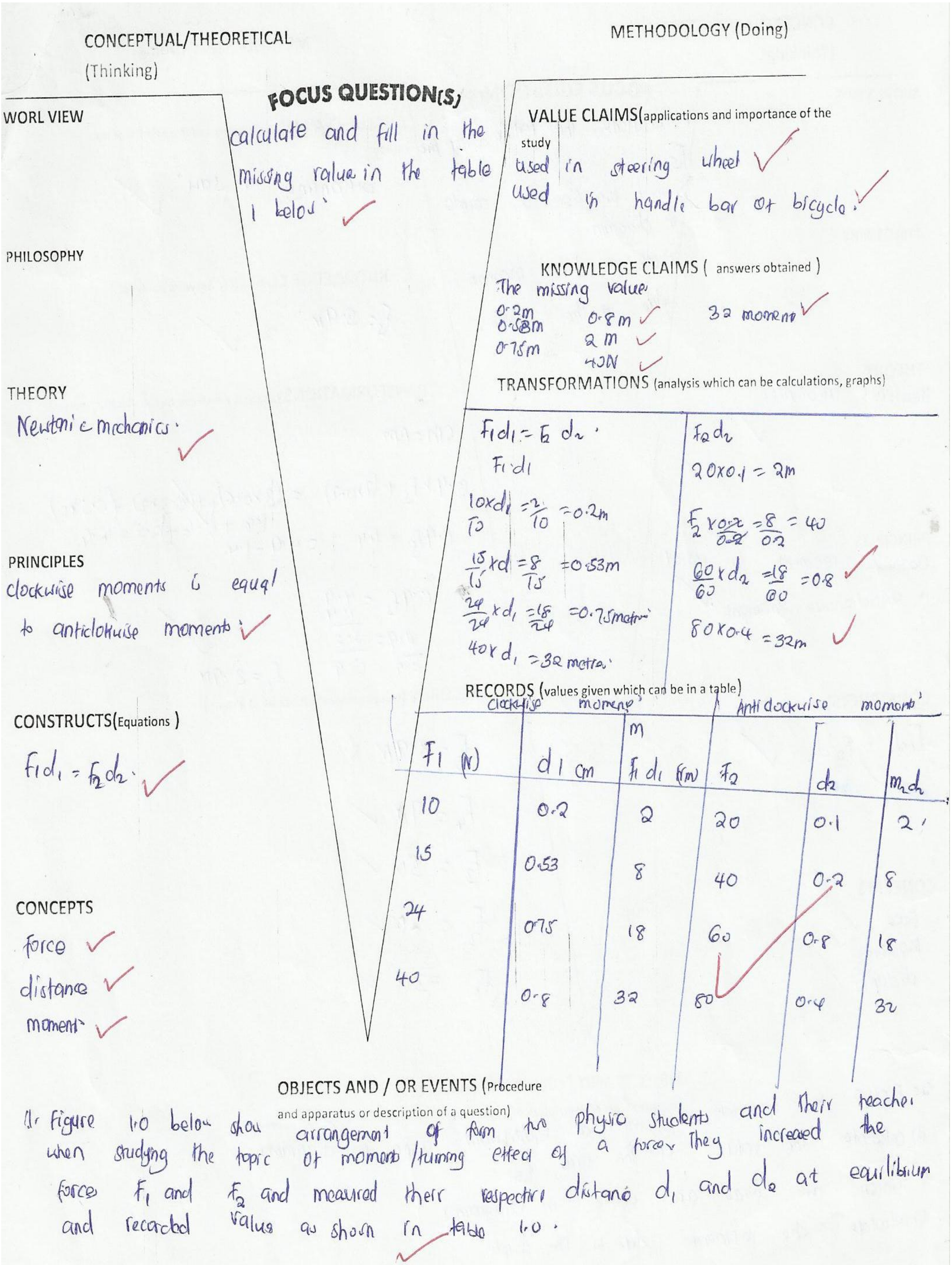


Figure 2.0

APPENDIX E: Sample of Student's Answers Using Gowin's Vee Heuristic Strategy.



APPENDIX F: Ministry of Education Science and Technology Research Authorization.

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref: No.

Date:
4th February, 2014

NACOSTI/P/14/8684/513

Daniel Kibet Mutai
Egerton University
P.O.Box 536-20115
EGERTON.

<u>RE: RESEARCH AUTHORIZATION</u>

Following your application for authority to carry out research on "***Effects of Gowin's Vee Heuristic strategy on secondary school students' conceptual understanding and metacognition in the topic of Moments in Physics in Uasin Gishu County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Uasin Gishu County** for a period ending **7th May, 2014.**

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

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

DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COMMISSION SECRETARY
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Copy to:

The County Commissioner
The County Director of Education
Uasin Gishu County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

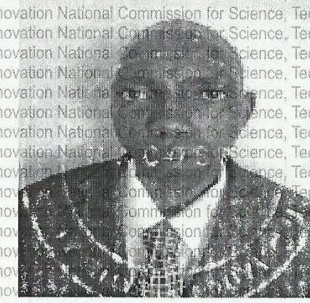
APPENDIX G: Research Permit

THIS IS TO CERTIFY THAT:
MR. DANIEL KIBET MUTAI
of EGERTON UNIVERSITY, 1108-30100
Eldoret,has been permitted to conduct
research in *Uasin-Gishu County*

on the topic: *EFFECTS OF GOWIN'S VEE HEURISTIC STRATEGY ON SECONDARY SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING AND METACOGNITION IN THE TOPIC OF MOMENTS IN [illegible]S, IN UASIN G[illegible]HU COUNTY.*

for the period ending:
7th May,2014

Permit No : NACOSTI/P/14/8684/513
Date Of Issue : 4th February,2014
Fee Recieved :Kshs khs1000.00



Applicant's Signature

Secretary
National Commission for Science, Technology & Innovation

CONDITIONS

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

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 935

CONDITIONS: see back page

APPENDIX H: Letter of Authorization from County Director of Education Uasin Gishu County

REPUBLIC OF KENYA

HARAMBEE

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
STATE DEPARTMENT OF EDUCATION

Telegrams: **"EDUCATION",** Eldoret
Telephone: **053-2063342** or **2031421/2**
Mobile : **0719 12 72 12/0732 260 280**
Email: cdeuasingishucounty@yahoo.com
: cdeuasingishucounty@gmail.com
When replying please quote:

Ref: No. MOEST/UGC/TRN/9/81

Office of The County Director of Education,
Uasin Gishu County,
P.O. Box 9843-30100,
ELDORET.

Date: 7th February, 2014

Daniel Kibet Mutai
Egerton University
P.O. Box 536-20115
EGERTON

RE: RESEARCH AUTHORIZATION

This office has received a letter requesting for an authority to allow you carry out research on **"Effects of Gowin's Vee Heuristic Strategy on Secondary School Students' Conceptual Understanding and Metacognition In the topic of Moments in Physics Uasin Gishu County, Kenya."**

We wish to inform you that the request has been granted for a period ending **7th May, 2014**. The authorities concerned are therefore requested to give you maximum support.

We take this opportunity to wish you well during this research.

VIOLA KIGEN
***for:* COUNTY DIRECTOR OF EDUCATION**
UASIN GISHU COUNTY

ISO 9001
BUREAU VERITAS
Certification
UKAS